Deep Time Iterations: Familiarity, Horizons, and Pattern Among Finland's Nuclear Waste Safety Experts

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This ethnography reconsiders nuclear waste risk's deep time horizons' often-sensationalized aesthetics of horror, sublimity, and awe. It does so by tracking how Finland's nuclear energy and waste experts made visions of distant future Finlands appear more intelligible through mundane corporate, regulatory, financial, and technoscientific practices. Each chapter unpacks how informants iterated and reiterated traces of the very familiar to establish shared grounds of continuity for moving forward in time. Chapter 1 explores how Finland's energy sector's "mankala" cooperative corporate form was iterated and reiterated to give shape to political and financial time horizons. Chapter 2 explores how workplace role distinctions between recruit/retiree and junior/senior were iterated and reiterated to reckon nuclear personnel successions' intergenerational horizons. Chapter 3 explores how input/output and part/whole distinctions were iterated and reiterated to help model distant future worlds in a portfolio of "Safety Case" evidence made to demonstrate the Olkiluoto repository's safety to Finnish nuclear regulator STUK. Chapter 4 explores how Safety Case experts iterated and reiterated memories of a deceased predecessor figure in everyday engagements with deep time. What emerges are three insights about how futures attain discernible features – insights about the "continuity," "thinkability," and "extensibility" of expert thought – that, I argue, can help twenty-first century experts better navigate not only deep time, but also unknown futures of nuclear technologies, planetary environment, and expertise itself.

Biographical Sketch

Vincent Ialenti is a socio-cultural anthropologist who studies how nuclear professionals endow uncertain futures with form. He has been a U.S. National Science Foundation Graduate Research Fellow (2011-2016), a Mellon Fellow at Cornell's Society for the Humanities (2015-2016), and a MacArthur Nuclear Waste Solutions Fellow at The George Washington University's Elliott School of International Affairs (2017-2018). He holds an MSc in "Law, Anthropology & Society" from the London School of Economics and a BA in "Philosophy, Politics, and Law" from State University of New York at Binghamton. Vincent has written public commentaries for NPR, Forbes, Sapiens, Physics Today, Nautilus, and other outlets. His work has been covered by Huffington Post, Forbes, Nevada Public Radio, Les Affaires, and the Long Now Foundation. At Cornell, Vincent designed and taught a first-year writing seminar called *Nuclear Imagination: Technologies & Worlds*. He is currently developing a second project on the 2014 drum breach accident at Waste Isolation Pilot Plant (WIPP), the U.S. defense nuclear waste repository in New Mexico.

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Abbreviations

ANT – Actor-Network Theory (sociological method)
ATS – Suomen Atomiteknillinen Seura (Finnish Nuclear Society)
BBC – British Broadcasting Corporation
BP – BP P.L.C., formerly British Petroleum
BSA – Biosphere Assessment (Safety Case model report)
BSD – Biosphere Description (Safety Case model report)
CLA – Construction License Application
CLAB – Sweden's Central Interim Storage Facility for Spent Nuclear Fuel
CNN – Cable News Network (U.S. media outlet)
CNNC - China National Nuclear Corporation
CSR – Corporate Social Responsibility
DOE – U.S. Department of Energy
DLA – Decommissioning License Application
EBS – Engineered Barrier System (safety case expert term for built repository)
EDF - Électricité de France
EK - Elinkeinoelämän keskusliitto (Confederation for Finnish Industries)
ENYGF - European Nuclear Society's Young Generation Forum (event)
EU – European Union
GE – General Electric (American multinational conglomerate)
GFM – Groundwater Flow Model (Safety Case model)
GTK – Geologian tutkimuskeskus (Geological Survey of Finland)
HUT – Helsinki University of Technology (now Aalto University)
IAEA – International Atomic Energy Agency
ICRP – International Commission on Radiological Protection
ICT – Information & Communication Technologies
IGDTP - European Technology Platform for Implementation of Geological Repositories
IYNC - International Youth Nuclear Conference
IVO – Imatran Voima (nuclear power company, now part of Fortum)
KAERI - Korea Atomic Energy Research Institute
KBS-3 – Kärnbränslesäkerhet ("Nuclear Fuel Safety") Repository (Sweden/Finland)
KQA – Knowledge Quality Assessment (Safety Case BSA modeling technique)
KTH - Kungliga Tekniska högskolan (Sweden's Royal Institute of Technology)
kWh – Kilowatt hour (electrical energy measurement)
KYT - Finnish Research Programme on Nuclear Waste Management
LMS - Landscape Model Setup (Safety Case model)
LUT - Lappeenranta University of Technology (Finland)
MRI – Magnetic Resonance Imaging (nuclear medicine technique)
MW – Megawatt (unit of power)
NAGRA - Switzerland's National Cooperative for the Disposal of Radioactive Waste
NASA – U.S. National Aeronautics & Space Administration
NEA – OECD Nuclear Energy Agency
NEI – Nuclear Energy Institute
NEUP – Nuclear Energy University Programs (U.S. DOE education program)
NPIC – Nuclear Power Institute of China

NPR – U.S. National Public Radio
NRC - U.S. Nuclear Regulatory Commission
OECD - Organisation for Economic Co-operation and Development
OL3 – Olkiluoto 3 (TVO/Areva nuclear power plant project)
OL4 – Olkiluoto 4 (a 21st century TVO reactor project that never went forward)
OLA – Operating License Application
POTTI – Posiva Research Database (knowledge management system)
PRISM - Power Reactor Innovative Small Module (sodium-cooled fast breeder reactor design)
PVO - Pohjolan Voima Oy (Finnish hydro/thermal power company)
RCA - Radionuclide Consequences Analysis (Safety Case model)
RDIPE - Moscow Scientific Research and Design Institute of Power Technology
RNT - Radionuclide Transport Model (Safety Case model report)
RSC - Rock Suitability Criteria (Posiva criteria for Olkiluoto repository rock conditions)
SAFIR - Finnish Research Programme on Nuclear Power Plant Safety
SCOT – Social Construction of Technology (STS theory)
SKB - Svensk Kärnbränslehantering AB (Swedish Nuclear Fuel and Waste Management Co.)
SMR – Small Modular Reactors (nuclear reactor design)
SROY – Saanio & Riekkola Oy (engineer consulting firm in Helsinki)
SSK - Sociology of Scientific Knowledge (study of science as a social activity)
SSM – Strålsäkerhetsmyndigheten (Sweden's Nuclear Regulatory Authority)
STS – Science & Technology Studies (interdisciplinary academic field)
STUK – Säteilyturvakeskus (Finland's Nuclear Regulatory Authority)
SUNY – State University of New York
TEM - Työ ja elinkeinotoimisto (Finland's Ministry of Employment and the Economy)
TEPCO – Tokyo Electric Power Company (Japanese electric utility)
TESM – Terrain and Ecosystems Development Model (Safety Case model report)
TVO – Teollisuuden Voima Oyj (nuclear power company)
UNSCEAR - United Nations Scientific Committee on the Effects of Atomic Radiation
UCS – Union of Concerned Scientists
UKIP – United Kingdom Independence Party
VTT – Teknologian tutkimuskeskus (Technical Research Center of Finland)
WANO – World Association of Nuclear Operators
WNA - World Nuclear Association
WNU - World Nuclear University

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A 2012 map of Posiva's Olkiluoto facilities given to visitors upon arrival.

Introduction: When Deep Time Becomes Shallow

Aerial Shot of Posiva's Onkalo Facility with the Olkiluoto Nuclear Power Plant in the Distance (Photo Credit: Posiva Oy).

It was summertime in Helsinki in 2013 and I was sipping coffee in an office with Risto, a modeler involved with Finland's nuclear energy sector's projects to build what will likely be the world's first operational high-level nuclear waste repository. The facility was to be built below the small island of Olkiluoto in Western Finland. There, a four-kilometer access tunnel led deep into a subsurface lab that aided scientists in forecasting the interacting geological, social, hydrological, and ecological conditions that might surround the repository over the next tens of thousands, hundreds of thousands, or even millions of years. Posiva's KBS-3 repository facility – with its key components made of copper, bentonite clay, and iron and its tunnels dug into hard granite bedrock[1] – was owned by Posiva Oy, a Finnish nuclear waste management corporation established in 1995. It was to be renovated and expanded to a depth of about 450 meters to make space for storing up to nine thousand tons of radioactive waste. After one hundred years of

[1]The KBS-3 concept, developed primarily in Sweden but also in Finland, was used by Finland's Posiva and Sweden's SKB nuclear waste companies. I have summarized the concept elsewhere: "To keep this dangerous, high-level waste from leaking over the many thousands of years during which it will remain active, the repositories will rely on four main barriers: First, used-up nuclear fuel rods are inserted into large, cast-iron inserts. Second, the iron inserts are placed in large copper canisters (see image above), which will then be welded shut. Third, the copper canisters are placed in the repository's underground tunnels and then surrounded by bentonite clay "buffers." This clay will absorb groundwater, which will make it expand and then, it is hoped, snugly encase the copper canisters. Fourth, the entire bundles are to be sealed in hard granite bedrock at about 500 meters depth" (Ialenti 2015).

accepting copper canisters containing spent nuclear fuel, the tunnel was to be backfilled, sealed off, and then abandoned.

KBS-3 Copper Canister & Cast Iron Insert Used to Encapsulate Spent Nuclear Fuel in Finland & Sweden.

Before this was to happen, however, a number of legal procedural requirements first had to be satisfied as part of the repository's construction and operations licensing procedures. In December 2012, Posiva submitted the most recent version of its Safety Case, the primary technical portfolio supporting the nuclear industry's License Application for a permit to begin formal construction of the repository. Risto did Safety Case modeling work—projects to quantify, represent, or simulate Western Finland's future worlds' conditions. The Safety Case detailed the repository's technical design, reported engineering principles and strategies for the facility, and contained numerous interwoven mathematical models and scenarios forecasting the repository's fate over the coming millennia. Its goal was to demonstrate to Finnish nuclear regulatory authority STUK that radionuclide doses to future populations will not exceed legally defined exposure maximums. Thus, some Safety Case experts produced reports with titles like *Climate Scenarios for Olkiluoto on a Time-Scale of 120,000 Years*. Others examined potential earthquakes that might occur as massive glacial ice sheets retreat from the region following the coming Ice Age fifty or sixty thousand years from now. The Safety Case passed STUK's review in February 2015 and Posiva was granted a repository construction license the following November.

Fieldwork among Safety Case experts like Risto immersed me in a scene in which deep or geological time horizons entered pragmatic frameworks of planning, policy, and regulatory science.[2] This was a scene in which thinking big or deep history or the long now became a practical regulatory science imperative.[3] It was a scene in which far future bodies, societies, and environments were engaged—in which relations between living societies of the present and the unborn societies imagined to dwell in distant futures were calibrated and recalibrated. Yet stretched-out time horizons like these were hardly novel in radioactive waste disposal contexts. They had precedents in Anthropology too, especially among archaeologists and evolutionary anthropologists whose work examines human-ecological relations in deep historical horizons.

Yet, as my fieldwork progressed, I found that the preconceptions about nuclear waste's deep time I had initially taken with me to Finland were breaking down. Engagement with deep time-reckoners like Risto was altering how I saw, related to, and wrote about distant future worlds. Deep time became an idiosyncratic assemblage of workplace artifacts, ideas, assumptions, and practices that my informants aimed to make more tractable, calculable, or finite through scientific, engineering, management, financial, and regulatory logics. This ethnography revisits nuclear waste's deep time – and the problems of intergenerational relatability, sublime unknowability, and sci-fi inflected futurology they often evoke – in ways inspired by my encounters with these future-gazing practices. It argues, in a deflationary spirit, that better understanding how visions of far future Earths emerge from mundane professional practices is an absolute prerequisite to thinking more soberly about nuclear waste risk amidst intense twenty-first century uncertainties surrounding the futures of nuclear technology, of Earth's environment, and of expertise itself. To do so, it tracks how nuclear professionals have iterated and reiterated

[2] For more on deep or geological time, see Rudwick 1992 or Gould 1987.
[3] For more on deep or big history, see Smail 2008. For more on the long now, see Brand 2000.

traces of the very familiar to endow their projects with continuities into futures and to pursue their deep time-reckoning endeavors. It concludes by deriving three insights – about the "continuity," "thinkability," and "extensibility" of expert thinking – for experts struggling to envision plausible tomorrows amidst intense uncertainty.

Gloom & Gravity, Stillness & Darkness

Before embarking for Finland in 2011, I watched Danish filmmaker Michael Madsen's 2010 documentary *Into Eternity: A Film For the Future.* The film projected aesthetics of desolation and bleakness, of austere machinery and industrial processes. Madsen portrayed the Olkiluoto project as a place where dark souls tended to the world's most lethal waste in a lifeless cave beneath a frigid island at the edge of the habitable world. The project was depicted as a place of gloom and gravity, stillness and darkness. With this scene set, Madsen told a story of nuclear waste experts speaking straightforwardly of their plans to engineer an underground facility resilient to the contingencies to befall the Olkiluoto region over the coming millennia. The moods, ambiances, and cadence of the film were stirring and the story it told was engrossing. Deep time appeared mysterious, overwhelming, awe-inspiring, and otherworldly.

For Madsen, deep time invited philosophical speculation about pollution ethics, human extinction, communication across millennia, and civilization's grandest aspirations. This was a common move among academics and public commentators. Science & Technology Studies (STS) scholars had already come to appreciate the United States' Yucca Mountain nuclear waste repository project's extreme intellectual and engineering demands (Bloomfield & Vurdubakis 2005). Social scientists had already reflected on the intergenerational responsibilities entailed by spent nuclear fuel's multi-millennial horizons of hazard (Shrader-Frechette 2005) and the imperatives they created to model very complex, contingent, and interconnected ecosystems, engineered facilities, and geosystems (1993). Physicist and science fiction author Gregory Benford had already written of nuclear waste's challenge of communicating with far future Others with different semiotic systems (2000). Social scientists had noted U.S. nuclear waste challenges of designing monuments to warn far future societies not to enter potentially hazardous repository sites (Galison 2012; Bryan-Wilson 2003). Humanities scholars had drawn upon philosophical theories of the sublime and the uncanny to articulate deep time's "ghostly human traces" (See Farrier 2016). Many of these questions and aesthetics reappeared in Historian of Science Peter Galison and filmmaker Robb Moss' 2015 documentary about containing nuclear waste risk, "imagining society 10,000 years from now," and the "idea that over millennia, nothing stays put" (2015).

Nuclear waste's deep time had sparked extensive pop-science and media coverage. It posed countless challenges to present-day societies seeking to imagine their far future counterparts. Yet – when I got know Safety Case experts like Risto throughout 2012, 2013, and 2014 – I found their imaginations captured by rather different sets of questions. Of course, they saw Madsen's questions as part of Finland's nuclear waste story. But they were caught up in scientific, legal, and engineering details – the technicalities and uncertainties of their work[4] – more than philosophical reveries on deep time's forbidding expanses or musings about future human semiotic systems. They often appeared focused, like other professionals in other highly specialized sectors, on markedly short-term futures as they grappled with daily challenges to which I as an academic researcher could surely relate. They asked questions like these:

[4] For an example of anthropological scrutiny of technicalities, see Riles' work on legal technicalities (2005).

> “Will Marja and Timo finish this project on schedule?” / When will Eero retire?” / “Will report X be finished by deadline Y?” / “Will our project get funding for another year?” / “At what time does my wife expect me to be home for dinner today?” / “Has Tuuli fallen into the disfavor of the new managers here?” / “Should I be spending more time with my family?” / “How can they reasonably expect us to finish this report by the end of the summer?”

They did this amid institutional aesthetics that were worlds apart from those in Madsen’s film. Safety Case experts worked in modest-but-comfortable office buildings adorned with fluorescent lights, coffee machines, clean cafeterias, saunas, tasteful prints of artwork on the walls, and unostentatious brick exteriors. Most sat in office chairs for much of their workdays running models on computers, scrutinizing regulatory requirements, poring over datasets, and when necessary, sometimes staying up late into the night to finish technical reports before an impending deadline. The experts spent much of their time working quietly, chatting lightly and joking amongst themselves, attending meetings, drinking coffee, looking over reports. Fieldwork nudged my attention away from distant future horizons and toward the short-term horizons of deadlines, schedules, funding politics, project phases, career stages, daily plans, five-year plans, contingency plans, human life courses, and so on. Nuclear waste’s deep time’s aesthetics of gloom, awe, and profundity faded from view—displaced by the ethnography’s here and now. Nuclear waste risk’s deep time became shallow.

Key Safety Case informants cautioned me not to be seduced by nuclear waste’s flashiest debates. I was to exercise careful restraint: to avoid simply reiterating the same old deep time questions, suffused with sci-fi tinged speculations, already so well-rehearsed and widely disseminated. Rumors circulated that certain Posiva higher-ups were not pleased with how Madsen portrayed the Olkiluoto project. Some told me how deep time sensationalism too often deflected public attentions away from substantive work on regulations, geoscience, engineering, financing, modeling, and management that occupied most of their workdays.[5] They stressed that, given their R&D work's urgency, they simply cannot afford to get lost in the existential dread of Madsen's farsighted ruminations. Some saw Madsen's inquiries as tired and overrated—as "nothing new." So I set out to participate with deep time ethnographically on my informants' terms. This disenchanted it for me. But it made it no easier to pin down.

Mundane Millennia

Nuclear waste's deep time took many forms. Sometimes it was a pile of paper reports or an electronic folder of pdf files. Other times it was a geological timetable on informants' office walls. Sometimes deep time was Safety Case experts' hallway conversations. Other times it was a narrative frame for describing a geological process. It entangled with the short-term futures of project funding conditions and the inner-workings of interpersonal office politics. It got caught up in Olkiluoto repository experts' work to maintain stable successions of recruitments and retirements, information transfer and training, financial solvency, and coherent organization continuously for no less than one hundred forty years until the facility's intended closure around 2120. Nuclear waste's deep time, in all its novelty, was made and remade through seemingly mundane networks of communication, documentary flows, formalities, routines, and patterned matrices of shared expertise.[6] It was as much about near futures and pasts as about distant futures and pasts. It was as much about surprise as about expectation—as much about the unplanned as

[5]For example, some questioned why *Into Eternity* – a film ostensibly about Finland's spent nuclear fuel disposal endeavors – focused so heavily on multi-millennial warning monuments that were proposed not in Europe's far North, but in the context of America's defense nuclear waste disposal efforts at WIPP in New Mexico.
[6]But, like others of related kind, these networks were also impelled by elements of non-structure, of surprise, freak accidents, the unexpected, the unforeseen, and the anomalous—spawning within networks comprised of countless gaps and incongruities through webs of non-knowledge and the conscious misrepresentations and misinterpretations that impel them.

about planning. It took shape in and through people webbed together with technologies, ideas, infrastructures, ecosystems, administrative apparatuses, customs, norms, affects, anticipations, and traces of the past. Deep time was, as anthropologist Richard Irvine has put it, “part of the phenomenal world impacting on people at the level of experience” (2014: 157, 168).[7]

A Photo of Nipsu the Pet Hedgehog Taped Above a Safety Case Geologist's Desk.

Deep time took form in everyday ecologies of affects, frustrations, aggressions, kindnesses, dreams, sentiments, regrets, ideas, and ambitions. As an artifact of people’s ordinary actions, the Safety Case itself could not be separated from how many of Risto’s colleagues were grandparents, others divorcees, others aloof loners, others rambunctious partygoers, while still others had recently become parents. Interpersonal dynamics sculpted deep time’s everyday manifestations. I began taking seriously how, for example, a senior informant trained for an Iron Man endurance competition as another informant of roughly the same age showed up to an interview mildly hung-over with two candy bars, a pack of cigarettes, and at least a few cups worth of coffee in hand. I noted how some spent summers crunching numbers in their office while others enjoyed time in the Finnish countryside at their

[7]Irvine has said the Anthropocene concept challenges us to “open to deep time,” to “find new ways of exploring the interrelationships between human and geological temporalities” (2014: 157, 168). This dissertation complements Irvine’s trajectory by inverting it: moving away from locating the human within deep time and toward locating deep time within the human.

family's *kesämökki* ("summer cottage"). One's daughter had a pet hedgehog named Nipsu; another decorated the wall near his desk with images of his Finnish Lapphund he printed off from his computer. One recently read Wittgenstein's *Tractatus Logico-Philosophicus* and another read works by Bruno Latour, Mary Douglas, Ulrich Beck, Alice Munro, and Marcel Proust. Still another, in his spare time, read famous works in Sociology, History, and Psychology. A security guard at a building housing a research nuclear reactor was a fan of the late-1980s early-1990s action-adventure television series MacGyver. In their childhoods, two experts – both geologists today – dreamed of someday becoming archaeologists. A high-status regulatory expert grew up fascinated by what she saw as the ostensibly more ecologically attuned lifeways of Native Americans. A hydrogeologist told me how she sees horseback riding as an enjoyable counterpoint to her professional work that helps her clear her mind outdoors in the forest. One informant went boxing with her daughter on Tuesdays to keep her arms, back, and shoulders moving after hunching over her computer all day.[8]

Deep time also emerged from Safety Case experts' technologies and technical modeling languages. Studying this ethnographically called for something like what STS scholars Collins & Evans have called Studies of Expertise and Experience (2002). It also called for engagement with Anthropology's longstanding interest in different cultures' instrumentalities: their tools, techniques, technologies, and many other means for accomplishing practical ends.[9] Deep time

[8] To take these details seriously is to construe "experts not solely as rational(ist) creatures of expertise but rather as desiring, relating, doubting, anxious, contentious, affective— in other words as human subjects" (Boyer 2008: 38). This is key to "engag[ing] the non-professional" dimensions their livelihoods (Boyer 2008: 44).

[9] See, for example, Ingold 2000 Latour 2002; Leach cited in Ingold 2000: 317; Mauss 1973; Pottage & Mundy 2004; Riles 2004; 2010; 2011; Strathern 1992a: 47, 83, 136; 1995; 1996; Suchman 1987: 53; Wagner 1981: 50, 89; 1986: 13, 93. My interest in how nuclear waste's deep time horizons caused mutations in everyday knowledge-practices is in part inspired by Anthropology's longstanding focus on how people reinvent, recontextualize, or retool their and others' instruments, ideas, and lifeways to adapt to shifting stimuli and (un)anticipated happenings.

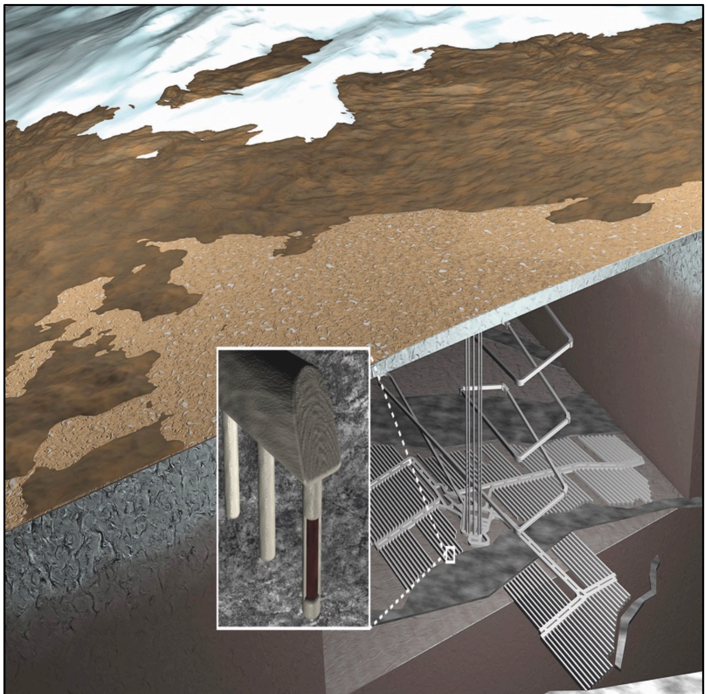
was both an artifact of expert knowledge-practice[10] and a response to the toxic materiality of nuclear waste itself. Tracking this ethnographically required ongoing contact with many highly-trained nuclear energy and waste insiders in Finland: physicists, engineers, geologists, artists, mathematicians, hydrologists, modelers, lobbyists, managers, chemists, finance professionals, lawyers, politicians, academics, to name a few. After a preliminary field trip in Summer 2011, I lived in Helsinki from January 2012 to August 2014. I took Finnish language courses, immersed myself in Northern European worlds, and sought out informants who were either insiders to or had something specific to say about Finland's nuclear energy in general or nuclear waste disposal efforts in particular. I chatted with these informants about life in Finland, about what captured their imaginations about their work, how they organized their time, how their time was organized for them, how they navigated uncertainties, and how they rested their minds leisurely outside the workplace. Our collaborative conversations were substantive, speculative, unstructured, frank, open-ended, and sometimes quite philosophical in spirit.

From a Visit to Finland's Nuclear Regulatory Authority, STUK.

I digitally recorded over one hundred fifteen interviews with informants drawn from the Technical Research Center of Finland (VTT), the Geological Survey of Finland (GTK),

[10]For anthropological work on knowledge and knowledge-practice, see e.g. Barth 1975; 2002; Crook 2007; 2009; Riles 2011b: 10. For anthropological work on experts and expertise, see e.g. Boyer 2008; Carr 2010. These literatures helped me understand how people worked with technical instruments and how technical instruments worked with people to create the nuclear energy knowledges that created visions of nuclear waste's deep time.

engineering consultancy Saanio & Riekkola Oy (SROY), Finland's Nuclear Regulatory Authority (STUK), lobbying association Confederation for Finnish Industries (EK), clay technologies consultancy B+Tech, Posiva Oy, Finland's Parliament (*Eduskunta*), Aalto University, Greenpeace, lobbying association Finnish Energy Industries, Friends of the Earth, power companies Fennovoima, TVO, and Fortum, the general public, and elsewhere.[11] Some worked on the Finnish Research Programme on Nuclear Waste Management (KYT), which, established in accord with Finland's Nuclear Energy Act (990/1987), oversaw the country's nuclear waste knowledge base. These conversations usually took place at informants' workplaces or at pubs, restaurants, or cafés. I took field notes on more informal conversations and email exchanges with nuclear sector insiders. I wrote notes about



Posiva's Illustration of the Olkiluoto Repository 100,000 Years in the Future (Photo Credit: Posiva Oy).

[11] To break my field materials down further: I recorded (a) fifty conversations with engineers, modelers, geologists, and other experts who could be considered insiders in Posiva's repository project, (b) ten conversations with experts who could be considered insiders in STUK's regulatory oversight of Posiva's repository project, Safety Case, and CLA, (c) thirteen conversations with artists, NGO workers, environmentalists, activists who were skeptical of Posiva's work and/or who held broadly anti-nuclear views, (d) eleven conversations with nuclear sector insiders who worked on the energy production side (as opposed to the waste disposal side) of Finland's and/or other countries' nuclear sectors, (e) eleven conversations with counter-experts and/or critical experts (in e.g. geology, engineering, social sciences, and architecture) skeptical of Posiva's work, (f) ten conversations with experts in academia and/or the private sector who specialized in the financial/legal aspects of nuclear energy in Finland, (g) six conversations with political actors who had something specific to say about Finland's nuclear energy/waste projects, (h) six conversations with bloggers, industry lobbyists, and environmental activists who held broadly pro-nuclear views, and (i) four conversations with other miscellaneous experts, artists, and/or members of the public who had noteworthy perspectives on nuclear energy/waste and/or culture in Finland.

friends', acquaintances', colleagues', and my own reflections on the politics, economy, culture, history, language, and experiences living in Finland. I collected many documents, reports, and other artifacts given to me by informants.

I had other more unique experiences too. In Summer 2013 I spent two days at a Safety Case expert's family's *kesämökki* ("summer cottage") and then visited Finland's Tytyri limestone mine. I visited a uranium and copper deposit geological research site with them. Another informant brought me to a laboratory working on the welding and nondestructive testing of the copper canisters in which Posiva plans to encapsulate Finland's spent nuclear fuel. In June 2013, I attended the European Nuclear Society's Young Generation Forum (ENYGF) event in Stockholm. While in Sweden, I visited Swedish nuclear waste disposal company SKB's underground Äspö Hard Rock Laboratory – a facility very similar to Posiva's Onkalo underground laboratory – and its CLAB interim storage facility for spent nuclear fuel. In September 2013, I attended the World Nuclear Association (WNA)'s annual symposium in London. These many conversations, events, artifacts, experiences, and notes comprised the field materials from which I derived this ethnography's empirical accounts. These accounts inspired me to scrutinize how nuclear waste's deep time emerged from experts' ordinary actions. What emerged is an ethnography of how my informants iterated and reiterated very familiar devices of thought and action – devices key to corporate organization, professional succession, regulatory science, expert predecessorhood, and more – as patterned means for reckoning deep futures amidst intense uncertainty.

Sisyphean Ants & Iterating Familiarity

Risto once recounted a childhood memory to me. He remembered sitting outside, decades ago, watching an ant continually trying to climb up a deep ridge of mud emplaced by a human bootprint in the ground. The ant kept climbing up, falling down, trying to climb up again, and falling down, *ad nauseum.* Risto was never sure whether the ant ultimately made it. Yet he was struck by two things. The first was the Sisyphean ant's tenacity in repeatedly trying to surmount what should have, like Safety Case deep time-reckoning, [12] perhaps been dismissed outright as an insurmountable obstacle. The second was the algorithmic simplicity with which the ant *iteratively* climbed up and fell down—following a simple *familiar pattern* that made the ant fail to navigate the uncertain challenges before him. Some of Risto's colleagues identified with ants too. They expressed feeling like but simple ants working within a larger Safety Case ant colony. They felt themselves inhabiting a collective intelligence that superseded any individual expert's intelligence. Risto's anecdotes helped me see what Safety Case deep time-reckoning was all about: (a) pursuing inordinately difficult challenges regardless of knowing whether these challenges can ever be accomplished with certainty,[13] (b) attuning critically to key familiar patterns being iterated and reiterated to lay stable grounds for thinking

A Nuclear Waste Disposal Expert Sifts Through Clays Being Considered for Backfilling the Olkiluoto Repository Tunnels After Facility Decommissioning Sometime Around 2120.

[12] See Evans-Pritchard 1929 for a classic anthropological discussion of time-reckoning.
[13] In adult Risto's case, the inordinately difficult challenge was one of modeling how radionuclides will move and disperse in underground rock and groundwater networks over the coming millennia.

about futures,[14] and (c) working in collaborations that, taken in their totalities, overflow any single person's comprehension yet still somehow work.

Following the leads of informants like Risto, I took seriously how nuclear insiders iterated with very familiar patterns of thought and action to establish continuous foundations for moving forward amid entangled time horizons and future unknowns.[15] Each chapter showcases this in one way or another. Chapter 1 shows how financial, corporate, academic, and anti-nuclear activists iterated and reiterated a unique cooperative corporate form called *mankala* to give pattern to the shallow political and economic time horizons of new reactor projects. Chapter 2 shows how formal workplace role template distinctions between *recruit/retiree* and *junior/senior* were iterated and reiterated among nuclear experts to endow intergenerational time horizons of personnel succession with more comprehensible pattern. Chapter 3 shows how formal distinctions between *input/output* and *part/whole* were iterated and reiterated by Safety Case experts to give pattern to scientific models of Finland's distant future time horizons. Chapter 4 shows how the forms taken by the remembered *predecessor figures* of an influential deceased expert named Seppo were iterated and reiterated – summoned, conjured, or channeled by living experts – to help give pattern to Safety Case deep time modeling projects in near-term horizons.

Together these chapters show how simple incessantly reiterated devices were foundational to the nuclear energy generation that produced the spent nuclear fuel that necessitated the Safety Case deep time-reckoning work that brought visions of far future Finlands into view. They show how

[14] Some key patterned in and through which Risto worked – as Chapter 3 will show – were distinctions made through devices like "input/output," "part/whole," and "iteration."

[15] Each chapter takes seriously anthropologist Ernest Gellner's view of how "time and its horizons are conceived [are] generally connected with the way the society understands and justifies itself' (1964: 1). This approach was inspired in part by how Henri Hubert called the nexus of "time as the fulcrum of intervals and time as a set of reference enabling an event to be positioned" (Hubert 1999: 19). It was also inspired by Crapanzano's work on the beyond, the horizon, the hinterlands, and the frontier (2004). It was also inspired by theologian Moltmann's notion of "horizons of expectation" (1996).

informants iterated them to order relations between people, ideas, money, computers, documents, institutions, companies, landscapes, non-human organisms, and countless other entities across space and time. They show how their familiarities had to be tended to and kept up by animate agents in practice for them to persist as loci of coordination. Constantly flickering in and out of my ethnographic field of vision, these devices helped endow context after context after context with more pattern or clearer meaning. As beacons of pattern, they introduced redundancy – an interest of both my informants and of anthropologists such as Gregory Bateson (1972) – into nuclear expert worlds' daily happenings. Iterative acts, gestures, and moves – in constraining and enabling fresh thinking, predicting, and relating always with reference to the familiar – loosely coordinated aspects of informants' inter-subjective and distributed webs of living collaboration. They were, in anthropologist Elizabeth Povinelli's terms, key to moving arrangements and derangements of existents in a plane of immanence (2014b). They helped resolve Posiva's deep time-reckoning projects and my informants' senses of place within them.

As an analytic, iteration – like mankala, recruit/retiree, junior/senior, input/output, part/whole, and predecessor – is not mine alone. In Chapter 3 informants enact "iteration" as a concept for describing how future revisions of the Safety Case portfolio will be arranged as a continuous progressive series until repository closure circa 2120. Many informants spoke too of the incessant repetitions driving "iterative" computer modeling techniques. I borrow "iteration" from them to guide my own analysis of how traces of the familiar were repeatedly evoked in series of elapsing moments. I was also inspired by informants' broad interests in the *forms* their collaborations, knowledges, and worlds took (See also Conclusion). In Chapter 1, for example, informants reflect on what makes mankala a unique "form" of corporation. Some Safety Case informants used the epithet "formalist" when criticizing colleagues for caring more about making aesthetically consistent reports and logically consistent models – "formally" linked together through Chapter 3's input/output and part/whole devices – than about their empirical rigor. I likewise scrutinize the forms that their iterations of the familiar took: how certain devices – from junior/senior to predecessor to mankala – became *loci of relations, never outside the immanent or concrete, from which patterns emanated and to which they attached*.[16]

I draw upon parallels between my informants' articulations and anthropological works on form, pattern, and aesthetics to build my analysis. Marilyn Strathern has written about how the "constraint of form" shapes exchange, gender, and reification—demonstrating how very specific limiting aesthetics must always be present to register difference and successfully activate, elicit, or enable relationships (1988: 180-182). Bateson saw systems of restraints as central to patterns, meaning, and redundancies in the world (1972: 410-412). He drew attention to the "pattern which connects" in mind, society, biology, grammar, and inanimate matter too (1979: 8). Eduardo Kohn has explored form's efficacy and the "effortless propagation of pattern that runs through our lives" (2013: 19, 227). Annelise Riles, in her anthropological work on pattern in network and document aesthetics, has approached form as a way to apprehend what is "too familiar" to be easily discerned (2000: 21). Works like these helped me articulate how informants' devices of familiarity gave pattern to the shared horizons of interpretation from which they, together, brought far future Finlands into view.

Generating and reinforcing patterns, formal devices such as part/whole or predecessor/successor did important work among nuclear professionals. They were iterated to index positions of and relations between – contrasts, correspondences, incongruences, conformities between – people,

[16] My approach to pattern is influenced by Kohn's interest in form and on "how specific configurations of limits on possibility emerge in this world, the peculiar manner in which these redundancies propagate, and the ways in which they come to matter to lives, human and otherwise" (2012: 19).

technologies, ideas, institutions, companies, teams, ecosystems, and more. They differentiated nuclear energy agents from one another as separate entities while also connecting them together as constituent parts of Finland's nuclear worlds as a whole. In Chapter 1, for example, a given agent's role in relation to the mankala helps specify his, her, or its position and responsibilities in Finland's broader nuclear financing circuit. In Chapter 2, formal succession roles like recruit/retire or junior/senior help specify nuclear professionals' positions in space (physical office space), status (influence/pay/stature), and time (generational cohort and career stage) vis-à-vis one another. In Chapter 3, Safety Case informants iterate input/output and part/whole to map both epistemological relations between their technical models and professional relations between them as expert people.[17] In Chapter 4, Seppo's predecessor personae are iterated and reiterated as means for achieving continuities between living and dead experts' knowledge-practices across time.

These familiar devices, figures, and formations were not inherent to any entity alone. They did not exist in the time or space between the entities. They did not exist between the entities and my, the analyst's, brain. The patterns they effectuated were *non-localizable* (Bateson 1972: 415)—alive in relations partial to each entity but definitive of none as a whole. Together they, in tandem with countless others I did not select for anthropological scrutiny, helped underpin and orchestrate significances. They helped create nuclear expert worlds' "spacetime" (Munn 1976)—endowing actions, moments, and practices with more schematic shape. They helped constitute the very persons, groups, and institutions that participated in them as well as the differences registered between them. They had to be iterated very similarly by a vast swathe of entangled agents to become efficacious. An expert simply could not relate sensibly to others at work if he

[17]This could be seen as what anthropologist Annelise Riles has called a sociality "twice" (2000: 91)

or she saw retiree or CFO as a lower position or earlier career stage than student intern. A deceased predecessor simply could not be tutored about new scientific innovations by an unborn expert. Very similar "transforms" (Bateson 1972: 415) of them had to exist in all iterators' minds for them to properly activate relationships. They had to be iterated in very specific constrained ways to make nuclear agent relations effectively appear (cf. Strathern 1988: 180).

Tracking these iterations helped me revisit nuclear waste's deep time as artifacts of thinking subjects (Miyazaki 2012) or creative subjects (Holmes 2009) who, like anyone else, were reflexive as they went about their day-to-day ordinary actions (Lynch 2000). My informants, like billions of others, iterated familiarities to give their worlds auras of continuity. In Chapter 1, there is Alaknam: a banking industry professional who helped endow Finland's early twenty-first century nuclear reactor purchasing arrangements with continuities across days, weeks, months, and years. In Chapter 2, Timo: a young motivated radiological protection specialist with career leadership aspirations and who often reflected on his position within nuclear sector succession's intergenerational continuities. In Chapter 3, Laura: a Safety Case expert who helped weave the farsighted portfolio's many interlocking models and datasets together into a continuous whole to be updated periodically until 2120. In Chapter 4, the surviving colleagues of Seppo: a former Safety Case project leader who died in a mid-2000s bicycle accident, but who achieved postmortem continuity in being frequently referenced anecdotally in troubleshooting moments nearly a decade after his death. I have masked their identities with pseudonyms.

Together these chapters show how iterations of the very familiar were as integral to nuclear waste's deep time as any speculative quandary about distant future semiotic systems, human extinctions, or multi-millennial warning monuments. My informants' deep time was an artifact of simple and ostensibly banal devices cloaked in the familiar aesthetics of laboratory, corporate, and regulatory institutional worlds sidelined in Madsen's film and other commentaries. They were upheld, in part, by delicate logical-causal patterns with relatively clear form that required ongoing iteration to persist.[18] Persisting, they generated familiar patterns that helped effectuate nuclear waste experts' representations of the most unfamiliar future worlds. Their power was in how they pointed beyond themselves toward their own patterned effects—toward the relational consequences they spawned. Borrowing them to anchor my own analysis taught me many lessons about nuclear professionals' commitments to persistence of spirit, to reflexive iterations of the familiar, and to the adaptive navigation of uncertainties.

What emerged is a multi-scalar perspective (See Edwards 2003: 221-222) on how familiar devices mediated the heterochronotopia – the interposed realities, imaginaries, and temporalities (Banerjee 2015) – that underpinned nuclear waste's deep future visions.[19] This is a poly-temporal ethnography[20] of how professionals wove together continuities between nuclear waste's many time horizons, deep and shallow, in practice.[21] Its approach can, I suggest, help one get to the

[18]Not everything in my fieldsite had clear form. Riles once noted how intimacy is not relations or knowledge (2004: 401). It can take form in gestures while intimacy itself remains formless. Unsorted matter and random events – which Bateson once suggested no person has ever seen, but has posited as examples of the formless noise from which new patterns emerge (1979: 416) – have no form. The concepts of them in the world do though. The empathetic tugs in Bateson's work on "empathy toward pattern" may have no form, while the patterns drawing one in do (8). The symbolic constructions "run wild" (Kohn 2013: 48) in anxiety's what-if worst-case thought-racings have form. But the anxiety impelling them, and the alienated feelings of being cut off from a broader field of habits it creates, as sensations are without form (49). Pain, ultimately unrepresentable, "has no cultural form" but "exists in all forms" (Riles & Jean-Klein 2005: 178). For humans – unable to live the experience of being, say, an insect or a bat – the sensation of living a wildly different organism's perception is out of reach. To us, it has no form. The totality of things in universe, like infinity, is a formed concept for something overspills thought and thus is ultimately formless from the perspective of human experience. Measurements of time have form but time's durative flow is formless.

[19] This is not a new focus for ethnographers. See, for example, the work on multi-temporality in global financial market worlds (Miyazaki 2003) or High Energy Physics laboratories (Traweek 1992). What is new is this dissertation's bringing these questions to bear on nuclear issues specifically through the anthropology of form, pattern, and aesthetics.

[20] For a sense of what I mean by polytemporal, see Sandywell 1998 or Bakhtin 1981. For a more elaborate discussion of "timescapes," see Adam 1998.

[21] This engages a nexus of interest to many anthropologists today: "phenomena operating at the limits of calculation and measurement" (Holmes 2009: 381), "theoretical, technical and professional commitments… at the limits of expert knowledge" (Miyazaki 2014: 130), and "imaginative horizons" (Crapanzano 2005). This also provides an

heart of how nuclear experts perform fantastical feats like designing, building, operating, and decommissioning nuclear power plants or reckoning Finland's far futures. This ethnography unpacks how Posiva's deep time-reckoning endeavors have plodded on stably even in early twenty-first century nuclear expert worlds that have been perhaps less Promethean, less epistemologically secure, and less optimistic than at any other point post-WWII.

But before I return to how this analysis relates to debates in Anthropology and to other ethnographies of nuclear issues, I will reflect on how Finland's nuclear sector worlds took shape in a late modern epistemological context in which many hopes, dreams, and technocratic projects had been colored, deflated, or sapped by failures of knowledge and foresight that accompanied recent crises. Even while many Safety Case experts labored fruitlessly like Risto's Sisyphean ant, their stoic pursuits of precision, wisdom, learning, technicalities, intellectual challenge, and deep time-reckoning maintained. Philosopher Edmund Burke might have emphasized here how challenges of immense difficulty, like building Stonehenge for example, can spark in the mind a feeling of sublime infinity ([1757] 1958: 139). But I point to something less uplifting: the profoundly unknowable character of the futures upon which nuclear insiders like Risto gazed. So I now explore three backdrop contexts – unknown nuclear energy futures,

A Representative From Russia's Rosatom Showing Me an Augmented Reality App that Projects a 3D Nuclear Power Plant onto a Flat Surface.

"ants eye view" (Geertz 1973: 23) of how nuclear energy's time horizons materialized "in vivo" or "in the wild" (See Holmes 2013).

unknown technocracy and expertise futures, and unknown environmental futures – in which informants iterated and reiterated the very familiar to carve out semblances of intelligibility amidst intense uncertainty.

Unknown Nuclear Energy Futures

At the time of my fieldwork, nuclear energy sectors across Western Europe and North America were mired in historical moment of questioned legitimacy, open futures, unsettled confidence, and shaky public understandings of nuclear energy technologies' promises and perils. Starry-eyed post-WWII Atoms for Peace utopianism – grounded by techno-optimism for engineers, scientists, technocrats, and large centralized hierarchical technoscientific assemblages like nuclear power – had long since attenuated. Post-1970s environmentalist thought had drawn mass attention to radioactive contamination risk. Post-9/11 wariness had recast nuclear power plants as potential terror targets and radioactive materials as potential terror instruments. Low-frequency but high-impact and high-visibility catastrophes like those at Three Mile Island, Chernobyl, and Fukushima had left many averse to pursuing nuclear reactors. Some countries, like Germany, moved to phase-out nuclear energy altogether. Others wondered how they would deal with the mass baby boomer generation retirements – alongside the challenge of recruiting the best and brightest STEM students for nuclear careers – as nuclear workforces aged in greying societies like, say, Japan, South Korea, Finland (See Chapter 2). Still others worried that nuclear reactor deals, especially in emerging or middle-income economies like India or South Africa, came bundled with geopolitical carrots and sticks or even paid off officials (e.g. Johnson 2015). No country had – despite notable progress toward burying spent nuclear fuel by the 2020s in Finland and Sweden – a solution in operation for permanently burying for its entire time horizons hazard.[22] In the United States, public sentiment toward nuclear energy could also be skeptical, ambivalent, or even apathetic—a far cry from post-WWII visions, hopefully awaiting fusion power, of nuclear someday producing energy "too cheap to meter."

Nuclear energy's economic unviability was approached with wary uncertainty. Some noted how nuclear reactor building projects had very high up-front costs in the billions, with energy payback time for nuclear plants being about eleven years compared to natural gas' half year (van Leeuwen in Biello 2009). With new reactor designs, profit was sometimes not seen for four decades—posing financial risks that fit poorly with more shallow corporate investment horizons. It had also become clear – especially after Japan's Fukushima disaster – that, in the rare event of a major meltdown, enormous cleanup costs render nuclear energy uninsurable: states and taxpayers would always have to bail them out. As Ralph Nader once put it: it is "telling that Wall Street, which rarely considers the consequences of gambling on a risk, will not finance the construction of a nuclear plant without a full loan guarantee from the U.S. government" (2013). This led many to see nuclear as untenable without military-style government purchasing,[23] without clean energy state subsides like those seen by wind, solar, and hydro, or without strong sovereign support for nuclear like that in China, India, or Russia where many new reactors were being built. Reduced natural gas prices sparked by U.S. innovations in shale fracking technologies tipped financial calculi away from nuclear. Jacobson & Delucchi meanwhile argued that global future energy needs could, by 2030, be achieved through solar, hydro, and wind alone (2009). Key nuclear promoters like the Nuclear Energy Institute (NEI) were reluctant to argue

[22]The Obama Administration's 2009 decision to abandon the United States' longstanding multi-billion-dollar project to build a permanent geological repository beneath Nevada's Yucca Mountain raised further questions about the logistical, scientific, political, and NIMBY dynamics of nuclear waste disposal. This decision may, however, be reversed under the Trump Administration.

[23] In a similar vein, some noted how nearly all major revolutions in reactor design have had strong government backing; private industry has only achieved incremental innovations on its own.

aggressively for a carbon tax – which could tip cost-benefit calculi in nuclear's favor – because many of the utilities they represented also had fossil energy holdings in their portfolios.

Early-2000s visions of a coming nuclear renaissance – in which nuclear energy was to resurge as a climate solution – deflated into challenges of warding off a nuclear dark age. It remained unclear what would replace the many aging reactors across North America, Western Europe, and elsewhere – like New Jersey's Oyster Creek Nuclear Plant, which began operating in 1969 – that soon had to be decommissioned, be given costly life-extension updates, or be replaced with new energy sources. Aging reactors, like Sosnovy Bor near St. Petersburg and in fallout-range of Helsinki, continued to operate riskily next to big cities. Japan, Switzerland, Taiwan and aimed to drop nuclear too. The new nuclear rollout in China turned out weaker than initial projections. Finland's new Olkiluoto 3 (OL3) reactor project, originally slated to go online in 2009, was still not yet operational and saw serious cost overruns. France announced plans to reduce its reliance on nuclear energy by twenty-five percent to fifty percent of its total energy portfolio. Generation III reactor building projects at Flamanville (France), Summer (South Carolina), and Vogtle (Georgia) proved to be alarmingly expensive. The global nuclear industry's center began moving from Europe and North America to China, Russia, and South Korea. China pursued nuclear projects in England; Russia's Rosatom in the U.K. Nuclear giants like Toshiba, Areva, and Westinghouse faced serious financial trouble. And while more new reactor projects are underway now than at any point in the past twenty-five years – with sixty-six under construction and another 158 planned – the WNA still describes nuclear energy futures as "challenging" (WNA 2016).

Yet some companies still had hope for coming Gen IV nuclear reactor design innovations—from small modular reactors (SMRs) to thermal, thorium, or fast reactors. Advocates pointed with confidence to Bill Gates' Terrapower reactor R&D investments. Yet it remained unclear how much funding for further R&D would be necessary before new designs would become commercially successful. And while some were hopeful that Gen IV fast reactors would someday consume weapons-grade plutonium, others worried about how the liquid sodium used to cool them can react explosively with air. While some were optimistic about General Electric's PRISM reactors, others noted how they require metal alloy fuels that swell and can break their surrounding cladding (Biello 2012). Some envisioned SMRs becoming more cost effective and hence more plausible investments for wider arrays of buyers. The vision was that SMRs would be uniformly built in factories and shipped via truck or rail to different installation sites. This would, some thought, be more efficient than huge Gen III plants, which had to be customized for specific locales and granted tailored regulatory licenses.[24] It could also be more flexible: if a reactor owner were to decide its three hundred megawatt (MW) SMR was not enough, it could simply purchase another unit to be installed next to the first—attaching new modules on as-needed bases.[25] Some dreamed that SMRs could generate energy for rural regions far from larger energy grids. Others saw them replacing aging coal plants.

But many were not convinced. A Union of Concerned Scientists (UCS) report questioned SMR cost effectiveness claims. It said that an SMR's cost per kilowatt hour (kWh) could actually be higher than that of a larger reactor if many ambitious cost-cutting goals were not achieved. They continued that "arguments in favor of lower overall costs for SMRs depend on convincing the

[24]The SMR was the most widely discussed Gen IV nuclear reactor type. Informants speculated that SMRs could lower nuclear's staggering initial investment costs. They too noted how smaller, lower-output, simpler reactor designs could someday be factory-built uniformly in one place and then transported via trucks or trains to individual installation sites with minimal on-site assembly. Gen III reactors, by contrast, had to be tailored to specific locales, customized for specific regulatory contexts, acquire their own unique construction licenses, be subject to more extensive safety analysis, and be assembled mostly on-site—creating costly non-uniformities between projects.

[25]Nuclear insiders distinguished between Gen III reactor designs' economies of scale strategies with SMR reactor designs' economies of series production strategies.

U.S. Nuclear Regulatory Commission (NRC) to relax existing safety regulations" concerning ten-mile emergency planning zones and weaker containment structures (Lyman 2013). The U.S. DOE was still arguing that SMRs could help America pursue energy security and climate goals so long as they became economically viable in a decade. The International Atomic Energy Agency (IAEA)'s "Innovative Nuclear Power Reactors & Fuel Cycle" project had foreseen forty-three SMRs installed globally by 2030 its "low" scenario and ninety-six in its "high" scenario by 2030. But, by 2016, only three SMR designs were in operation. They were not in the U.S. but in Russia, Pakistan, India, and China. More SMR projects were in the construction phase in Argentina, China, and Russia. New SMR designs by Westinghouse, Bechtel, NuScale Power, KAERI, NPIC/CNNC, GE-Hitachi, RDIPE, and Holtec were under development. The DOE's and IAEA's projections still appeared too rosy (Ialenti & Tomlinson 2016).

Yet some still saw climate change solutions in nuclear power's powers to generate steady, predictable, baseload energy without leaving large land footprints or emitting carbon. Self-described ecomodernist thinkers saw it as key to what some called a "good Anthropocene" in which "humans use our extraordinary powers to shrink our negative impact on nature" (Breakthrough Institute 2015). Climate pragmatist or radioactive green [26] pro-nuclear environmentalists supported nuclear power in the name of economic prosperity, environmental flourishing, poverty reduction, and human advancement.[27] Some noted how a recent NASA Goddard Institute study estimated that 1.8 million lives could be saved if fossil energy were replaced by nuclear (Kharecha & Hansen 2013). Others pointed to how, say, Sweden had rapidly

[26] Many of these pro-nuclear environmentalists relayed their personal histories of coming to support nuclear energy to me in narrative forms resembling "conversion" or "coming out" tales. This was sometimes done strategically to convince other environmentalists to follow suit and voice support for technologies long unpopular among environmental activists. These sorts of narratives can also be observed in Robert Stone's 2013 documentary *Pandora's Promise*.

[27] For more on ecomodernism and climate pragmatism, see Atkinson et al. 2013 and Asafu-Adjaye et al. 2015. "Radioactive green" environmentalism is discussed in Bryce 2013 and Ialenti 2013.

decarbonized much of its energy system by embracing nuclear energy over oil in response to 1970s oil shocks. Still others pointed to what they saw as France's ostensibly positive experience with nuclear power. Meanwhile, certain climate scientists were going public and making pro-nuclear climate policy recommendations (Caldeira et al. 2013). But would nuclear ever fully gain ground as an accepted climate solution among publics and politicians? Or would it continue to be associated with environmental contamination, cancer, or meltdowns?

Pro-nuclear environmentalism remained a niche view. Many anti-nuclear activists and intellectuals dismissed it as but an extension of nuclear industry insiders' re-branding campaigns to greenwash nuclear as a tool for decarbonization. Others questioned whether enough nuclear plants could be built, and enough fossil plants not built, quickly enough to have a reasonable impact on carbon emissions. While some conceded that Europe might need nuclear power because it does not have ample natural resources to power itself in a climate friendly way using hydro, solar, and wind alone (MacKay 2009), some were simply skeptical of how a decision to invest in a nuclear power plant would also be a political decision to empower the corporations, governments, technocrats, managers, scientists, financial elites, engineers, and politicians that will oversee it. This was thought to create regulatory capture or revolving door risks.[28] Others worried that more nuclear energy would lead to more nuclear weapons. Some pointed out how nuclear power plants were not technically emissions free, as greenhouse gasses were emitted during construction and uranium enrichment processes. Still others noted the emissions that resulted when nuclear weapons uranium was downblended for use in nuclear power plants as

[28] Different countries had different terms for these elite coalitions—"nuclear mafia" in South Korea or "nuclear village" in Japan, for instance.

part of the US-Russia Megawatts to Megatons program.[29] Then there were the terrible labor conditions endured by Navajo uranium miners in the American Southwest (Fettus & McKinzie 2012) and by African uranium miners working for French nuclear companies (Hecht 2012).

These unknown futures of health, economic, political, environmental, and technological innovation uncertainties interwove across North American and Western European nuclear energy worlds. But the way they converged in Finland made it an especially interesting case study. A country of but 5.5 million inhabitants, Finland was a place where various stages of the nuclear fuel cycle folded into one another. It was, for instance, home to Onkalo in Olkiluoto, Finland—the underground laboratory that will likely become the world's first operational permanent geological repository for spent nuclear fuel. It was home to four operational nuclear reactors as well as the active but pricey and delay-ridden new reactor construction project OL3. Plans for an OL4 fell through as many questioned the merits of Fennovoima's Hanhikivi 1 new reactor project, which had Russia's Rosatom as its nuclear technology supplier. While purchasing a reactor from Russia was seen as taboo throughout much the West, Finland had, since 1977 and 1980 respectively, had generally positive experiences with its Soviet-built Loviisa 1 and 2 reactors. The Loviisa plant was playfully nicknamed "Eastinghouse" because of its Soviet reactor fitted with Western safety systems and controls. Finland was also home to uranium mining potential eyed by international mining companies, a research reactor at Aalto University (formerly Helsinki University of Technology) in Espoo, and memories of the 1986 Chernobyl disaster's fallout raining down on its soil. When I lived in Finland, cesium from the disaster remained detectable in, for instance, mushrooms and reindeer. Ethnographic research among the

[29] This refers to the United States-Russia Highly Enriched Uranium Purchase Agreement completed in December 2013. In this agreement, the United States began buying low-grade uranium downblended from Russian nuclear warheads determined to be in excess.

country's nuclear professionals gave me an insider peek into how many of these challenging twenty-first century unknowns converged in a specific place.

Unknown Expertise Futures

I conducted fieldwork during what many saw as a broad crisis of expertise in corporate, governance, academic, financial, and intellectual cultures across North America, Western Europe, and beyond (Meridian 180 2013). Politicizations of expertise – climate expertise being a prime example (Conway & Orskes 2010) – in the media, popular debates, academia, and elsewhere had opened expert knowledge to the scrutiny of ever more counter-experts and lay publics. The rise of new ICT infrastructures rearranged who, how, and if one became an influential thought leader. In the world of advertising, the mass comprehensibility of post-WWII mass markets had been sliced up into the many niches of late twentieth century targeted markets and was then sliced up further into hyper-personalized metadata-informed twenty-first century online ad targeting. Endless deluges of web content, twenty-four-hour news cycles, and social media circuses had left many lost in jungles of information. A globalist collapse in transnational dialogue dampened starry-eyed technocratic-multiculturalist enthusiasms (Riles 2016: 184).[30] Tom Nichols proclaimed the "death of expertise" itself.[31] The universality, hardness, production,

[30] As Riles put it: "[C]onfidence has vanished. The United Nations no longer convenes global conferences; it authorizes military action through its Security Council, that is, when that body is not blocked by disagreements among its members. Gone is the faith in progress through deliberation in the global public square. Gone is the faith in technocratic expertise that made it possible to imagine that all kinds of knowledge and political points of view might be assembled into a singular document. Gone also is the notion that there is no outside to the global form" (2016: 184).

[31] To quote Nichols (2014) at length: "I wonder if we are witnessing the 'death of expertise': a Google-fueled, Wikipedia-based, blog-sodden collapse of any division between students and teachers, knowers and wonderers, or even between those of any achievement in an area and those with none at all… what I fear has died is any acknowledgement of expertise as anything that should alter our thoughts or change the way we live. A fair number of Americans now seem to reject the notion that one person is more likely to be right about something, due to education, experience, or other attributes of achievement, than any other… we now live in a world where the perverse effect of the death of expertise is that, without real experts, everyone is an expert on everything… There are no longer any gatekeepers: the journals and op-ed pages that were once strictly edited have been drowned under the weight of self-publishable blogs (like, say, this one).

and use of expert knowledge had been questioned through the late twentieth century's so-called deconstructive, postmodernist, and poststructuralist thought movements. Social theory after these turns found itself grounded on more limited coordinates that looked roughly as follows:

> polyvocality/~~master-narrative~~, partiality/~~totality~~, contingency/~~pattern~~, fragmentation/~~teleology~~, particularity/~~universality~~, play/~~theory~~, irony/~~objectivity~~, reflexivity/~~assertion~~, heterogeneity/~~singularity~~, poetics/~~truth~~, discourse/~~substance~~, form/~~content~~, flux/~~static~~, immanence/~~transcendence~~, material/~~immaterial~~.

A 2012 *Scientific American* article noted an "anti-intellectual conformity" that was "gaining strength in the U.S. at precisely the moment that most of the important opportunities for economic growth, and serious threats to the well-being of the nation, require a better grasp of scientific issues." Reflecting on what had "turned so many Americans against science," the author noted politicizations of expert knowledge gaining ground on both sides of the political spectrum (in debates about stem cell research, vaccines, climate change, evolution etc). He noted how "the intellectual tools currently being used by the political right" to foster anti-scientism had origin in the "academic left," which had – since the 1960s-70s – drawn "ideas from cultural anthropology and relativity theory to argue that truth is relative and subject to the assumptions and prejudices of the observer" (Otto 2012). Experts like physicist Peter Higgs became concerned that they "wouldn't be productive enough for today's academic system" and wondered whether "work like Higgs boson identification" would even be "achievable now as academics are expected to keep churning out papers" (Aitkenhead 2013). Academic audit cultures (See Strathern 2000) and what computer scientist Cyril Labbé called the publication "spamming war started at the heart of science" (Van Noorden 2014) also spread across Western European and North American academic worlds.

The Humanities and Social Sciences grew wary of their uncertain fates. Academic events with names like "The Arts & Humanities: Endangered Species?" or the "End/s of Anthropology" sprouted up. Politicians targeted entire academic fields (e.g. U.S. GOP Senator Coburn's 2009-2013 campaign against NSF Political Science funding). Broad analytical interest in expertise itself proliferated.[32] In Anthropology, some diagnosed these challenges as compounded by the discipline's deadlock between scientific rationalism and postmodern nihilism (Povinelli 2014a). Others diagnosed them as compounded by a "vulgar Foucauldian" poststructuralism that – in replicating, often unwittingly, the experience of a "professional-managerial class" and encoding "a kind of neoliberal cosmology in miniature" – encouraged anthropologists to perform routine "ritual denunciation[s] of anthropology" and "acts of self-condemnation" under the aegis of reflexivity (Graeber 2014). Still others diagnosed them at as compounded by how the "suffering subject" had moved to the very "centre of anthropological work" since the 1980s and hence led anthropological research to focus disproportionately on those "living in pain, in poverty, or under conditions of violence or oppression" (Robbins 2013: 448). Others lamented emphases on circular "discourse about discourse and writing about writing" (Dalton 2002: 60) in a twenty-first century Anthropology valuing what Paul Rabinow has called "representation of representations" (1986: 250).[33] STS scholar Bruno Latour (2014) summed up Anthropology's twenty-first century uncertainties concisely:

> Consider the situation: here is a battered scholarly discipline, always uncertain of its scientific status, constantly plagued by successive and violent "turns" (the "ontological turn" being only the more recent), a field which always finds itself dragged into the middle of harsh political conflicts,

[32] See e.g. Boyer 2008; Carr 2010; Collins & Evans 2002; Holmes & Marcus 2005; Mitchell 2002.
[33] This is also evident in what Holbraad & Pedersen have described as the "reflexive injunction to treat the 'self' as an object as well as a subject of anthropological scrutiny" prominent in Anthropology since the 1980s poststructuralist turn (2009: 371-372).

> a discipline that runs the constant risk of being absorbed by neighboring specialties and voted out of existence by deans and administrators impatient of its methods and ideologies, a discipline that accepts being crushed under the weight of all the violence and domination suffered by the many populations it has decided to champion.

Soon millions would reject globalism, multiculturalism, elites, scientists, technocrats, and academics at the ballot box. When I returned to America's Ivy League after fieldwork, I saw academic intellectuals lose media wars for public hearts and minds. Public derision of seemingly holier-than-thou politically correct academic intellectuals and their seemingly coddled elite university students had grown. Fox News' *Campus Craziness* program reported, in an exposé mode, on Duke University's "safe space" for "male-identified students" to "help men proactively deconstruct their masculinity." Breitbart News had headlines like "Here's Why There Ought to Be a Cap on Women Studying Science and Maths" or "'Science Proves It: Fat-Shaming Works." Fewer saw pricey university educations as paths to upward mobility. The American Dream seemed a vestige of a bygone era. Paypal founder Peter Thiel gave twenty young people one hundred thousand dollars each to drop out of college to focus on inventing, designing, or creating. Anti-expert sentiments reared their heads when pollsters failed to predict Hillary Clinton's loss. Big data expertise had become associated with global surveillance capitalism. Suspicions of Russian hacking had cast doubt on intelligence and cybersecurity experts.

Anti-expert sloganeering was key to Trump's rise. Henry Kissinger called Trumpism "a reaction of Middle America to attacks on its values by intellectual and academic communities" (Goldberg 2016). Cornell University's post-election student "cry-in" event made national news. Stories of the University of Pennsylvania's "post-election safe space complete with puppies and coloring books" went viral (Soave 2016). Netizens debated whether events like these were inclusive, infantilizing, both, or neither. It became clear that academic intellectuals could not respond to the alt-right by simply becoming the alt-left. Latour noted the limits of what he called trickle-down epistemology (2016)—of closed circles teaching humanistic nuance to only certain students in certain universities and then assuming those sensibilities will percolate down, over, or up to the rest. The Oxford English Dictionary named "post-truth" its Word of the Year. No longer was it radical for a postmodern academic to critique reality. The U.S. President became the most influential deconstructionist of Western governance norms and regimes of truth of all. Trump proposed budget blueprints with draconian cuts to Arts and Humanities. In April 2017, science became something to march on Washington for.

The Trump moment, the Brexit moment, and the rises of nationalist-populism in Europe were depicted in global media outlets as interconnected upheavals that sprouted up abruptly across the West. But tracking these mega-narratives ethnographically from within (nuclear) expert cultures complicated them by revealing their rises as far more gradual.[34] Fieldwork showed me how mid-2010s anti-expert public spectacles were but new iterations of discontents that had been growing throughout many twenty-first century technocratic failures. Faith in experts had, for example, deflated after events like the late-1990s dotcom bubble or the British Petroleum (BP) Oil Spill. It was sapped when safety experts failed to prevent the Fukushima meltdown, when economic experts failed to predict the post-2007 global financial crisis, when 9/11 was unforeseen, or when Iraq was invaded on false premises about WMDs. Radical contextuality, difference, flux, and polyvocality had clearly triumphed long before any "alternative facts," "post-Truth," or "fake news" media talking point took form.

[34] This broad-brush portrait need not be wholly discarded as fake news balderdash. Aspects of it were plausible. But it did fail to capture countless important country- or locality-specific nonconformities about, as examples, Finnish trust and media.

My anthropological fieldwork among hard scientists, engineers, humanists, lawyers, finance experts and others – and my working between a private U.S. university and networks of EU-based nuclear experts – required me to navigate these overlapping layers of uncertainty that spanned numerous cultures of expertise, academia, and technocracy. Studying Finland's experts became particularly thought-provoking. Finnish social scientists had long noted how "Finns value things such as Enlightenment, state, bureaucracy and technology" and "in general count on expertise, technology and authorities" (Berg 2009: 97, 114) in a place where "people trust each other, corruption is rare and social morals high" (Litmanen 2009: 196). There, a "belief in enlightenment thinking" was said to have created conditions in which "[s]cience and education" are taken as core values "which characterize and construct national identity" and in which "faith in technology" fosters "almost a mania for new technology" (2009: 192, 198). Erkki Laurila, central to Finland's post-WWII science policies,[35] was notable for having described and stoked Finns' yearnings for national technological independence. Laurila described this as *Ilmarinen's Finland*, a reference to the smith in Finland's national epic Kalevala who made the magical artifact Sampo.

In the twenty-first century, Finnish social scientists emphasized the societal faith and solidarity entrenched in "trust in technology and its ability to produce welfare; a Finnish political culture consisting of legalist tradition; corporatism; the strong position of administrative bodies; and the involvement of academic intellectuals in the creation of the national ideology" (Kojo 2009: 235).

[35] Laurila participated in the Linkomies Committee (1958-1963), where he advocated that the Finnish state take the lead as a powerful agent of science policy in pursuit of national development. Some say the intellectual basis for Finland as a technological nation were developed by 1960.

One scholar noted Finland's icon of the "virtually infallible" engineer.[36] Some told me that Finland is a place where "the modern project just works."[37] Indeed Finland was often cast as unique in its high levels of trust in its domestic civil servants, experts, police, educators, pilots, engineers, and welfare programs (Eurobarometer 2004). Many noted its population's warmth to big, centralized, hierarchical institutions like nuclear power plants, public transport systems, ministries, and the welfare state. Critical Finnish commentators noted how Finland is a "country that places faith in the rational mind of an engineer" (Kalliala 2011). Many Finns' broad faith in technology, expertise, education, and technocracy was palpable to me as an American ethnographer.

Yet ethnographic immersion complicated these idealizations. A frustrated Greek citizen living in Finland said Finns lack a certain "poetic predisposition"—embracing sober pragmatism and trusting competence, propriety, authorities, and rule governed-formality disproportionately. A humanist colleague lamented how Finland's consensus-valorizing debate culture fostered boring non-adversarial talk radio and failed to cultivate healthy critique.[38] A critically minded architect told me of 1980s Bourdieu-inspired commentaries on Finnish cultural codes, social class, hierarchy, and cultural capital norms that depicted Finland as the anti-France: embracing naïve materialist realist sentiments without emphasis on cultural subtexts or contexts. Many Finns – in self-descriptive, auto-analytical, self-essentializing, or critical modes – saw these sensibilities as

[36] Markku Lehtonen has put it this way: "The exceptionally high trust of the Finns in their authorities, nuclear industry and Finnish engineers contrasts with the 'institutional distrust' in the UK (Bickerstaff et al. 2008), and the 'society of defiance' in France (Algan and Cahuc 2007)… The origins and the discursive role of the virtually infallible 'Finnish engineer' (Lammi 2004) merit further analysis, as an explanatory element for the operation of trust in nuclear policy and discourse. (2013)

[37] They would refer to Finland's famously successful education system, its public transport system, public provision, and welfare state too.

[38] That said, others lauded the civility of Finnish debate culture's *asiat riitelevät, eivät ihmiset* ("the issues fight, not the people") ethic.

central to what they saw as Finland's often-uncritical embrace of expert knowledge. Finnish colleagues lamented how Finland's still-high political trust levels [39] had fostered public complacencies and blind loyalties.[40]

Yet media outlets abroad were quick to depict Finland as but one front in a growing global nationalist-populist push. [41] This was not arbitrary. The far-right nationalist-populist *Perussuomalaiset* ("True Finns" or "Finns") party's Timo Soini entered the country's coalition government as Minister of Foreign Affairs and Deputy Prime Minister. The anti-immigrant group Soldiers of Odin patrolled Finland's streets "protecting" Finns from refugees and foreign migrants (Rosendahl & Forsell 2016). *Perussuomalaiset* politician Teuvo Hakkarainen floated the idea of exiling gays and Somali refugees to a Baltic Sea island. Jussi Halla-aho – a PhD in

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[39]Finland's political-epistemic uncertainties resonated with many across Europe, North America, and elsewhere. But they were out-of-sync in key ways too. Societal trust, for one, was still approached in ways it simply was not outside Finland. Oxford's Reuters Institute's 2016 Digital News Report showed that, of twenty-six counties, Finns' overall trust in their media outlets was highest: sixty-five percent reported trusting domestic news (Newman 2016). Of European countries, Finns were also placed sixth for trusting in Parliament, fifth for trusting politicians, and fourth for trusting parties (Kestilä-Kekkonen & Söderlund 2016). Many Finns I met told me they trusted civil servants and educators more than politicians or the *broileri* (political "broilers") at the top of Finland's trusted ministries. And while my Finnish colleagues critiqued how societal decisions there were often made in small non-participatory committees with solutions announced only after closed meetings adjourned, Transparency International still deemed Finland the second least corrupt country on Earth in 2015. Finland retained its high performance on various quality of life rankings. Statistics like those in the 2015 OECD "How's Life In Finland?" report not only reinforced Noble Nordic stereotypes, but also instilled a cross-partisan national pride that, unlike elsewhere, was not tightly coupled with anti-establishment outrage. The OECD report's findings are worth quoting at length: "In general, Finland performs well across the different well-being indicators. Only 3.6% of Finnish employees regularly work very long hours compared to the OECD average of 12.5%. Finland has a high level of educational attainment: 85.9% of the adult working-age population have completed at least an upper secondary education compared to the OECD average of 77.2%. This is also reflected in the good literacy and numeracy skills of Finnish adults. Social network support is also high: 94.8% of the Finnish report having friends or relatives that they can count on in times of trouble compared to the OECD average of 88%" (OECD 2015).

[40]As a researcher noted on *Tampereen Yliopisto* (University of Tampere)'s Pathways to Political Trust blog: "[We] should be careful in drawing the conclusion that the higher the trust in society, the better for society. Distrust is, in fact, an integral part of a healthy democracy. Continuous loyalty to those in power makes people blind and incapable to realistically evaluate the incumbents and their actions. Instead, for democracy to function as it should, it needs 'informed skepticism', that is to say, citizens capable to critically evaluate both the decision-makers and the decisions that they make" (Kestilä-Kekkonen 2016).

[41] Euroskeptics in Finland and abroad had, since the dawn of EU integration, channeled what Holmes has called integralism (2000)—stoking longings for organic national solidarities, defensively rejecting modernity's alienations through anti-elitism, and evoking antirealisms recalling Europe's long-sidelined Counter-Enlightenment philosophical traditions.

Slavic Philology, a Finnish Parliamentarian, and later a MEP – had been investigated for ethnic agitation in 2008. His blog claimed Islam sanctifies pedophilia, gesturing to how Muhammad consummated his marriage with his wife Aisha when she was nine or ten years old. Finland's Supreme Court convicted Halla-aho of ethic agitation and of disturbing religious worship in 2012. He was a member of the Finnish far-right nationalist group *Suomen Sisu*. Oslo terrorist Anders Breivik cited him as an inspiration for his attack. Finland's Ritva "Kike" Elomaa, a former pop idol and female boxing champ became a right-wing populist politician too.

Political shifts affected Finland's experts and their counterparts in the U.S. alike. This had epistemic consequences. Finns under age thirty-five had, compared to their elders, become more skeptical of news media (Newman 2016). Talvivaara mine's wastewater chemical leaks had spread nickel, cadmium, zinc, uranium, and aluminum into Eastern Finland's ecosystems since 2012. More began to wonder whether Finland's domestic extractive industry really worked in their interests. Finnish social scientists and Humanities academics feared future layoffs, funding cuts, nationalisms, and populist rejections. Finland had seen downsizing, cost cutting, and layoffs in universities, research institutes, and consulting firms since 2007-2008's global financial market turmoils. Meanwhile, in the U.S., protest politics channeled raw anger, disillusionments, animal spirits, and disenchantments of kinds that could never be domesticated by the scrupulousness of the Finnish engineer. Trump's charismatic authority would contrast with the ideals of the measured, calm, detached temperament of, say, the STUK technocrat. Among many, alt-right penchants for off-the-cuff provocation made any so-called Finnish Lutheran work ethic of rule-following propriety seem naïve.

Political crises affected nuclear expert worlds. Security was increased at the Aalto University research reactor after Breivik listed it as a useful terror target. Finland's nuclear company Fennovoima, founded in 2007, saw a surprise investment by Croatian company Migrit Solarna Energija that could have re-stabilized a then-shaky project. Rumors circulated that it had ties to Russia. Finland's government ultimately rejected its request to join the Fennovoima mankala. Media coverage of this colored public sentiments toward Finland's new nuclear projects by cloaking them with auras of Russian meddling. Teemu Lahtinen – a far-right Suomen Sisu member and also Espoo's Vice Chairman of the City Board & Chairman of the Corporate Group Division – lauded nuclear power's national energy independence perks.[42] After Brexit, the UK Atomic Energy Authority CEO warned that "more than 1000 clean-energy exploration jobs may be lost if the UK exits the EU" (BBC 2016). Nationalist-populisms shaped energy debates. Certain United Kingdom Independence Party (UKIP) politicians found themselves supporting nuclear power on energy independence grounds but rejecting climate change.[43] A day after that vote, a *Forbes* blogger claimed Brexit would "boost nuclear energy" by supporting a UK nuclear workforce that "speaks English." He attributed the French-Finnish OL3 project's financial and logistical problems to "language barriers" impeding "project management" (Adams 2016).

Despite all this, many foreigners I met in Finland were, like me, still occasionally refreshed by Finland's population's avid reading and Finnish language ideology's aversions to

[42]Lahtinen told me he has little problem with the highly educated economically valuable STEM immigration nuclear energy attracts, especially if newcomers are open to assimilating into Finnish culture.

[43] This split pro-nuclear ideologies between so-called ecomodernist pro-climate-change-mitigation advocates versus the energy independence advocates who saw nuclear as a means for securing national control over one's energy generation. They often agreed on nuclear but disagreed on climate. In Europe, these arguments evoked fears of Russia shutting off flows of gas or energy to Europe. Many were also concerned about cyber attacks on energy grids.

tyhjänpuhuminen ("empty talk") and embraces of direct, concise, careful speech.[44] Others lauded many Finns' *moni kakku päältä kaunis* ("many cakes look pretty on the outside") spirit of being wary about being seduced by ostentatious exteriors. So too did many laud Finns' emphasis on keeping one's word.[45] An Estonian told me how his compatriots saw Finland as always wanting to be a "perfect student" by doing everything properly, by-the-book, and with precision. Others chatted with me about how public deference to expert authority in Finland had been conditioned by the country's relative historical lack of major technoscientific disasters and relatively few ministry corruption scandals.

These commentaries on Finnish society were part of an ecology of perspectives on (un)certainty, expertise, and technocracy alive as I conducted fieldwork. As backdrop details to everyday life, they subtly calibrated Finnish attitudes toward expertise and conditioned the behavior of Finnish experts. For example, many informants had cultivated an ethos of restricting oneself from speaking outside one's own domain of expertise and instead respectfully deferring to those formally empowered to speak on given subjects. While this ethos of propriety and deference among and to experts was present in, say, the U.S. too, it was simply more prevalent in Finland. As another example, Finnish governance and political agents appealed, as Chapter 1 will show, to renderings of ostensibly Northern European or Finnish virtues of societal cohesion, trust, cooperativeness, and transparency to explain and justify nuclear energy initiatives. Still, many felt that Finnish solidarities with and under technocracy were on the wane. These uncertainties were exacerbated by senses of Finland's unknown economic futures as its traditional forestry

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[44] This was thought to vary regionally and according to socio-economic position. For example, Savolaiset from Eastern Finland were stereotyped as smooth talking tricky sophists. A Tampere native noted how, upon moving to Helsinki, people were "talking nonsense all the time" by – say – warmly saying "lets get dinner sometime!" when running into someone on the street without actually planning to ever do so.

[45] As it was said, *sanasta miestä, sarvesta härkää* ("take a man by his words and a bull by his horns"). This emphasized that one's word is one's honor.

industries (like lumber, paper manufacturing, pulp processing) restructured, as the global reach of its once booming ICT sector led by Nokia retracted, and as some of its mining and metallurgical companies faced ongoing financial turmoil. With nuclear waste's deep time, longstanding pessimisms about humanity's long-term future – perhaps haunted by Lutheran visions of the universe's ultimate fate of annihilation not transformation (Moltmann 2003: 75) – entered the fore. This added new layers of uncertainty to how Finland's experts, nuclear and otherwise, would ride out global crises of expertise.

Unknown Environmental Futures

I conducted fieldwork during a moment of global climate crisis, biodiversity loss, resource extraction, and pollution that – through notions like sustainability – challenged entire populations to extend timespans of their ecological awareness outward toward intergenerational and sometimes even multi-millennial horizons. Grappling with extreme long-termism was no longer a task just for, say, the geologists, theologians, paleontologists, astrophysicists, archaeologists, evolutionary biologists, or nuclear waste experts. Environmental ethics had recast the challenge of rethinking humanity's place in the deeper history of Earth's environment as a pressing societal task. This led entire populations to ponder how, to borrow words from anthropologist Tim Ingold, from "the perspective of millions of years, the duration of our lived experience, of 'our time,' appears utterly inconsequential" (1986: 129).[46] The moment called for public reflection on how humans and non-humans might live otherwise on a damaged planet needing more long-termist intuitions.

[46] That is, as theologians might put it, it forced them to confront the "seeming insignificance of human purposes within the immense time-span of the universe" (Welker & Polkinghorne: 2000: 8).

Many suggested we had entered a new geologic epoch called the Anthropocene—one ushered in by humanity's own transformations of Earth's climate, erosion patterns, extinctions, atmosphere and rock record. Some saw this as a hubristic or narcissistic exaggeration of humans' effects on the world. Certain geoscientists argued that the Anthropocene, an age in which humans became geological agents, should be periodized as having begun at the dawn of the Atomic Age (Than 2006). Others argued that it began with a post-WWII Great Acceleration of greenhouse gas levels, deforestation, biodiversity loss, and ocean acidification speeding up post-Industrial Revolution Earth System processes. Still others saw it as a belated recognition of planetary carbon feedbacks ongoing since the nineteenth century (Luciano 2014). Some humanists conceded that established frames in postcolonial criticism, Marxism, globalization, and subaltern studies were unprepared for how the Anthropocene fused human species history with the history of capital—merging natural history with human history (Chakrabarty 2009). Others derided the Anthropocene idea's reductive application of species-thinking – rather than a critique of capital – to environmental problems caused primarily by only certain socio-economic brackets of certain nations (Malm 2015). Yet others argued that the Anthropocene concept ended "nature" as the stage upon which the human story must be set, pointing to how Fertile Crescent "agrilogistics" subdivided human thought and routines across human/non-human lines in ways leading to the current climate crisis (Morton 2014). Soon Pope Francis would assert that there "can be no renewal of our relationship with nature without a renewal of humanity itself" and that there "can be no ecology without an adequate anthropology" (2015: 88).

The Anthropocene idea proved to be remarkably generative for humanists. Plasticene, Cthulucene, Anthrobscene, Eurocene, Betacene, Misanthropocene, Planthropocene, Capitlocene, Anthropo*s*cene, and other Something-Other-Than-Anthropocene concepts emerged in the wake of this “charismatic mega-category” (Reddy 2014). The catchiness of the catch-all term-gone-viral elicited reflection, wordplay, and debate as it traveled the anthropogenically altered planet it also described—generating fresh vocabularies, terms, critiques, lexicons, articulations, and wordplay as it moved. Anthropocene’s *anthropos,* cousin of *humanitas*, spawned more lively debate among anthropologists than did the holism of Holocene’s *holos*. Latour thus saw Anthropocene as a “gift” to Anthropology, as it placed (undifferentiated) human agency “smack in the center of attention,” how it posed the challenge of tackling “again the connection between what used to be called ‘physical’ and ‘cultural’ anthropology,” and how it rested on the same “fault lines” as did the field’s four-subfield structure (2014). Some suggested anthropologists ought to start thinking about what it means to be “writing culture in the anthropocene” (Kirksey and Helmreich 2010: 548). Some highlighted the Anthropocene’s “geostory” and new “Gaia-politics” not of “politics-vs-science” but “politics-with-science” (Latour 2015). Others moved to resituate the human within the deep time chronotope of Big History of geological time (Irvine 2014). At every turn, the Anthropocene idea challenged thinkers to think humanity, planet, and futures afresh.

However, as Latour noted, the jury remained out on the notion’s staying power or “half-life” (2015: 147). The International Union of Geological Sciences’ Subcommission on Quaternary Stratigraphy’s Anthropocene Working Group had not yet validated the term as an official geological interval. This indexed uncertainties about the future legitimacy of a term that had already layered uncertainties about humanistic critique, geo-historical periodization, and the singularity versus plurality of humanity atop deep environmental uncertainties. Yet Anthropocene still evoked geological time horizons that renewed popular and academic interests in nuclear waste regimes’ deep time. At the same time, Safety Case work in Finland plodded on according to schedules first established in the early 1980s. Hardly any informants were interested in the Anthropocene concept despite the deep parallels between their and Anthropocene theorists' time horizons. And vice versa. Further, while in the U.S. I met many who assumed that Finland – with its outdoorsy mystique and electric cars – had a far stronger environmental conscience than elsewhere, few realized it, in practice, had underwhelming carbon emissions per capita. Disconnects like these called for more ethnographic work to track, describe, and preserve manifestations of everyday long-termism, environmental future-gazing, and deep time-reckoning already thriving today in scenes of planning, policy, scientific, and technocratic practice like those in Helsinki and Olkiluoto today.

A *siirtolapuutarha* in Helsinki. I lived here for one month in 2014.

Mediating how Finland's nuclear experts reckoned environmental futures was how they developed personal relationships with/in local ecologies. I was often genuinely charmed by how many informants – even highly-trained PhDs working in extremely complex fields and shouldering intense workloads – took personal time to hike through the forest, to pick berries (*marjastaa*) and mushrooms (*sienestää)*, to barbecue *nakki* or *makkaraa* (hotdogs or sausage) outside with friends and family, to chop wood at their *kesämökki* ("summer cottage"), to garden at their *siirtolapuutarha* (a gardening/cottage "allotment" in the city), to swim, to cycle, or simply to do gardening or yard work at home. These outdoorsy habits jibed with the portrayals of

Finns as somehow closer to nature than other Europeans.[47] Finnish semiotician and musicologist Eero Tarasti (a former pupil of Lévi-Strauss), for example, made the analogy that culture is to nature as the aesthetics of continental European classical music is to the aesthetics of the symphonies of Finland's late Romantic composer Jean Sibelius. While exoticizations of Finns as forest folk were generally overblown, many did clock many hours outside. Lifelong everyday experiences with outdoor landscapes, together with educational training, endowed informants with forms to draw upon when envisaging environmental futures. This calibrated their affections toward plant and animal life. They affected whether an expert became a passionate, curious, sophisticated student of Earth's ecosystems.

One of this ethnography's contentions is that, if patterns of environmental awareness and long-term thinking – and the familiar devices iterated to put them into effect – can be salvaged in careful anthropological writing, then temporal sensibilities more amenable to the current global environmental crisis can be cultivated. With these unknowable futures for nuclear energy, expertise, and environment in view, the next section unpacks tensions and resonances between my approach and influential perspectives in Anthropology. It presents iterating and reiterating familiar patterns as a key mode through which unknown nuclear energy, expertise, and environmental futures have become seemingly more intelligible or navigable.

Anthropological Form

[47] Noting how Finns' outdoorsy habits resemble those of "old-time forest people," curators of Budapest's Museum of Ethnography's 2009-2010 *How We See the Finns* exhibit described both (a) Finns' "dual existence" extending simultaneously "outwards toward the civilized Scandinavian" and "inwards the barbaric longing for the woods" and (b) Finns' tendencies to "withdraw from civilization and return to the woods" and hence to "solitude" (2009: 16, 100). Those equating Finland with forest not only drew from imageries surrounding the Finnish *jätkä* ("lumberjack") or the twentieth century successes of Finland's forestry and paper industries, but also in depictions of Finland's forest-dwelling "pagan" past that have long circulated throughout Europe. Note that, according to Olaus Magnus' 1555's *A Description of Northern Peoples*, "Finland, the northernmost land, together with Lappland, was once during pagan times as learned in witchcraft as if it had had Zoroaster the Persian for its instructor.

This study is broadly aligned with efforts to re-function ethnography to bring anthropological thinking to bear on contemporary debates about issues ranging from policy to technology, from science to finance.[48] Each chapter is a multi-authored text artifact of nuclear experts undertaking idea-work side-by-side with me. My informants and I toe a fine line between description, idealization, and speculation to produce accounts only partially useful as matter-of-fact historical descriptions of nuclear expert life in specific places and times. The aim is instead to develop informants' ideas by drawing on anthropological analysis of form, pattern, and aesthetics in ways inspired by Anthropology's interest in collaboration.[49] But this constitutes only a partial "deferral to subjects' modes of knowing" (Holmes & Marcus 2008: 81-82).[50] The main intent is rather to

[48] For more on these efforts see Holmes & Marcus 2005 or Fischer 2009 or Rabinow 2008). Dialoguing with expert informants, I also "study up" (Nader 1972).

[49]See Konrad 2012 for more on this. Anthropology's turn to collaboration parallels that in other fields like, for instance, Comparative Law (Riles 2015) in a broader moment in which "[c]ollaboration has moved to the fore in the human or social sciences" (Pottage 2014: 264). Now those traditionally cast as the subjects of ethnographic research are often recast as co-theorists, collaborators, or even paraethnographers (Holmes & Marcus 2008) co-producing theory with the anthropologist (Rappaport 2008). Following these leads, this dissertation enrolls "research participants/collaborators as partners in the research process" (Fluehr-Lobban 2008: 175). This is inspired by moves to "sacrifice the *individualism* as the subject position that has been at the core of anthropology's approach to research, publication, pedagogy, and above all, thinking" (2011: 202; quoted in Riles 2015: 167) and to experiment with various "new forms of collaboration" (e.g. Matsutake Worlds 2009). This broader turn to collaboration can be seen also in (a) in the growing volume of social scientific studies of collaborative consumption, (b) in the buzz surrounding the rise of new collaborative sharing economy platforms like Zipcar, Uber, Airbnb, or Lyft, (c) in management studies' foci on notions like collaborative supply chain or collaborative advantage, (d) in embraces of more collaboration-friendly open office workplace arrangements, (e) in the increased visibility of collaboration management consultants in corporate contexts, (f) in participatory strategies to enroll local actors more collaboratively in international development projects, (g) connected capitalist initiatives – "collaborations in which business must do good in order to maximize shareholder value" – in which profit-seeking companies enhance their image via partnerships with NGOs, governments, local communities, or civil society groups aimed at seemingly socially responsible ends, and (h) in STS research on how relations between experts and lay publics have been shifting from more hierarchical, objectivist, trust-based "Mode I" arrangements to more reflexive, deliberative, collaborative "Mode II" dialogic relations.

[50] While aiming to do justice to my informants' nuanced perspectives, this dissertation also aims to achieve a certain analytical distance – a subtle mediating interpretive gap – by infusing them with insights from other anthropologists from various places and times who have worked with other informants from various places and times. I channel anthropological voices from years, decades, and centuries past on as-needed bases to help my informants and I articulate our viewpoints with greater precision. Mixing established STS and Anthropology literatures on knowledge, time, form, succession, and instrumentality with ethnographer-informant dialogue shapes my field accounts in ways that do not constitute a full deferral to informants' accounts. Rather, it posits and then builds upon analytical starting points that my informants have laid out for me. I do this by reiterating selected familiar devices – devices that my informants iterated and reiterated for their own purposes – as anchors for my chapters. This inflects my poststructuralist work of contextualizing, situating, re-describing, and historicizing my fieldsite with theoretical anthropological and actor-derived commentaries on form and iteration. This is unpacked further in the Conclusion.

identify "parallels at the level of form" (Leach 1970 [1954]; Riles 2004: 400) between my and my informants' parallel interests in, as examples, form and iteration.[51] From this in-between space I curate ethnographic accounts partly as empirical descriptions of reality and partly as quasi-allegorical think-piece fables harboring insights for better grasping nuclear waste's deep time.[52] I present these insights in ways that, I hope, will encourage – among other experts elsewhere – further reflection on the kinds of personal dynamism, intellectual nimbleness, and practical adaptivity needed to persist amidst expertise's, nuclear energy's, and Earth's environment's uncertain tomorrows.[53]

I have discussed how nuclear experts worked in, on, from, and near familiar patterns they iterated wittingly or unwittingly, ironically or straightforwardly, playfully or soberly, instrumentally or out of habit when navigating conditions of unfamiliarity. These familiarities could be reiterated by computers, in everyday speech, in documents, or implicitly acted upon even when unspoken. As in Latour's thinking or ANT, they were not human-specific.[54] They were what Kohn, semiotician C.S. Peirce, or neuroanthropologist Terrence Deacon (2012) would

[51]I thus situate this project in Anthropology's "new terrain for the play of commonality and difference across academic and nonacademic forms of knowledge" but attuning to how "anthropological representations and the world they represent come together in certain shared practices of knowledge" (Maurer 2002; Miyazaki 2003: 255; 2006b: 149; Riles 2000). That is, it taps into parallels between the various modalities, questions, tools, and techniques that capture anthropologists' and my informants' attentions and imaginations day-to-day. In chapter 2, for example, informants' auto-analyses and iterations of input/output and part/whole resonated with anthropological debates about structure/agency and mereology/mereography. In Chapter 4, as another example, Seppo's surviving colleagues' characterized their collaborative relations in ways that resembled functionalist Anthropology. This is also about "finding a point of access from *within* the ethnographic material" (Riles 2000: 6).
[52]To use Povinelli's terms, this dissertation performs and exposits the de-skinning or unhinging of collaborating selves – ethnographer and informants – becoming otherwise through interaction forming and re-forming collaborating selves, groups, or worlds (2014a).
[53] My ethnographic accounts can be read as hortative in spirit—operating in an imperative-subjunctive mode that exhorts other experts elsewhere to entertain parallel cross-disciplinary interlocutions and "retoolings" (Meridian 180 2013; Riles & Miyazaki 2013) with one another. From this, a more nuanced, self-aware, and subtle understanding of the figure of the expert in the twenty-first century could emerge. What sort of certain intellectual dynamism, nimbleness, and adaptivity is needed during a twenty-first century moment of uncertain global economic, geopolitical, and environmental uncertainty in non-nuclear expert worlds? The Conclusion unpacks this more.
[54]As Kohn, following C.S. Peirce on "thirdness," notes, "generality itself is a property of the world and not just something we humans impose upon it" (2013: 10).

call real—generating habits, generals, and regularities by way of “constraints on possibility” (Kohn 2013: 158) shared by the animate and inanimate. If human or non-human agents were to cease to iterate a familiar device like input/output or part/whole, a given set of patterns might have disappeared too. They were therefore not inalterable structures immune to human intervention, but rather patterns enacted by thinking, speaking, reflexive agents inter-subjectively. In this sense, my approach conforms to dominant poststructuralist emphases on practice, emergence, polyvocality, dialogism, global interdependence, contestation, or hybridity. Iterations of devices like mankala or junior/senior, each chapter shows, could well – and perhaps only – unfold in complex, messy, uncertain, power-laden, ambiguous, non-totalizable fluxes. They could, as in Rabinow’s anthropology of the contemporary, be iterated and reiterated in countless creative indeterminate ways in and for countless nonlinear pathways. These were the scenes in which nuclear waste’s deep time materialized.

However, this dissertation does not focus solely on contextualizing, historicizing, situating, fleshing out complexity, or performing open-ended concept work. It has been selectively curated to show how even the messiest postmodern emergences owe the semblances of coherence within them in part to agents’ enduring iterations of very familiar devices taking very specific forms. This was essential how emergences eventuated in practice. Iterating a device like predecessor/successor helped generate patterns-in-the-world. This was testament to how form “hails and constitutes subjects” (Larkin 2015) and can spread an “aesthetic of controlled heterogeneity” (Riles 2000: 120) to constrain and enable arrangements and derangements of the emergent. The devices upheld patterns that spanned the human and non-human, the sentient and non-sentient, and the living and non-living.[55] Emphasizing them placed nuclear expert humans and their technologies, or nuclear technologies and their expert humans, at the center of analysis by not wedging a sharp distinction between them. From this in-between space emerged deep future auguries.

This ethnography is a work of poststructuralist Anthropology. But it is also inspired by structuralism's sense of the importance of essential binary oppositions like, in Chapter 2, input/output or part/whole. It takes seriously how Lévi-Strauss (1960), critiquing Russian Formalist Vladmir Propp, saw form and content as of the same concrete character rather than abstract and concrete respectively. It was inspired in part by how *The Savage Mind's* bricoleur could only pull together "pre-constrained" elements that, in taking specific forms, restricted "possible combinations" and set a "limit on their freedom of manoeuvre" (Lévi-Strauss 1966: 19). Yet this study has very different means and ends than structuralism. It is not about the universalities or particularities of devices like part/whole or input/output, about any timeless deep grammar of cognition, or about the historical origins of culture. It does not postulate that there is or is not a hidden order behind messy realities. Nor is its analytical starting point the rubric of individual/society. The familiar devices I reiterate are simply those that proved integral to Finland's nuclear energy expert worlds during a lived moment of ethnographic production: my 2012-2014 fieldwork plus my time writing-up at two U.S. universities afterwards. I do not argue, as a crude structuralist might, that these devices represent anything essential or unchangeable about Finnish nuclear energy worlds. This ethnography merely shows how the future horizons I

[55] Patterns and form, following Deacon (2012), can be discerned in, for example, whirlpool form generated by geometric constraints of specifically positioned physical matter. I therefore caution against reducing form, relations, and patterns to mere abstractions in the human brain. This too follows C.S. Peirce, who saw the distinction between matter and mind as of degree not kind. Nonlife could have form too. The orderings of speleogenesis in caves, with their patterned stalactites and stalagmites, have form. Safety Case modelers' carefully coded computer applications and the designed hardware running them have form. Form was more about sorting than sentience.

studied were always already tethered to loose trajectories established by incessant iterations of familiar devices and patterns that contoured nuclear world emergences.

Foregrounding relation over relata – and the formed over the flux – runs counter to how many New Materialisms prefer "*un*formed synonyms" like matter, objects, things, or material and consequently background how arrangements and derangements of form can induce or activate "affective and cognitive dispositions," "set[s] of assumptions," "experiential states" and more (Larkin 2015). This study was inspired more by how, say, Strathern does not stress the materiality of objects themselves (as does Marshall Sahlins' "practical reason") but rather the "specific form and shape they take" to effectuate objectification, reification, and personification through elicitation, anticipation, and relations (1988: 176). So, like many New Materialisms, this study backgrounds questions of "what is form?" or "what is matter?" and foregrounds the material consequences of the forms that devices like mankala or junior/senior have taken. It focuses on practice more than, say, Aristotelian or Platonic questions about form versus matter. It does not assume that simply moving the agency of animals, machines, or other non-humans to center of one's study can extend one's analysis beyond the human in meaningful ways. What becomes key when I ask, say, "what are the effects of the part/whole device in concrete practice?" are the relations and patterns doing so makes visible.

This ethnography does not reject – but also does not emphasize – the ambiguities, portabilities, mobilities, or interpretive flexibilities of devices such as recruit/retiree or predecessor/successor across globalized milieus. Doing so would double the commonsense self-descriptions of twenty-first century worlds that define themselves by how things, things, ideas flow across spatial and temporal contexts. Hence, the ethnographic question is not how global forms (Ong & Collier 2005) or immutable mobiles (Latour 1986), as standardized packages, are decontextualized and recontextualized or combined and recombined globally across deterritorialized assemblages. This ethnography's focus is rather on how the most radically agreed-upon, commonly used, least-contested, black-boxed devices of familiarity (See Ialenti 2014a) – which were ultimately non-localizable – were iterated locally to lay grounds for navigating unknowns.[56] This gives a peek into how Finland's nuclear energy worlds emerged in a certain place and time as artifacts of patterns within patterns within patterns *ad nauseum*. This does not emphasize devices like mankala or junior/senior's movements' *breadth* across a globalized space (object-biographies), but rather their patterned effects' *depth* in a very limited spacetime of ethnographic immersion. It is not about how these devices are designed, to or from where they travel, or how they are received or innovated upon once received there. It is, following Kohn, about how the "human mind... traffics in generalities, abstractions, and categories" and how "form" is "central to human thought" (2013: 157).[57]

This ethnography periodically references works influential in Anthropology prior to its so-called 1980s postmodern, poststructuralist, literary, or reflexive turns. This is not to advocate any return of classic anthropological theory. I reference works by anthropologists Jack Goody, E.E. Evans-Pritchard, Bronislaw Malinowski, Mary Douglas, Myer Fortes, and Claude Lévi-Strauss only when their ideas dovetail more closely with informants' para-anthropological ideas than do more prevalent twenty-first century Anthropology themes like ontology, multi-species ensembles, or precarity. That is, I draw on them only when they help get closer to the fieldwork materials at hand. My warmth to Anthropology's long-term history was inspired in part by Safety Case informants' own long-term horizons. Posiva's and STUK's nuclear waste projects were slated to

[56] A goal is to, as Riles has put it, "apprehend what is already too familiar… to be apprehended with ease" (2000: 21-22). For more on defamiliarizing, see the Conclusion of this ethnography.
[57] This ethnography does not explicitly reject any global-local rubric or mobilities paradigm. It simply backgrounds these commonly asked questions about continuities across space to get at alternate questions about familiarity, form, and continuities across time.

continue until the Olkiluoto repository's decommissioning around 2120. This inspired me to replicate something like the longsightedness of my informants' projects on the terrain of my own anthropological project—both studying and performing long-termist expertise as a method and object.[58]

This ethnography's approach has tensions and resonances with influential ethnographic approaches to nuclear issues too. That body of literature, despite its small size, is very rich. Francoise Zonabend (1993) has, for instance, studied the everyday lives of workers at and residents near a French radioactive waste processing facility. Miyazaki (2014) and Riles (2013) have provided insider views of Japan's post-Fukushima financial market and regulatory worlds. Lisa Yoneyama has explored the politics of memory, forgetting, and commemoration at Hiroshima (1999). Hugh Gusterson has taught us about the affects, rituals, personalities, and worldviews of nuclear weapons scientists at California's Lawrence Livermore National Laboratory (1996) and also about American military and nuclear ideology broadly construed during and after the Cold War (2004). These thinkers have contributed much to the social scientific literatures on nuclear energy and nuclear waste.[59]

The work of three nuclear ethnographers stands out as especially pertinent to my study. The first is Adriana Petryna. Her work on injury-based compensation claims after Chernobyl raised fascinating questions about how social equity, the rational-technical management of populations, and the objectification of suffering has made and remade political order and personhood during Ukraine's post-Soviet marketization and democratization (2002). Her concept of biological

[58] In Anthropology, Hirokazu Miyazaki has taken a similar approach to studying hope in Fijian gift-giving by replicating the hopeful orientations of his informants on the terrain of his anthropological analysis (2004). That is, just as Miyazaki posited hope as his method and object, I posit long-term thinking as my method and object.
[59] For an overview of social studies of nuclear energy, see Solomon et al. 2010. For an overview of social studies of nuclear waste, see Solomon 2009.

citizenship showed me how *bios*, bureaucratic categories, and survival can co-produce one another after nuclear catastrophe. Petryna's work inspired me to take seriously how nuclear technologies, and the immense institutional apparatuses upon which they are predicated, can order and reorder worlds. It gave me a compass for tracking how uncertainties are navigated in scenes of intense scientific indeterminacy and ethical ambiguity. During fieldwork, Petryna's thought reminded me again and again that, however well-functioning a given nuclear energy milieu may be at a given moment, it still harbors a capacity to, in the case of a large-scale accident, suddenly become absolutely altered for an indefinite future. For me this placed an ominous asterisk next to the relative stability of Finland's nuclear expert worlds. It reminded me that the nuclear milieus I studied, and the familiarities upholding them, could be otherwise.

Then there is Gabrielle Hecht's work on nuclear energy and national culture in post-WWII France (1998). Hecht's concept of technopolitics – strategies for designing, selecting, or using technologies for political aims – showed me how interrelations between politics, technologies, and culture weave complex social fabrics. I became better attuned to how security culture, economic conditions, and political ideologies – and even WWII and Cold War geopolitics of the bomb – were ever-present backdrops to all of my ethnographic encounters. Hecht's concept of technopolitical regimes helped me parse the entangled institutions, practices, ideologies, corporate organizational forms, (national) identities, and personalities that interwove to constitute Finland's mankala circuit as described in Chapter 1. Hecht's work on Africa and the making of the global uranium markets (2012) often drew my attention to the geographic and political-economic aspects of nuclear energy production. It also assured me I could not take the "Finnishness" of Finland's globally connected nuclear sector at face value. Hecht's concept of nuclearity – attentive to the shifting and contentious technopolitics of how things, risks, places, and technologies do or do not get classified as nuclear in the first place – helped me understand why Finland's twenty-first century uranium mining potentials could be exploited under radically different conditions than those in Africa decades before.

Joseph Masco's ethnographic work on nuclear technologies was also an inspiration. Masco has studied the lives of the many entangled groups – from Pueblo nations to nuclear weapons scientists to antinuclear activists – and how they retooled concepts of citizenship, national security, nature, race, and time when living near Los Alamos National Laboratory (2006). Drawing insights from Walter Benjamin, he has shown how the phantasmagoria of nuclear destruction distracted attention from the everyday U.S. nuclear weapons economy and anesthetized publics to a Cold War normal. Influenced by Sigmund Freud, Masco's concept of the nuclear uncanny has captured the sensory dislocations and cognitive confusions of the Atomic Age. Drawing on Immanuel Kant's notion of the sublime, he thoughtfully analyzed the bomb's incomprehensibility and institutionalization (2012). Masco's work showed me how subtle concepts from the Humanities can be combined with careful ethnography to form a powerful anthropology of nuclear worlds. My interest in Safety Case experts' Biosphere Assessment project in Chapter 3 was initially piqued by Masco's work on how Cold War Earth Sciences investments and the subsequent growth of the climate sciences produced today's planetary visions of Earth as biosphere (2010). His insights on nuclear nation-building (2006) helped me appreciate how, as I describe in Chapter 1, Finland's national cultural imaginaries and Finland's nuclear projects could not be detached from each other.

Yet my ethnography's vision departs from those of these prominent ethnographers in key ways. My ethnography is less *problem-driven* and less *novelty-oriented*. Petryna focused on life and death decisions of health and compensation following a historically catastrophic nuclear meltdown. Hecht focused on exploitative neocolonial dynamics to exceptional uranium trade relations in Africa and national reconstruction after a major global war in France. Masco focused on nuclear war, destruction imagery, and national security in the most powerful country on Earth. Their attention to problem-spaces jibes with the emphasis on problems and problematization in Rabinow's anthropology of the contemporary (2008). Their focus on charismatic, contested, well-known spaces of ethical urgency resonates broadly with other works of post-1980s anthropologies of technoscience, corporations, and disaster. This ethnography, however, is more about the ostensibly unproblematic normality of a small country with a relatively stable nuclear waste program. My chapters focus not on the radically novel or innovative, but on mundane issues of financing logistics, succession, collaboration, and predecessorhood. Backgrounded are Humanities concepts for understanding mindwarping spaces of explosive sublimity or uncanny strangeness. Foregrounded are ubiquitous pattern-generating devices like part/whole and input/output that would surely bore many *Into Eternity* fans. Of interest are not nuclear technology breakdowns, but rather the quiet plodding upkeep of the familiarities that support them.

This reveals the everyday grounds upon which future visions – including those of nuclear waste's deep time – became unknowable but not unthinkable, uncertain but not unnavigable. I study these futures less to show what has been thought about nuclear futures – or the unthinkable of national security (Masco 2010: 23-24) or the unthought of nuclear disaster preparedness (Sayre 2011) – and more to tap into the becoming-thinkable of unknown nuclear tomorrows in and through iterating familiarities. Attuning to these grounds for thinkability can, I argue in the Conclusion chapter, foster more sober, grounded, and historically sound ways of keeping a cool head in conditions of intense uncertainty. It can open clearer headspace for thinking the next nuclear-environmental crisis as well as those one million years from now. Extending my analysis toward multi-millennial horizons and toward broad and enduring devices like input/output, part/whole, recruit/retiree, junior/senior, and predecessor/successor can, I hope, complement influential ethnographies of nuclear energy that are scaled to year-to-year or decade-to-decade timescales. The goal is simply to complement those works with a more widely-scaled analysis focused not only on older cooperative forms like mankala – which emerged in pre-WWII Finnish hydropower projects and had long precedents in Finnish lifeways before that – but also forms like predecessor or input/output that have shaped people's thinking for ages.

Taking this long view reveals nuclear energy futures as no more about previously-unfamiliar devices invented than tried-and-true familiar devices reiterated. So whereas Masco might stress the Atomic Age's "new forms of consciousness, new means of being in the world" (2006: 1), I complement his trajectory by stressing how nuclear's new forms and means, like those eliciting visions of distant future Finlands, never emerged *ex nihilo* but were fresh twists on existing forms and means. My first academic study similarly showed how the U.S. Yucca Mountain repository project, an emblem of novel futurism and high modernism, was grounded on archaic legal-procedural forms that long predated even the nation-state idea (Ialenti 2014a). Focusing on governance regimes' long-lived forms' auras of legitimacy reveals nuclear waste's deep time as being about more than just twentieth and twenty-first century epistemology, ethics, equity, or responsibility.[60] It links it also to some very fundamental thought and action patterns that have grounded future-reckoning long before experts and their technologies (or vice versa) split the atom.

Dissertation Overview

[60] For an example of scholarship made in this spirit, see e.g. Shrader-Frechette, 1993 or 2005.

This dissertation is organized as follows. Chapter 1 provides background into some of Finland's nuclear sector's idiosyncrasies by examining its mankala nuclear energy corporations: limited liability companies run like zero-profit cooperatives that have brought together consortia of Finnish corporations and municipal energy providers to purchase, finance, and share the output of jointly owned energy generation facilities. It is titled *Noble Nordics & Nuclear Power: Forming Cooperative Energy in Finland's Mankala Circuit*. Of interest is how the mankala corporate form served as a locus for entangling motley consortia of cooperating experts—ranging from nuclear engineers to finance insiders, lawyers to politicians, technocrats to lay publics, academics to environmental activists. It shows how iterations and reiterations of mankala – in my conversations with a banking industry insider named Alaknam – were interspersed with figures of what I call the Noble Nordic: a stock character harboring ostensibly uniquely Northern European virtues of trust, cooperativeness, societal cohesion, and transparency. This shows how the rapid tempos of finance and politics shook nuclear reactor purchasing and building projects in twenty-first century Western Europe, North America, and elsewhere. Pointing to how iterations of the mankala device laid grounds for cooperation, it shows how a turn to corporate form can get at how, why, and where nuclear reactor projects succeed or fail amidst unknown futures. That is, it demonstrates how some of Finland's nuclear power plants – which have produced the spent nuclear fuels that have necessitated Safety Case experts' deep time visions – have generated the capital necessary to be built and then maintained throughout their multi-decade project-lives.

Chapter 2 explores how mass baby boomer retirements, deflated youth enthusiasm for nuclear technologies, and nuclear energy projects' multi-decade and centurial time horizons entangled in European and North American nuclear professional worlds. It argues that these triple challenges call for a shift in attention from tacit knowledge to talent pools—toward pre-career personnel regeneration processes that help fashion STEM youths before they people nuclear energy worlds. This taps into a blind spot in tacit knowledge inflected analyses of nuclear expertise which take the cast of characters peopling nuclear workplaces as given without attending to how, why, and from where they arrived there in the first place. Engaging with this is essential during today's nuclear energy sectors' human resource, demographic, and public acceptance crises. I explore this alongside a young Finnish radiological protection specialist with leadership ambitions named Timo. Reflecting on field experiences at ENYGF in Stockholm and at a 2013 WNA symposium in London, this chapter is informed by anthropologies of succession, social reproduction, and inheritance. It shows how informants like Timo iterated and reiterated *workplace role template* devices like recruit/retiree or junior/senior to endow intergenerational time horizons with clearer pattern. This shows how nuclear energy worlds attained continuities in being populated year-in-and-year-out with fresh personnel. Posiva's deep time-reckoners inhabited continuities like these. This chapter is titled *Regenerating Nuclear Energy: STEM Youth Aspirations & Workplace Peopling*.

Next is a brief "Interlude" section that further details Posiva's Safety Case experts' projects to segue into Chapters 3's and 4's more direct engagements their deep time-reckoning practices. After that, Chapter 3 examines how Safety Case experts collaboratively modeled distant future ecosystems and geosystems. It draws on anthropological work on form and pattern to unpack how forward-looking models were assembled and interpreted practice. Describing the Safety Case portfolio's organization as *self-similar*, it explores how devices like input/output, part/whole, and iteration were iterated and reiterated to support continuities between each scale, level, and domain of it. This endowed it with semblances of coherence. It shows how the Safety

Case portfolio was organized, perhaps unwittingly, in fractal patterns to maximize comprehensibility and continuity across complex interlocking models. It explores how reflexive Safety Case experts thought through these collaborations via imageries of forests, Nazca Lines, and ant colonies. I explore this alongside Laura—a Safety Case chemist and project leader. I conclude by showing how the portfolio's internal logical relations and Safety Case experts' collaborative relations co-created one another as mirrors of one another. I show how this reveals aspects of familiar devices of continuity that, while essential to modeling practices in regulatory science contexts, are often eclipsed in social scientific portraits of them. This chapter is titled *Ants, Forests & Nazca Lines: Modeling Collaboration in a Self-Similar Safety Case*.

Chapter 4 is an anthropological intervention into nuclear insiders' own studies of knowledge management and expert loss. It is informed by anthropologies of ancestors and philosophical reflections on specters and hauntology. The chapter presents Seppo-As-Anecdotes, Seppo-As-Voids, Seppo-Being-Succeeded, and Seppo-As-Predecessor as four modes through which figures of a dead Finnish nuclear waste scientist I call Seppo were reiterated by Safety Case insiders to retool their collaborations in the decades after his death. Critiquing the "one expert, one body of knowledge" assumptions that have grounded nuclear knowledge management reports, this chapter argues that nuclear insiders should cultivate an ethic of becoming sensitive to their own dividuality—of reflecting on how insights from expert forebears live on in and through their work. This would heighten their predecessor consciousness in important ways amidst twenty-first century nuclear sector demographic shifts. Knowledge management studies should, I argue, therefore attune not just to how nuclear experts' *thought* (as a noun from the past) can be reified and preserved before/after an expert loss event, but to how a deceased nuclear expert's *thinking* (as a gerund in the present) can live on in the thought patterns of surviving colleagues in "what would Seppo do here?" troubleshooting moments. Attuning to how these predecessor persona figures were iterated can reveal subtle entanglements between nuclear waste risk's deep time and the shallow horizons of a single human life course. This chapter is titled *Specters of Seppo: The Afterlives of Safety Case Expertise.*

This ethnography's Conclusion reiterates this Introduction's opening questions about deep time-reckoning with insights from Chapters 1-4 in view. What emerges is a revised framing of deep time that emphasizes how shorter-term horizons – like those of finance, politics, succession, collaboration, and predecessorhood – first had to be upheld by incessant iterations and reiterations of the very familiar in order for Safety Case deep time auguries to take form. This reiteration of deep time-reckoning can, I argue, help prep minds for changing courses as futures careen toward even deeper planetary crises. The Conclusion thus reiterates the three entangled challenges I explored in this Introduction chapter – unknowable expertise, environmental, and nuclear energy futures – with insights about familiar devices of long-term continuity derived from Chapters 1-4 in view. From that emerges three insights – about the continuity, thinkability, and extensibility of expert thought – that I suggest can help experts of many stripes navigate this historical moment of intense political-epistemic uncertainty. Specifically, they can help an expert self-overcome his or her professional silo-thinking and glimpse how expert thought is woven together inside and outside nuclear energy and waste worlds.

(Chapter 1) Noble Nordics & Nuclear Power: Forming Cooperative Energy in Finland's Mankala Circuit

During fieldwork mankala nuclear energy corporations[61] were limited liability companies run like zero-profit cooperatives. They convened consortia of Finnish corporations and municipal energy providers to purchase, finance, and share the output of jointly owned energy generation facilities (Puikkonen 2010). I was first introduced to this corporate form[62] while sitting outside at Siltanen café in Helsinki with Alaknam: a banking industry professional who moved from elsewhere in Europe to Finland years ago and who worked closely with mankala companies. Alaknam was, like me, intrigued by how mankala cooperation was often presented as a distinctly Finnish way of financing a nuclear reactor. Mankala was iterated and reiterated by many of Finland's nuclear professionals—from engineers to finance insiders, lawyers to politicians, technocrats to lay publics, academics to environmental activists. This tightened their cooperative ties. During fieldwork I explored mankala's origins, nuances, and implications with Finland-based academic colleagues, members of the public, anti-nuclear activists, media professionals,

[61] While mankalas were originally convened to finance hydropower facilities, my interest is in their use in Finland's nuclear energy sector.

[62] Precedents for my analysis of mankala as a "corporate form" can be found in social theoretical work on corporate personhood (e.g. Iwai 199; Supiot 2007; Teubner 1988) with roots in longstanding jurisprudential debates about legal personality (e.g. Dewey 1926; Radin 1932). Anthropologists have made rich contributions to these debates. For example, anthropologists illuminated themes of corporate/legal personhood through insights about multiplicities versus singularities of personhood (e.g. Douglas 1995), selfhood versus personhood (Mauss 1985), the "double" personhoods of embodied kings versus sovereign kingships and a king's body versus a body politic (Shever 2010), social processes constituting persons and things (Mundy & Pottage 2004), and how reification, relations, and exchange form the (in)dividuality of persons (Strathern 1988). Some have brought these themes to bear on contemporary issues like the "too big to fail" problem (Riles 2011a) or PR, branding, and CSR campaigns' "corporate oxymorons" (Foster 2009). Others have thought beyond legal-economic renderings of the corporation as a mere nexus of contracts by conducting fieldwork on the (external) effects of corporations on workers, consumers, environments, or communities and the (internal) workings of corporations' values, practices, norms, motivations, rituals, worldviews or beliefs (Urban & Koh 2013: 140). Still others have done ethnography on how the corporate form "shapes and is shaped by daily life" to "shift away from default conceptualizations of corporations as solid, unified, self-knowing, and self-present actors that relentlessly maximize profit and externalize harm" (Welker et al. 2011). All this said, Welker et al. remind us how, "[t]o date, one cannot discern a coherent set of research questions or competing schools of thought characterizing the anthropology of corporations" (2011: S5).

politicians, and business and government insiders. In this chapter, I show how the mankala model was iterated to help draw together the broad financing coalitions that initiated the nuclear reactor projects that produced the radioactive waste that elicited Finland's nuclear sector's deep time-reckonings. That is, these coalitions helped generate the capital that helped Finland's nuclear sector generate energy and, by extension, the spent nuclear fuel that spawned the regulatory requirements that called for Safety Case models of far future worlds. Ethnography of the mankala circuit can, therefore, provide crucial background context for the study of Finland's nuclear waste situation.

Made by Mankala

Legal and financial experts described mankala as follows. A company owning about X% of a zero-profit mankala company would pay about X% of the total costs to build, maintain, and manage a jointly-owned nuclear reactor and thus get about X% of its energy output in return. A mankala company's ownership diversity was designed to pool capital from many sources and thus to disperse risk and liability such that no cooperators had to, to use one insider's words, "bet their entire company" when buying or using a mankala reactor. If an owner-company were to need more energy from the reactor at some point in the future, it could negotiate with other owner-companies to try to buy more shares of the mankala company and hence pay more of its operating and maintenance costs. If it were to want less energy, it could sell its shares – assuming there would be a company willing to buy them – and pay commensurately less of the reactor operating and maintenance costs. If at some point an owner-company would defect from the mankala or dissolve in bankruptcy, the remaining owner-companies, it was hoped, would have incentive to either (a) invite new owner-companies to enter the mankala to replace the exiting owner-company or (b) buy the exiting owner-company's shares simply to keep the mankala from which they derive energy afloat. The specific terms of these arrangements were not dictated by legislation, but defined by legal technique on case-by-case bases through private "Articles of Association" contracts.

Many informants were eager to discuss with me, the anthropologist, the ways the mankala corporate model was iterated in tandem with what they saw as Finnish national culture's specificities. Cast sometimes as "a unique Finnish practice" (Tuomisto 2012), mankala cooperation had long befuddled international investors who "found Mankala companies challenging to analyze" because it was a "Finnish practice without good international benchmarks or comparables" (Treialt 2009). Mankala collaborative spirit was, among certain banking industry insiders, often associated with supposedly uniquely Northern European propensities for societal trust, cooperativeness, cohesion, and transparency.[63] Mankala circuit insiders like Alaknam had intellectual interests that paralleled anthropologists' interests in how variations in how corporate life works can coevolve with variations in regional or national cultures (See Urban & Koh 2013: 149). Some were also curious about how local twists on the conventional corporation can emerge from different places' different laws, norms, and expectations regarding how companies should be run (cf. Welker et al. 2011: S9). Activist and critical academic informants told me how mankala composed and was composed by what Management scholar Ilkka Ruostetsaari has called Finland's "old cohesive energy elite" (2010).

I responded to my informants' insights by tracking how mankala became a nexus at which Finnish national identity, nuclear energy, and elite cooperative spirit were invented and reinvented out of and through one another.[64] My approach resembled that of anthropologist

[63] My interest in this speaks broadly to anthropologists' efforts "to pluralize, relativize, and contextualize corporate forms geographically and historically" (Welker et al 2011: S6).
[64]As in other chapters, I use the term "invention" in a way inspired by anthropologist Roy Wagner 1981.

Robert Foster: "unwrapping the bundle or tracing the nexus" of actors that have comprised mankalas, exploring the many "structuring agencies" through which mankalas have materialized (2009: 99-100).[65] Cues from both anthropologists and informants inspired my analysis of the mankala corporation not as a mere bucket of wealth or web of contracts, but rather as an ever-shifting tangle of relations between companies, people, machines, ideas, finances, countries, computer programs, and so on. Studying the various spirts in which informants iterated and reiterated mankala revealed how moments of political-economic stability versus instability sorted and re-sorted relations of trust, feelings of cohesion, and opennesses to transparency among mankala circuit cooperators. This demonstrated how Finnish nuclear and nation futures were envisioned together and how uncertainty was navigated amidst entangled crises of knowability.[66]

The sections to follow chronicle how informants iterated mankala alongside familiar stock character figures I call Finns-As-Noble-Nordics, Finns-As-Tristes-Nordiques,[67] and Finlands-In-Fragmentation. These figures were sometimes iterated as plausible portrayals, other times as heaps of hype, and still other times as tropes increasingly inapplicable to a changing Europe. Yet such self-essentializing was essential to how Finland's nuclear sector insiders endowed their uncertain futures with pattern. It was key to Finland's self-concept as a technological nation. It was inseparable from how mankala helped organize loci of relations, funding flows, and coordinative powers that intersected during Finland's elites' early twenty-first century nuclear reactor purchasing initiatives. These almost archetypal figures' stabilities realigned when

[65] As in Foster's work, these "structuring agencies" included "laws, regulations, trade associations, scientific associations and subcontractors" and so on (Foster 2009: 99-100).
[66] This demonstrated, to again borrow words from Welker et al., the "complex and fractured ways in which elites make sense of the uncertainties with which they live and the consequences their everyday work can unleash" (2011: S12).
[67] For non-anthropologist readers: I present "Noble Nordics" as a play on debates about the idealized "noble savage" (e.g. Hames 2007) and "Tristes Nordiques" as a play on Claude Lévi-Strauss' classic *Tristes Tropiques* (1973 [1955]).

Finland's political-economic outlooks realigned and vice versa. Discussing this, many informants were eager to tap, tinker with, and reflect upon them sometimes in a spirit of playful self-parody, other times of somber self-deprecation,[68] other times of proud promotion, and still other times of candid self-analysis. Seemingly trivial intellectual feats like these can, I show, provide crucial windows into how and why nuclear power projects do or do not materialize. This can, by extension, provide glimpses into how and why, say, nuclear waste's deep time-reckoning does or does not materialize. But seeing this first requires further ethnographic context.

Noble Nordics, Tristes Nordiques, & Finlands-in-Fragmentation

Talk of Finnish trust, cooperativeness, cohesion, and transparency arose often in public and academic conversations about Finland's nuclear energy sector. *This Is Finland* – a website published by Finland's Ministry for Foreign Affairs' "Finland Promotion Board" – wrote a 2011 article about a poll conducted in Finland after Japan's 3/11 Fukushima Daiichi nuclear disaster. The article described how, even while public support had slipped in the wake of the Fukushima event, 85% of respondents still considered Finland's nuclear power plants "absolutely safe" and 48% remained in favor of increasing Finland's nuclear capacity. After asking locals why this was, the author explained, "the word 'trust' is still heard loud and clear here: trust in the technological capabilities of the nuclear engineers, in the terrain, in the transparency, openness

[68] Propensities for self-deprecating, light-hearted self-caricature was not rare in Finland either. It was, for example, also observable during the country's televised Independence Day Presidential Dinner & Gala in December 2012, where countless Finnish politicians, civil servants, business elites, and celebrities danced to the late Kari Tapio's Olen Suomalainen ("I am Finnish"). This song was a parody of Toto Cutugno's L'Italiano. The lyrics went follows: "Here is a nation from whose tears many oceans could be made / There are many lonely people here / so much forbidden love / that even paintings or longing love songs cannot explain / Life here is hard work / And rarely does one have good luck / The only one who knows this is the Finn / There are stubborn folk in this country / If friends are close to each other / the only things that can separate them are death and officers of law / We walk uphill with sadness in our souls / But get up there by force and grit / After a bend of the road we go to another bend just to see it wasn't worth it after all." (Translated January 2013).

and honesty of the operators and construction companies, as well as of the regulators" (Libermann 2011). To quote some of her interviewees:

> "We can trust the authorities. We're more cautious than in Japan. I'm in favor of more nuclear power plants in Finland. There is currently no better source of energy, and Finland needs electricity." / "I visited a Finnish nuclear power plant once, and ever since then I've known that the plants are in good hands and good condition." / "For Finns it's the norm to trust the authorities. If STUK, the radiation and nuclear safety authority, says it's safe, we believe that too." / "There are loads of other, bigger threats in the world apart from nuclear power. So I'm neutral about it." / "Nuclear power is safer in our country than in others" / "It's a Finnish characteristic: Whatever happens, we trust the authorities. It's worked for us so far. But there's room for more discussion, like in Germany."

Talk of Nordic or Finnish trust also permeated media discussions of Posiva's Olkiluoto spent nuclear fuel repository project. As the BBC reported, "[i]n Eurajoki in Finland, where the local council decided seven years ago that it would like to see the waste from the country's nuclear reactors buried in its backyard, the T-word is everywhere, nestling alongside its spiritual siblings openness, honesty and transparency" (Black 2010). This resonated with a 2006 BBC article written by the same journalist after he met with higher-ups from Posiva Oy:

> "It boils down basically to trust," comments [Posiva manager] Timo Äikäs. "When you make a decision concerning this kind of thing, which takes us to 2100 when the final sealing takes place, there will always be uncertainty. So you have to have trust." But Timo Äikäs believes his system and his team deserve the trust they have found in Eurajoki, and that Onkalo will prove as safe a resting place for highly active radionuclides as can be found, barring any surprises with the local geology. (Black 2006).

Finland had long been cast as unique in its high levels of trust in its domestic civil servants, experts, police, educators, pilots, ministries, engineers, and welfare programs (Eurobarometer 2004). This was evident in the early stages of my field immersion. Researchers said that Finland had “high level of trust among citizens, a cooperative attitude in society and a sense of solidarity, and high-quality public services from national to local levels” (Markova 2014). Others described Finland’s world-renowned public education system as a “system built on trust… [that] leads to real results, leads to teachers and students and members of government all wanting to live up to the trust given to them rather than simply scraping by” (Kain 2011). Academics studied trust’s relation to social capital in Finland (Iisakka 2006), trust’s “culturally unique” character as perceived by international students at Finnish universities (Watanabe 2008), and trust’s bearing on Finns’ high levels of participation in voluntary organizations such as sports associations, charity associations, and cultural associations (Kankainen 2009). These findings resonated with what Finnish President Sauli Niinistö said to CNN’s Richard Quest during the World Economic Forum at Davos: “one of the elements of why we feel that Finland is a good country” is “because we have social cohesion still very strong.” As a Helsinki-based Russian expat recalled a drunk Finn once telling him: the “most important thing about living here is *luottamusperiaate* (the principle of trust)… in Finland we trust each other. We trust officials, police, and people” (Bogdanov 2012).

Academics, journalists, members of the public, and other commentators characterized neighboring Nordic countries similarly. A research article titled “The Surprising Ingredients of Swedish Success” noted how “Scandinavian societies have developed a unique culture with a strong work ethic and strong ethical attitudes regarding the claiming of welfare benefits… [and] high levels of trust and social cohesion” built up even “before the advent of the modern welfare state” (Sanandaji 2012: 39). Depictions like those comprised a familiar internationally circulating stock character I call the Noble Nordic: the figure of the modest, cooperative, educated, practical Northern European who was supportive of welfare programs, human rights, and scientific inquiry. There was a vibrant international press market for English-language commentaries othering Finland as a small, egalitarian, stoic, unassuming, peaceful, cooperative country in Europe's far North in which trust abounded and quality of life was miraculously high. Examples included *Newsweek* dubbing Finland "The World's Best Country" (Foroohar 2010) or *The Atlantic*'s 2013 article "The Secret to Finland's Success with Schools, Moms, Kids—and Everything," which gloated that Finland "has cheaper medical care, smarter children, happier moms, better working conditions, less-anxious unemployed people, and lower student loan rates than we do. And that probably will never change" (Khazan 2013). It was, a few years later, unsurprising to see Bernie Sanders routinely mentioning Nordic social democratic successes during his 2016 U.S. Presidential campaign.

Alongside depictions of Finland-As-Social-Democratic-Utopia circulated the figure of what I call Finns-As-Tristes-Nordiques. This evoked depictions of a frigid little country in the margins of Europe's far North in which melancholy, iciness, shyness, gloom, and alcoholism reigned—a land of frustrated *herraviha* ("master-resentment") and populist begrudging of authorities, bosses, and other Finnish and non-Finnish fat cats. While representations of the taciturn or laconic Finn were but crude stereotypes, ethnographic immersion revealed idiosyncrasies abounding in the relatively homogenous country in which gestures of modesty, directness, pessimism, humility, and lighthearted self-deprecation were obviously commonplace. These renderings circulated alongside senses that Finnish business professionals valued humility, modesty, and leisure time over profits—or how Finland's "low-profile rich" tended to "hide" their wealth and "shun publicity" in an egalitarian culture in which "flamboyance is seen to be uncouth" and "there is almost a feeling that wealth is something to be ashamed of" (Toivonen 2011). They were coupled with portrayals in the mainstream Finnish newspaper *Helsingin*

Sanomat of Finns' alleged "Lutheran Work Ethic" (Kettunen 2012). They interspersed with academic analyses, and domestic press articles about those analyses, of Finns' penchants for *hiljaisuus* ("quietude" or "silence") or being *omissa oloissaan* ("to oneself")—that is, making space for oneself and others to be "undisturbed" in "thoughts and actions" (Carbaugh et al. 2006).

Public, media, and academic depictions of Finns-As-Noble-Nordics and of Finns-As-Tristes-Nordiques influenced and were influenced by Finnish publics' self-descriptions of their own cultures, ethoi, and histories. Commentaries from outside Finland were recursively incorporated as part of how, where, and why these emblems of national culture were iterated domestically. Countless Finland-based people I met were interested in international perceptions of Finns. When SUNY Binghamton anthropologist Pamela Smart briefly visited Finland to study the politics of Helsinki's proposed Guggenheim Museum project, *Helsingin Sanomat* write an article about her upbringing in New Zealand, her academic training at Rice University, her research on museums, and other life events that led her to choose Helsinki as her ethnographic field site. Smart's interest in Finland was itself a public interest story that elicited a para-ethnographic Finnish media text about her background. When the BBC would cover Finnish sauna culture or when U.S. media would valorize Finland's highly unionized teachers, Finnish media outlets took note and sometimes responded by reporting on those foreign reports. At times I felt tempted to write my own domestic media commentary about these Finnish media meta-reflections and title it "An Article About Finland's News Articles About News Articles About Finland." I resisted this urge. But I never quite shook how so many Finns from so many walks of life seemed to be acting, at times, like amateur anthropologists unto themselves.

My tendency as an anthropologist is to abstain from making grand theoretical claims about any essential features of the Finnish national psyche. Mine is no structuralist study of the lingering influence of Finland's national epic *Kalevala* or its late nineteenth century National Romantic moment. I posit Noble Nordics, Finns-As-Tristes-Nordiques, and Finlands-in-Fragmentations not as valid scientific descriptors of cultural realities but as pragmatic tags for self-descriptions I observed as having powerful agency when iterated by informants as auto-commentaries on Finnish society. Many friends made tentative self-essentializations of their own Finnishness. I even heard rumors that certain *Perussuomalaiset* enjoyed the self-aware farcicalness of holding gatherings at Helsinki's Zetor restaurant. Owned by a member of Finnish rock group Leningrad Cowboys, Zetor was decorated with heaps of iconic artifacts and stereotypical imageries of rural Finnish culture. The half-joke was that a nationalist political group, easy to criticize as exaggerating Finland's national distinctiveness' importance, felt most at home in a restaurant known presenting itself as almost comically hyper-Finnish. This was just one example of the subtle propensities for reflexive self-characterization that I encountered among countless Finns. Many Finns joked about their own obsessions with others' opinions of them. I heard this joke many times:

> An American, a Frenchman and a Finn went on a safari in Africa. They were walking through some bushes, and suddenly they came across an elephant. How did they react? The American said: "I wonder how much money I could get for those tusks." The Frenchman said: "I wonder what kind of a love life this elephant has." The Finn asked: "I wonder what this elephant thinks of me."

Traces like these were artifacts of common impulses to self-essentialize the Finnish *volksgeist*. They revealed much about the reflexive formation of Finns' twenty-first century identities. This unromantic (in)organic nationalism was too pervasive to ignore. Sometimes it struck me as quite funny. But it was also helpful for apprehending shifts in broader structures of feeling (Williams 1954) unfolding across Northern Europe. I noticed growing pessimisms about Finland's capacities for continuing to sustain cooperative spirit nationally, locally, or even among families. I call these figures Finlands-In-Fragmentation: evocations of Finland's increased internationalization since its 1995 EU accession, the liberalization of its "new economy" (Funahashi 2013), and the rise of its populist nationalist *Perussuomalaiset* political party and fringe anti-immigrant groups like *Suomen Sisu*. They indexed many Finns' anticipatory nostalgias: future-oriented longings for that which was not fully gone yet but which was anticipated to dissolve more completely in the future (Choy 2011: 28). They were also, as Chapter 2 demonstrates, marked by generation gaps: younger Finns were, for example, far more likely to be linked up with friends internationally online or to have lived in other countries through, say, EU Erasmus study abroad programs.

These propensities co-evolved in Finland as ways of grappling with "the moment after the collapse of pure faith in neoliberalism" (Riles 2013: 556) with which I engaged from 2012 during fieldwork. With that in view, the next section explores how figures of Finlands-in-Fragmentation, Noble Nordics, and Tristes Nordiques were iterated and reiterated in tandem with public, media, and academic commentaries on Finland's nuclear energy sector. Untangling this, I suggest, can foster better understandings of the professional worlds – composed in part by national identity imaginaries, overlapping corporate ownerships, and insider self-reflections – that iterations of mankala helped sculpt. These iterations helped endow Finland's nuclear energy futures with more discernable pattern.

Nuclear Nordics

Many Finns seemed to no longer feel secure in what they saw as a once-more-powerful sustaining trust across Finland's post-WWII social fabric. Some brushed these melancholy interpretations off as mere glum Tristes Nordiques miserablism. Noble Nordic virtues were still, after all, being evoked to justify Finland's embrace of nuclear power. Finnish academics noted how TEM operated in cahoots with powerful actors in industry, the media, and *Eduskunta* (Finland's Parliament) to generate a "pro-nuclear network" and a "hegemonic political discourse" such that "opposition to nuclear power had become stigmatized" and it had become "not fashionable to write critical reports about nuclear power" (Lampinen 2009: 44; Litmanen 2009: 201). They explained how, as such pro-nuclear networks fed media outlets information, many in the early 2000s came to think that "Finland needed nuclear power for a number of reasons: (1) because the consumption of energy was increasing; (2) because otherwise Finland would become even more dependent on energy from Russia; (3) because Finland was committed to reduce greenhouse gases; (4) because without the fifth nuclear reactor the competitiveness of Finnish industry would collapse; (5) because of a positive nuclear decision Finland would be able to invest more in the research and development of renewable energy sources; and (6) because this was the only way Finland could secure the structures of the welfare state" (Litmanen 2009: 206). Politicians and other elites still, Finnish academic colleagues noted, evoked societal "faith" and "solidarity" to present "utopian visions related to the development of nuclear power: a broad trust in technology and its ability to produce welfare; a Finnish political culture consisting of legalist tradition; corporatism; the strong position of administrative bodies; and the involvement of academic intellectuals in the creation of the national ideology" (Kojo 2009: 235).

Yet when I arrived in Finland in 2012, faith in nuclear power's Promethean promises was, for some, shaky. Some skeptical members of Finland's public, intellectuals, politicians, and environmentalists – as well as certain leftists who cast Finland's embraces of nuclear energy as a "symbolic message for the continuation of this kind of Western vanity lifestyle" (Berg 2009: 101) – had become disillusioned with Finland's ambitions for reactor new builds. Some participated in anti-nuclear demonstrations like the Olkiluoto Blockades, in which activists blocked roads surrounding the Olkiluoto nuclear power plant. Others developed more idiosyncratic activisms like Case Pyhäjoki—a "transdisciplinary artistic expedition" to "explore artistic perspectives on the vast changes planned in Pyhäjoki, through the planning of a nuclear power plant at the site." Greenpeace placed a "monument of selfishness" in a Helsinki park memorializing names of MPs who voted in favor of expanding the country's nuclear capacity. Many lamented what they saw as Finland's all-too-trusting complacency with regard to nuclear risk. As a wisecracking Finnish academic once told me, hyperbolically: "in Finland you get to observe a near total societal embrace of Foucauldian discipline and governmentality." Finnish rock band Eppu Normaali's ironic 1980 song *Suomi-ilmiö* ("Finnish Phenomenon"), written soon after the United States' 1979 Three Mile Island nuclear accident, expressed sentiments akin to these:

> Although in Harrisburg one needs to lock one's windows / Finland is always safe / Harrisburg is somewhere on another planet / it could never happen here / beneath the birch and the star / Can perfection exist in any form? / Yeah of course, among other things, at [home of two nuclear reactors] Olkiluoto / None are as smart as an engineer / its perfect / the button and pipe / Uranium splits / and produces the lamp's light / but no other countries other than Finland are free from risk / We have quite a selection of infallibility / [former President] Kekkonen, a Finnish-Soviet Treaty of Friendship, and [power company] Imatran Voima / no danger fits in our routines / unless in

> China the Finland phenomena would occur / Uranium splits / and produces the lamp's light / but no other countries other than Finland are free from risk. (Translated 9/4/2012).

Critical activists were skeptical of how Noble Nordic trust, cooperativeness, cohesion, and transparency manifested in Finland's halls of power. Oona – a professional environmentalist in her early thirties – told me of how politicians in *Kokoomus* (Finland's mainstream-conservative National Coalition Party) had taken "advantage of Finland's historical efforts to nurture the spirit of the Winter War," the Finnish "ideal of consensus," and the public's sense that "a small nation has to be united and cooperative" to limit public dissent and justify their economic and environmental policies. Oona was skeptical of collusive relations within Finland's "locus of power" spanning industry lobbying association Confederation for Finnish Industries (EK), TEM, old heavy industries, and established political parties like *Kokoomus*. Oona associated these dealings with what some called Finland's *hyväveliverkosto* ("dear brother network"): informal communities of elites in Finland who, behind a veil of secrecy and mutual trust, use their connections to rise to positions of influence and to circumvent formal decision-making procedures. The *hyväveliverkosto* notion conjured images of handshaking behind closed doors, of decisions made informally during hunting or skiing trips, of drunken sauna nights in which huge societal deals were hashed out, and of the ongoing favor-for-a-favor camaraderie of powerful Finnish men's *lehmänkauppa* ("cow trade"). She saw such collusions, premised on trust relations within tightly networked communities of elites, as reaching their apex at EK's office at Eteläranta 10 in Helsinki. Oona noted how Eteläranta 10 had become as much a "cultural concept" as an "actual place" in light of its stereotype as the spot "where the big boys work, the big boys play, and the big boys go to sauna."

Yet other informants were warmer to Finland's governance and business cultures' tightly knit ties. Marita, an EK lobbyist in her late twenties, told me how she saw *hyväveliverkosto*-style nepotism as confined mostly to Finland's "olden days" as there were realistically "not many of these 'sauna nights' anymore." She, like many others, emphasized how Finland's having cohesive trust bonds in its halls of power enabled the "small country" of about 5.5 million to secure strategic advantages for itself through through-the-grapevine communications via what many called *puskaradio* ("bush radio") or *viidakkorumpu* ("jungle drum"): rumors, gossip, and informal exchanges that traveled speedily throughout small, tightly-knit networks. She too iterated figures of the Noble Nordic, Tristes Nordiques, and Finlands-In-Fragmentation in our conversations about Nordic nuclear. With that in view, the next section explores how Finns' auto-interpretations evoking ostensibly uniquely Finnish or Nordic societal patterns interfaced with figurations of mankala to help generate Finland's nuclear energy sector as an assemblage of cooperating people, institutions, firms, companies, technologies, agencies, and locales. It shows how second-order self-essentializations of both Finnishness and mankala cooperation's role, history, character, and agency were both internal and external to the specific work that mankala's iteration and reiteration did to coordinate Finland's nuclear worlds.

Mankalas Multiple

Mankala ownership relations entangled companies-inside-companies-inside-companies-inside-companies *ad nauseum* or owners-of-owners-of-owners-of-owners *ad nauseum* in ways that could resemble – to borrow one informant's analogy – Russian Dolls inside Russian Dolls inside Russian Dolls inside Russian Dolls *ad nauseum*. Not part of any stock market, mankalas aimed not to generate profit for shareholders, but energy for owners. During fieldwork, TVO, for example, owned two nuclear reactors in Olkiluoto and was building a third. TVO was founded in

1969. As a mankala, it was composed of multiple owner-companies, many of which were energy companies. TVO's largest owner-company was Pohjolan Voima Oy (PVO), itself a mankala made up of multiple owner-companies, which itself owned hydropower and thermal plants in Finland. Within the PVO mankala were owner-companies such as Finnish paper and pulp manufacturers Stora Enso Oyj and United Paper Mills Oyj. Among the fifteen other owner-companies inside PVO were energy company EPV Energia Oy, the City of Helsinki, Ilmarinen Mutual Pension Insurance Company, the City of Pori, and Finland's chemicals industry group Kemira Oyj. Another key owner-company in TVO was Finland's Fortum Power & Heat Oy, which was not a mankala company. Fortum owned Finland's two other operational commercial reactors, located in the municipality of Loviisa. Other owner-companies within the TVO mankala were Finnish energy companies EPV Energia Oy, Karhu Voima Oy, and Oy Mankala Ab as well as Kemira Oyj. The Finnish State owned 61.9% of Fortum and thus, by extension, had an indirect stake in TVO. TVO owned 60% of nuclear waste management company Posiva as well. Fortum owned the other 40%. As in Riles' analysis of post-Fukushima TEPCO, "ownership structure [was] significant" for Fortum and TVO, as they were based on "neither private ownership nor collective ownership but, rather, an intractable web of mutual obligations" (2013: 558).

Fennovoima ("Finnish Power") was a newer mankala established in 2007. The consortium inside it, Voimaosakeyhtiö SF, contained over sixty owner-companies around the time of its establishment. At that time, Voimaosakeyhtiö brought together local Finnish municipal energy companies, large formerly state-owned Finnish mining and metals companies like Outokumpu and Talvivaara, Finnish food and grocery cooperatives, and S-Group. Within S-Group were twenty-two regional cooperatives working in Finnish markets for groceries, restaurants, hotels, auto sales, service stations and agricultural supplies. Also inside S-Group was the cooperative bank S-Pankki, plus thirteen local cooperatives. Anyone holding an S-Pankki "S-Etukortti" credit and debit card was considered a "client-owner" of S-Group, which paid out bonuses to client-owners' S-Pankki accounts when they made purchases at S-Group retailers. Since S-Etukortti ownership represented the client-owner's owning a tiny piece of the S-Group cooperative, the money paid into client-owners' S-Pankki accounts was not considered legally as a "discount" but rather as "profit." Therefore, S-Group was said to technically have well over 1.5 million owners. Hence, anyone who owned an S-Etukortti during Fennovoima's first few years also owned a piece of S-Group which owned a piece of Voimaosakeyhtiö which owned a piece of Fennovoima which, in the future, was to own a nuclear reactor. Therefore, anyone who had an S-Etukortti at that time would have, if one followed this chain of interlinking ownership, owned a small piece of Fennovoima's prospective nuclear reactor.

Fennovoima's 2013 Projection of How Pyhäjoki's Hanhikivi 1 Nuclear Power Plant Would Look When Built.

The Voimaosakeyhtiö consortium owned 66% of Fennovoima. 34% was originally owned by E.ON—the German energy giant that was to act as Fennovoima's nuclear reactor technology supplier. After E.ON divested from Fennovoima in 2012, Rusatom Overseas became

Fennovoima's reactor technology supplier and bought E.ON's 34% share. While the tag "Rosatom" was a shorthand referring to hundreds of clustered corporations and subsidiaries, much of it had previously been, as an environmental activist told me, the Ministry for Atomic Energy of the Russian Federation and, before that, the Ministry of Nuclear Engineering and Industry of the USSR. The Rosatom subsidiary established in Finland to work with Fennovoima was RAOS Voima Oy. Like the TVO and PVO mankalas, the Fennovoima mankala entangled multiple entities from multiple sectors of Finland's economy to generate energy. It both owned and was owned: it owned a reactor and also was owned by cooperating owner-companies. As an informant told me, once – when Fennovoima financial experts tried to calculate precisely who, at the end of the day, owned Fennovoima – they were ultimately unable to do so: the chains of owners-within-owners-within-owners they tracked just kept on going. Their conclusion was that *most of Finland* technically owned a tiny share of the prospective reactor.

This opened Fennovoima's mankala to comparisons with TEPCO. While TEPCO was not run like a cooperative, many pension funds, private investors, corporations, and mega-banks across Japan's economy held TEPCO bonds and/or shares in their portfolios. Financing and ownership of it was thus distributed widely across a national economy (Miyazaki 2014: 129). This, for many, fed perceptions that TEPCO was more than just a normal company: it was endowed with a special national purpose. In the event of a major meltdown, TVO and Fennovoima could, as TEPCO did, face rapid bankruptcy risks affecting diverse companies, municipalities, and other investors positioned widely across the country. If not for legally enforced liability caps, they would see disaster response costs, environmental cleanup costs, and nuclear accident compensation costs far exceeding anything TVO or Fennovoima could afford on their own. As in

Japan, a Finnish nuclear disaster would likely force financial calculations into a “regime of incalculability” (Riles 2013: 651) marked by debts so enormous and complex that they would be unlikely to be, or even impossible to be, ever repaid. Government intervention, in circumstances like these, appears inevitable. In Japan in 2012, for example, TEPCO was widely called “Too Big To Fail,” and was given a one trillion Yen government bailout. It was also, effectively, put under state control.

Opening up nuclear power companies’ ownership relations ethnographically made evident how corporations’ figurations as autonomous entities only emerge “out of a field of relations” (Foster 2009: 100). It revealed mankala as a boundary object (Star & Griesemer 1989) iterated and reiterated to coordinate action among diverse entities. It enabled an analysis of different “scales of corporate action” (Welker et al. 2011: S6). It revealed how mankalas took shape as seemingly impenetrable jungles of relations-within-relations-within-relations more amenable to ethnographic description than to financial calculation. Mankala ownership was not unambiguously private nor public, but rather an interleaved admixture difficult to pin down. It hinged on, to borrow words from Riles describing TEPCO, an “utter interdependence of fates—of each individual and enterprise, and of the market and state” (2013: 558). These interdependences were strengthened by how the ownership and management of the mankala cooperatives had closer, less impersonal, relations with one another than they would in a more typical corporation in which shareholder ownership is alienated from the management of the company through its ownership’s stock market commodification.

This all helped Fennovoima and TVO appear as sites in which Finnish national cohesions, corporate structure, and energy futures intersected. But there were also other ways to interpret mankala ownership relations. For a Fennovoima manager, his mankala's distributed ownership had the makings of a good PR campaign. If TVO was Finland's "Industrial Power" company, then Fennovoima – especially given its ownership by so many local municipal energy utilities – could be seen as Finland's "People's Power Company." This evoked sentiments of national-cultural cohesion, egalitarianism, and shared fates among small populations. The wide range of Finnish entities and people with direct or indirect stakes in TVO and Fennovoima – from the Finnish State to mining companies to local municipal energy companies to food companies to hotels – reinforced these sentiments. This made mankala a site at which Noble Nordic, Tristes Nordiques, and Finlands-in-Fragmentation self-essentializations trafficked as explanatory devices among insiders and their academic observers. These corporatist spirits were reinforced by the mankala circuit's reach across multiple realms of Finland's economic, political, and public landscape. Laws requiring strong majorities of owning-companies inside nuclear mankalas to be of domestic Finnish origin reinforced conflations of "mankala" and "Finnishness" too.

Cohesions among mankala owner-companies had to be actively maintained. As a Fennovoima higher-up once told me, despite various schisms and rivalries variegating Finland's nuclear energy sector, there had long been enduring trust in there being shared interests in achieving effective cooperation within mankala consortia. This vague sense of mutual trust was thought to reinforce mankala cohesions. Alaknam made similar claims. He associated mankala with Finnish business cultures' amplified attention to "personal relationships" and the "churchtower principle": the "idea that it is safest to cooperate with people inside your closer circles." This evoked Noble Nordic cooperative figures. But it had also long meant that only companies seen as amply established, trustworthy, or favored in the eyes of mankala consortium organizers could realistically join these energy-sharing "clubs." To Alaknam, mankalas at times resembled selective "brotherhoods" in which, in order to have a chance at entering into a mankala's cooperative relations, one first had to be perceived as a favored or favorable cooperator. At the same time, these closed-off networks, for critical activists, were what gave mankalas a dubious elitist, exclusionary, or collusive flair recalling renderings of Finland's *hyväveliverkosto*. Alaknam portrayed this as follows:

> A mankala is still a club. You don't enter the club just like that... and existing shareholders have the preemptive right to buy from those selling. Look at one of the reasons Fennovoima was created: it was created by people who disappointed not to be allowed into the club of TVO. So they left and created their own club. So mankala is still a club. It is flexible, but only between the club owners. They don't accept just anyone in, just because. If someone gets into difficulties, they others have to buy or to clear them out. So you don't want to be partners with a weak partner or untrustworthy parties."

Mankala insiders' feelings of cohesive partnership were in part determined by how mankala was iterated and reiterated to support patterned cooperative bonds between them. These patterns looked different from different perspectives. In being given nametags like "TVO" or "Fennovoima," a mankala company could appear as a standalone corporate person. Media depictions like those in *Helsingin Sanomat* often singularized nuclear companies in this way. Yet from the vantage of mankala circuit insiders like Alaknam, they appeared as bundles of (corporate) persons composed of many other (corporate) persons (cf. Strathern 1991a). Mankala relational patterns could thus be viewed either (a) in their as fictive oneness as unitary legal persons or (b) in their multiplicities in containing a multiplex of aspirations, relations, people, and things within. Therefore, like a corporeal person, mankalas could be seen as discrete or as composed of many entangled relations.[69] They were at once single bodies and bodies multiple (cf. Mol 2003). A corporation could, after all, be reified as "simple, steady, singular and unchanging... marked by a highly rigid division between inside and outside" while also enfolding myriad overlapping cooperative relations within (See Riles 2011a: 39).

Shared commitments to iterating mankala, reified as a unity yet coordinating multiplicities, drew owner-companies together. Mankala was a locus of shared fates, wills, and interests. Alaknam reflected on how mankala insiders' cohesions were bolstered by how many had long trusted that, despite whatever frictions existed between them, it remained in all their interests to ensure that the mankala "principle" itself would never collapse by being ruled illegal or by losing credibility due to a mankala publicly fragmenting or becoming insolvent. This shared motivation to maintain mankala cohesion in the face of unknown futures spanned owner-companies. The government was supportive of the mankala model and nuclear power overall (Stenqvist & Lindstrom 2013: 5). This all hinted at why – when the legality of mankalas was challenged at the EU level by anti-nuclear Finnish Greens Satu Hassi and Heidi Hautala in 2010 – the Finnish Energy Industries lobby launched a "massive defence" of the mankala principle (*Helsingin Sanomat* 2010).

With this in view, next section explores how Finland's mankala nuclear cooperations teetered and realigned – but never fully dissolved or collapsed – amidst growing political-economic uncertainties and thorny politics surrounding owner-companies' investments and divestments in them. It shows how informants' iterations of mankala enduringly persisting into futures. Yet it

[69]See Strathern 1995b for a rich anthropological discussion of "relations."

also shows how mankala – and the figures of Noble Nordiques, Tristes Nordiques, and Finlands-in-Fragmentation it materialized in tandem with – was iterated in drastically different spirits as crises of expertise took greater hold.

Chronicles of Mankala

Alaknam saw public spats between TVO and Fennovoima – namely, 2012's squabbles about whether the latter would be granted access to Posiva's nuclear waste disposal facilities – as a "fight between brother and sister." He also saw Noble Nordic trust – and Tristes Nordiques fears of shamefully losing face in Finnish business cultures – as key to Finland's mankala circuit's cohesion:

> [With a mankala] it's difficult to convince international banks to lend because international banks would only look at the document, at the law, at the precedent. In Finland, we would also look at all these cultural aspects: who is behind it? We would trust that no one would take the risk of putting a mankala company in bankruptcy because they would lose their fame, their face, and so on. They would ruin the entire mankala concept, and everyone would suffer because one would screw up. In Finland, that would be very harsh for those who hear that. It is a soft regulation. It cannot be written, it cannot be agreed. But it is very important.

Alaknam stressed how, in situations in which trust in mankala was strong, mankala rights and responsibilities could remain largely unwritten and thus could create conditions for fluid cooperation. In 2012, Alaknam described how mankalas had long been sustained mostly by "gentlemen's agreements" and oral contacts that once sufficed in a country in which collaborators could, from the get-go, assume Noble Nordic mutual trust in one another's aligned interests in cooperating. When conditions of cooperation[70] between owner-companies were seen as strong, trust seemed an inexhaustible resource. An extension of trust could be reciprocated with a counter-extension, which could then be reciprocated with yet another counter-extension, and so on, indefinitely. In such moments, cooperators saw themselves achieving fluid cooperation by, to borrow words about trust from Miyazaki, holding dimensions of their agencies in "abeyance" such that "uncertainty, unknowability, and helplessness [was] deferred and hence obviated again and again" (Miyazaki & Raffnsøe 2015: 185).[71] When extended and counter-extended successfully, trusty cooperation seemed to have no upper limit—no maximum at which it had to be capped. Space opened up then for discussion of Noble Nordic virtues. Alaknam, for example, pointed to common figures of Finnish societal trust as grounds for churchtower principle cooperation. Mankala insiders' senses of cooperating on stable plateaus of cohesion supported the fruitful back-and-forth relationality some called *luottamusperiaate*.

In 2012's moments of relatively greater mankala circuit stability, Alaknam ventured more speculative, playful, imaginative auto-analysis of mankala relations in his conversations with me. He speculated ambitiously about parallels between (a) how trust facilitated mankala companies jointly purchasing, owning, and sharing expensive nuclear reactors that the individual companies comprising them could not afford individually and (b) how trust facilitated rural Finns jointly purchasing, owning, and sharing, say, an expensive tractor or crop sprayer they could not afford

[70] What I refer to here as trusty cooperation should be evident in previous sections' discussions of trust and cooperation. For a similar discussion, see Miyazaki's work on how Japan's population's "vague shared sense of trust" (2014: 134) was altered during and after the Fukushima nuclear disaster.

[71] When fluidly extended and counter-extended, however, trust seemed to have no upper limit. This was written into the performed movements of foregrounding/backgrounding and scaling/rescaling of notions like trust, collaboration, collusion, and cooperation animating the unfolding of my account.

individually.[72] In more optimistic moods, he was more apt to draw on popular Noble Nordic renderings to reflect on imaginative parallels between mankalas and *talkoot*: a kind of "traditional" cooperative event in which friends, neighbors, or acquaintances in Finland meet at a scheduled time to collectively accomplish a task without anyone being compensated monetarily.[73] Alaknam meanwhile speculated ambitiously about whether the mankala corporate model could be retooled to "add value" or be "bankable" outside Finland. He dreamed of mankala-like corporations being implanted in other "small countries" like Lithuania that might wish to purchase a nuclear reactor but did not have all the necessary capital to do so held in any single place. A "little piece of cooperative corporate strategy from Finland" could, Alaknam dreamed, help them surmount resource-, risk-, and liability-pooling hurdles.

Other informants partook in freewheeling speculation about mankala's business-cultural origins and essences in 2012 too. For example, I met a Finnish lawyer who compared its structure to that of Denmark's wind power cooperatives, which had pioneered decentralized renewable energy supply there since the 1970s OPEC oil crisis. Both cases involved familiar corporate forms – a LLC and a partnership respectively – being run like cooperatives. And just as Denmark

[72] This description resonated closely with discussions of cooperation, trust, and joint-ownership of farming equipment in Ray Abrahams' 1991 ethnography *A Place of Their Own: Family Farming in Eastern Finland.* In both examples, cooperation was predicated on sort of an "only stable trusted partners should be invited to cooperate with us" mentality. As Abrahams noted, "Finnish farmers do not enter lightly into such arrangements, and most cases of joint ownership of machinery and other equipment occur between people who have known and come to trust each other over many years" (152). It also intimated resonances between (a) "overlaps of membership" in mankalas in which owner- companies owned shares of other owner-companies that owned shares of other owner companies *ad nauseum* and (b) "overlaps of membership" in Abrahams' Finnish farmers' joint-ownership of farming equipment. For example, "Ilmari Turunen had a large stock of his own machinery, and engaged in an exchange of services with four others, a fertiliser drill with one other, a crop sprayer with four others, a potato harvester with six others, a combine harvester with one other, a slurry tank with one other, a winch with two others, and a ditching disc with one other. There is some overlap in the membership of these different groups" (156).

[73] To Alaknam, a *talkoot* was a curiously informal, traditional, even archaic form of economic cooperation. He was interested too in how a tacit assumption held by many of a *talkoot*'s helper-volunteers was that the recipient-host would be willing to reciprocate and become a helper-volunteer himself or herself if he or she would be invited to someone else's *talkoot* in the future. His curiosity about whether *talkoot* was but a vestige of a more traditional (Finnish) gift economy from ages past was evident.

mandated minimum local-community ownership share percentages for cooperative wind turbines, Finland mandated minimum national-domestic company ownership share percentages for mankala reactors. Informants' comparisons, however, had their limits. Denmark's more-grassroots wind cooperatives were, after all, aimed at local democratic community ownership of small-scale energy provision. While it now provides one-sixth of Finland's energy, the TVO mankala was, in contrast, initially founded for industrial purposes as a clubbish cooperation among elite economic powerhouses working in a tight-knit sector of Finland's economy. While Fennovoima informants were proud of the company's many local municipal utility owner-companies, it drew powerful industry and commerce agents together from widely across Finland too. TVO and Fennovoima were also, in part, subject to the wills of powerful multi-nationals – Areva and Rosatom respectively – that provided them with reactor technology, and those that would supply their reactors with fuel throughout their operating lives. These power-relationships did not loom over local Danish wind turbine holders' decisions.

The Finnish lawyer informant also playfully compared what he saw as the "more traditional" spirit of relations behind Finland's early mankalas and the "more traditional" relationships he saw as suffusing Japan's corporate and government worlds. This evoked parallels between Finland's and Japan's corporatist sociopolitical arrangements. It also evoked parallels between Finland's *hyväveliverkosto* and *lehmänkauppa* motifs and Japan's tight-knit elite "nuclear village." Indeed, in popular imageries, Japan was thought to have, for example, credit and debt markets with a "highly-domestic, inward-looking and relational quality," which Miyazaki has analyzed as, in part, an achievement of "conscious effort" among Tokyo's financial market professionals working to maintain it after 3/11 (Miyazaki 2014: 133). My informant's appeals to "tradition" guiding Japanese capitalism were reminiscent of longstanding legal and anthropological debates (a) about Japan's small- and medium-sized companies in which many shareholders see themselves as kin, (b) about whether the Japanese *ie* ("household") should be analyzed more as a kinship unit, as an economic unit, or even as a sort of corporation, and (c) about how, as Riles has noted, Japanese judges are known to sometimes put the strict letter of corporate law aside when it seems incompatible with their understanding of acceptable kin relationships (Riles 2011a: 37-38).

Yet this chapter's core goal is not to evaluate the plausibility of Alaknam's or my lawyer informants' speculative comparisons between Finnish, Danish, or Japanese business worlds or corporate structures. It is simply to gesture to how – amidst rosier early 2012 contexts in which Finland's mankala circuit appeared more amenable to generalizable renderings of Noble Nordic trust, cooperativeness, cohesion, and transparency – informants felt more at ease embarking upon freewheeling, imaginative, and amateurish historical, or even quasi-anthropological, flights of thinking about mankala's essence and origins. This demonstrates how, for my informants, evoking a distinctly cooperative Finnish national business culture appeared, in those times of greater optimism, intuitively more apt. It helps track how informants' auto-analyses, self-reflections, and self-essentializations became integral to their self-concepts as professionals inhabiting Finland's mankala circuit, thereby contouring the constitution of and steering the functioning of mankala itself.

Informants' open reflexive spirits maintained, in moments of 2012 mankala optimism, when they reflected on parallels between Finland's mankala nuclear companies and Finland's cooperative companies like OP-Pohjola Group, mutual insurance companies like LähiTapiola Group, the forest owner cooperative Metsäliitto, the egg-producers cooperative Munakunta, or the animal breeding cooperative Faba—members of the Confederation of Finnish Cooperatives, also known as the Pellervo Society (Kuisma 1999). From that angle, as two economic historian academic colleagues saw it, mankalas appeared as permutations of a Finnish history of cooperative capitalism which itself appeared as a permutation of other European histories of cooperative capitalism like those of, say, Germany (See Chandler 1990). There were, for instance, weaver cooperatives in 1840s England and cooperative stores in 1860s Denmark too. Denmark had dairy cooperatives in the 1880s. In 1933, President Roosevelt sent a task force to Northern Europe to study rural Scandinavian electricity co-ops as models for U.S. programs for electrifying rural areas and reducing unemployment (See Hall 1988).

Noble Nordic depictions entered the fore in those discussions too, as such cooperatives had long been seen as evocative of Finns' and other Nordics' general opennesses to working together.[74] Finnish public, media, and academic discourse had also already incorporated international representations of Finnish cooperative capitalism like those in a 1937 episode of the United States television show *March of Time*:

> [I]t was through a cooperative system of production and consumption on a nation-wide scale that frugal Finns turned for economic salvation. In great modern plants cooperatively owned by their customers, Finns carry on 25% of all retail trade, 60% of all wholesale business. In Helsinki alone, one cooperative, Elanto, divides the profits from its 314 shops and 15 restaurants, among the shareholders who patronize it.

Mankalas, from the perspectives of analyses of Finnish cooperative capitalism that developed both inside and outside Finland's borders, appeared then as tools a small-but-rich country

[74] Internationally, Finnish cooperative companies were often held up as evocative of Finns' broader cooperative spirits. For example, there lingered memories where I grew up in Central Massachusetts of Finnish-American immigrants in the United Cooperative Society of Fitchburg setting up, for example, agricultural produce and dairy distribution cooperatives in the first half of the twentieth century (Syrjala 1947). In Upstate New York – not far from my current academic home base at Cornell – there lingered memories of the Spencer Co-Op, which was "started in 1928 by a group of Finnish farmers with a capital of seven hundred dollars obtained by selling five-dollar shares" and at which, by the twenty-fifth year of its founding, "yearly business amounted to $2,800,000."

deployed to compete with larger and even richer countries by capitalizing on Finns' abilities to cooperate more closely, reliably, and efficiently than might be possible elsewhere. This seemed to affirm lobbyist Marita's sense of Finland's economy's cooperative-competitive advantage. Yet many remained skeptical, as Oona was, of how such energy-sharing collaborations operated among Finnish business, governance, and energy insiders. This brought more unsavory figures of scheming business leaders, hidden tax advantages, and behind-the-scenes collusions among Finnish corporations, banks, ministries, and lobbying associations into my conversations with Finnish anti-nuclear environmentalists. For instance, a Finnish Green politician told me of how, as mankalas produce just energy and not profit for owner-companies and were thus untaxed – a feature that differentiated them from more typical corporations – they could be seen as anti-competitive "elite clubs" violating principles of tax justice. Skeptical Finnish academic colleagues told me too of how mankalas resembled relations that upheld the cartels that operated in Finland prior to its 1995 accession to the EU.

Others dismissed mankalas as living fossils left behind by Finland's bygone national-capitalist (See Jensen-Eriksen et al. 2012) past, which they saw as having been eroded with Finland's liberalization over the past thirty or so years into Finlands-in-Fragmentation. Alaknam lamented how recent years' transformations in Finland's business-cultural, legal, and economic landscapes had made it so what had long been implicit about mankala technicalities had to be made explicit, formalized, written down, or more unambiguously codified. This, to him, indicated increased legalization and decreased reliance on interpersonal trust relations. The mankala corporate model – as well as the renderings of trust, cooperation, and openness that were thought to sustain it – was mutating amidst twenty-first century realignments. The need to more legalistically encode mankala relations in contracts became acutely evident as Fennovoima's ownership relations – its “very scattered ownership by Finnish industrial, trade and municipal companies” (Tuomisto 2012) relative to that of TVO – began to wobble, fragment, and realign increasingly throughout my field stay.

Growing uncertainties shook, sliced up, and realigned trust in mankala cooperations increasingly throughout 2013 and 2014. Both TVO and Fennovoima saw rocky roads. Fennovoima saw a struggle to maintain owner-companies. After a series of divestments since 2012, Voimaosakeyhtiö’s initial sixty owner-companies fell to only forty or so in 2014, triggering a struggle to achieve the clear Finnish national ownership that the government required—a mandate established to ensure mankalas’ cohesions remained somewhat aligned with Finland’s broader countrywide cohesions. This rule also indexed hesitancies to extend trust to non-domestic Finnish companies.

By September 2014, many worried that the geopolitical crisis in Ukraine was scaring off Fennovoima investors (Rosendahl 2014). Finland’s Environment Minister Ville Niinistö criticized Fennovoima’s dealings with Rosatom as reminiscent of Finland’s wary, but sometimes (often reluctantly) cooperative, Cold War era relations with the Soviet Union. When Fortum announced its plans to invest in Fennovoima in December 2014, a Finnish academic dubbed Fennovoima’s, Fortum’s, and Rosatom’s “behind-the-scenes” dealings a “*lehmänkauppa,*” noting Fortum’s interest in extending its reach to hydropower in Russia, a key market for Fortum (YLE 2014). Yet still, when one nuclear waste informant read something I wrote in which I voiced skepticisms about mankalas’ democratic purity, he dismissed my work as an essay like those “from the Russian troll factory from St. Petersburg.” Yet soon after, in 2015, a little-known Croatian company Migrit Solarna Energija appeared seemingly out of nowhere to invest in and rescue a then-shaky Fennovoima project. Rumors that it had ties to Russian leadership circulated.

Finland's government ultimately refused to let it join the mankala.

The TVO Mankala's Olkiluoto 3 Site in 2014 (Photo Credit: Hannu Huovila).

Some attributed these instabilities to how Fennovoima's owner-companies' cohesions were simply not as resilient as those of the older, more "traditional" TVO mankala, which had long been comprised of owner-companies with more shared interests, more shared histories and fates, and more similar roles in more closely related sectors of Finland's economy. Others read this as symptomatic or emblematic of a countrywide sense of Noble Nordic cohesion – of participating in a shared Finnish national project – dissipating into Finlands-in-Fragmentation. Others brushed these skepticisms off as unrealistic products of Tristes Nordiques pessimism. Still others downplayed the situation, suggesting that mankala cooperation defections were much less severe for Fennovoima than they would have been for TVO given how the former was not yet responsible for overseeing an operational reactor.

As years went on, the TVO and the France's Areva faced mounting uncertainties too. While it was initially anticipated that TVO's OL3 reactor would be in operation by 2009, the project saw extensive delays. The project saw cost overruns that raised the reactor's anticipated price tag from €3b to over €8.5b. This led TVO and Areva-Siemens to sue one another for billions of euros in compensation. In October 2017, OL3 was not planned to be operational until May 2019. TVO also planned to have a fourth reactor, OL4, built in Olkiluoto. However, in May 2014 TVO sent a request to TEM soliciting a five-year extension of OL4's original five-year go-ahead decision. Their request was rejected in September 2014.

TVO and Fennovoima were grappling with Finland's and nuclear energy's uncertain futures. When I met Alaknam in 2014, he was more somber. He did not venture to co-theorize speculatively about mankala cooperations' relatedness to Finns' more general propensities for cooperation. Gone too, it seemed, were the days of his and his colleagues' ambitious dreams of capitalizing on exporting the mankala corporate model to new contexts in other countries. Alaknam grew concerned that the mankala model was being overstretched or extended[75] too far in its adoption by certain new renewable energy projects in Finland like wind.

As uncertainties layered upon uncertainties, mankala was iterated in many different spirits. A longtime rationale for mankala cooperation had been that mankalas generated "cheap energy" closer to production price than to the market price defined by Nord Pool Spot—the transnational electrical energy market operating between Norway, Sweden, Denmark, Estonia, Finland, Lithuania, and parts of Germany. However – amidst new uncertainties about nuclear energy's economic feasibility and trends toward greater subsidies for renewables – it had become unclear whether mankala companies could deliver these savings then or in the future. In late 2013, a Finn working at a multinational accounting firm told me of his uncertainties about whether the financials of mankalas really added-up anymore: one could see owner-companies paying more for mankala nuclear energy than for energy bought from Nord Pool. As one mankala circuit insider put it in 2013, if Finland's economy had no future, nor did Finnish owner-companies, and thus nor did new mankala reactor projects. As Alaknam told me in 2014: "to finance and build a

[75]For more anthropological analysis of "extension," see Miyazaki 2005 and Wagner 1981: 27.

nuclear reactor, you need to believe in the future." High-impact low-frequency events like the Fukushima disaster, in Finland as in Japan, helped obviate the widely shared past assumption that nuclear power would be cost effective (Miyazaki 2014: 129). The serious financial struggles that nuclear companies like Westinghouse and Toshiba saw in the years ahead have since raised additional concerns globally about nuclear energy's economic viability.

Mankala cooperations were shaken, reorganized, critiqued, and scrutinized. Uncertainties obviated how mankala relations emerged from interleaved public-and-private mash-ups of national and international partnerships, coalitions of owner-companies, regulatory and governmental actors, and long chains of subcontractors that could in moments of instability wobble, fragment, or realign in unanticipated ways. By 2014, the anticipatory nostalgia many felt toward attenuating national cohesion, trusty solidarity, or cooperative spirit became palpable in nuclear professional worlds. This affected the spirits in which idealized renderings of Noble Nordic or Finnish cooperative propensities were being iterated. New pessimisms brought Tristes Nordiques and Finlands-in-Fragmentation figures to the fore.

Alaknam's renderings of a generalized trust permeating Finnish business cultures diffracted into talk of many different strains of (mis)trust. That is, it diffused into more qualified, precise, cagey reflections on – to list some examples – specific mankala owner-companies' (mis)trusts in the plausibility of cooperating in the long-term on new reactor projects, specific mankala owner-companies' (mis)trusts in their own financial futures, Finland's (mis)trusts in cooperating with Russian companies, Finland's public's (mis)trusts in nuclear energy company managers' intentions, Finland's public's (mis)trusts in nuclear experts' competences and environmental consciences, my own (mis)trusts in the information shared with me by ethnographic informants, and so on. Mankala circuit uncertainties spawned a profusion of (mis)trusts of many gradients, valences, and orientations being iterated and reiterated across the ethnographic landscape. (Mis)trust in and by whom? How strong or weak was the (mis)trusting and how long had it been that way? What triggered actor X, actor Y, and/or actor Z to realign his, her, or its (mis)trusting? Which particular qualities of a (mis)trusted entity were to be foregrounded and which were to be backgrounded in negotiations of its (mis)trustworthiness? Was such lost or gained (mis)trust easily recoverable or losable?

Conditions of uncertainty elicited more focused exactitudes in informants' reflections on Noble Nordic cooperativeness' or Finnish trust's alleged centralities to mankala cooperation. This widened trust's range of categorical distinctions. These representations shifted and re-shifted as entangled political, financial, and interpersonal uncertainties waxed and waned in shallow time horizons. When trust in the mankala circuit became increasingly unstable, relations between owner-companies refracted and diffracted, aligned and realigned. Informants' auto-descriptions wavered back-and-forth between allusions to the micro-scale of (mis)trusty mankala circuit relations and the macro-scale of (mis)trusty Finlands-in-Fragmentation societal relations. Mankala insiders became more restrained in how they speculated about mankala's cultural essence. Deflated informants ceased to riff on ideas with me in such self-aware, playful, open-ended, imaginative, quasi-anthropological, open ways. Renderings of Tristes Nordiques, *herraviha*, *lehmänkauppa*, and *hyväveliverkosto* eclipsed past spritely optimisms. So did anticipatory nostalgias for (a) TVO's owner-companies' golden past of simpler cooperative cohesion and (b) Finland's starry-eyed early 2000s embraces of nuclear energy futures.

Different people in different contexts iterated mankala variably with more positive, negative, or ambivalent spins. Each perspective seemed to get at something essential about mankala without fully capturing its essence. Growing uncertainties obviated how senses of trusty cooperation had long upheld mankala projects' internal cohesions. It obviated how trusty cooperation was perceived to be gained, betrayed, earned, lost, accumulated, diminished, extended, withdrawn, and reapportioned amidst (un)certainty. Once-more-stable grounds for ongoing rapport, mutual intelligibility, and shared security trembled as informants' new permutations of (mis)trust folded into one another, blurred together, and flickered in and out of one another. Past rosier renderings of mankala cohesions' gradients, valences, and orientations were sliced up and reorganized in cagier milieus. Trust was cast less as an invisible glue that tacitly held together mankala cooperators and more like a felt restless flow of intensities accumulating explicitly in spaces of close relationality and dissolving in spaces of suspicion and misaligned interests.

Indeed, Fennovoima's mankala saw some owner-companies defect and others join. After Fukushima, Fennovoima had to switch technology suppliers from a Germany-based to a Russia-based company. TVO increasingly realized that the OL4 new build was unlikely to materialize. But something endured through and through: a widely shared commitment to iterating and reiterating mankala as a locus for organizing nuclear facility ownership relations. I close this chapter by reflecting on the implications of my informants' persistent iterations of mankala.

Mankalas Maintained

Alaknam and I sustained our commitments to reflecting on the mankala corporate model's minutia despite countless other destabilizing, and perhaps more attention-grabbing, nuclear events unfolding around it and us.[76] The payoff was a peek into how mankala cohesion became both more contested and more integral in a milieu rife with unknown futures. This peek revealed how mankala was, despite instabilities, still being iterated over and over again to structure and make sense of Finland's nuclear energy sector worlds. It revealed how mankala could effectuate patterns of relation that looked more like *collaboration* from some perspectives (e.g. interpersonal working-togetherness between mankala circuit insiders or between ethnographer and field informant), more like *collusion* from other perspectives (e.g. critical academics or environmental activists' indictments of a mankala *hyväveliverkosto* or old energy elite), and more like *cooperation* from still other perspectives (e.g. the more detached relational patterns that emerged from the mankala corporate model's legal technicalities).[77] Seen from any of these angles, self-essentializations of mankalas' supposedly deep Finnishness were prevalent. This all helped shape how Finland's nuclear sector, and the visions of the future within it and contouring it, emerged in practice.

Simple commitments to iterations of mankala, and the tangles of events and agents implicated in the circuitries of relations it helped coordinate, played a strong role in orchestrating the Pyhäjoki and Olkiluoto reactor projects. Even when TVO was shaken and Fennovoima's ownership consortium was reorganized, mankala persisted as a locus for ownership relations, pooled capital, and consolidated power. This endowed mankala insiders with bases of shared intelligibility and inertia into the future. It gave them senses of how to relate to each other and

[76]Doing so helped us retain focus on, as Foster might also have, the "specificity of corporations without backsliding into a discussion of capitalism instead" (2009: 97).
[77] This demonstrated how a "collaborative 'whole' exists only as the set of radically diffracted observations generated by participants" or as a "multiplicity of devices or participant observations whose 'collaborations' cannot be grasped from any one perspective" (Pottage 2014: 363). It indexed how "what may seem cooperation to one party may appear as exploitation or intrusion to another" in "interchanges [that] may or may not be marked as collaboration" (Strathern 2012: 109).

what to do next. While TVO's and Fennovoima's mankalas became more diffuse or unstable at times, they never dissolved into bankruptcy. Foundations of trust, belief, and mutuality that both underwrote and transcended the mankala formations never fully dissipated. The layouts of roles, duties, and responsibilities sketched by TVO's and Fennovima's Articles of Association contracts generally remained intact. Mankalas continued to link together myriad professionals from various walks of life, academic training backgrounds, and positions within nuclear sector ownership ties. The matrix of action this established continued to help generate both Finland's nuclear energy and Finland's nuclear energy experts. From those emerged the spent nuclear fuel that elicited Posiva's deep time-reckoning Safety Case portfolio.

Iterations of mankala were crucial to Finland's nuclear worlds. Yet mankala was extremely easy to overlook. Very few Finns I met had ever heard of the term. Finland's educated publics, at best, vaguely knew that TVO and Fennovoima were cooperative ownership setups. In 2012, a Finnish business professor, who I continue to suspect had never heard of the term either, laughed when I told him over drinks that the mankala corporate structure was a distinctly important feature of Finland's nuclear sector. My continued fieldwork assured me that I was correct. From the outside, mankala appeared as a banal technicality that, due to its sheer boringness, deflected attention from itself. This kept it off many media and academic commentators' radars. From the inside, however, mankala was iterated and reiterated as a fragile yet essential part of nuclear Finland's lifeblood. These iterations chartered nuclear sector ownership and financing coordination. They generated relational patterns that prevented mounting uncertainties from descending into radical unknowability. The everyday familiarities these patterns introduced into informants' lives helped them feel at home in complex corporate worlds as they moved forward together as political-economic uncertainties grew. Persistent commitments to iterations of familiar devices like mankala were, in this way, integral to achieving radically intricate technoscientific feats like nuclear power in Finland.

Alaknam thought that, if Fennovoima were to have fully collapsed, it would have called the grounding principles of mankala cooperation into question in courts and public debates. This would have been a public spectacle that denaturalized the mankala corporate model and obviated its weaknesses among owner-companies. It would have publicized or even democratized scrutiny of the mankala model's technicalities for Finnish publics accustomed to encountering "Fennovoima" or "TVO" only as personified unitary corporate entities like any others. If Fennovoima were to have toppled, the Voimaosakeyhtiö cooperative behind it would have unraveled into a cacophony of uncoordinated relations in need of repair. Mankala cooperation in principle could be ruled illegal, or at least become more widely considered unrealistic, in twenty-first century Finlands-in-Fragmentation. But mankala never reached this breaking point. Unyielding iterations of it maintained. Mankalas kept nuclear projects alive and iterating with political consensuses and funding flows. Following this ethnographically showed me how successes or failures to achieve mankala cohesion determined how, why, and where nuclear reactors were or were not built in Finland.

To study iterations of mankala was to study a much broader circuitry of relations than is usually analyzed in commentaries on nuclear waste risk's deep time. Studying political and financial time horizons meant studying horizons much briefer than are usually emphasized in social studies of nuclear waste's deep time. Yet political, epistemic, and economic shifts are key to any nuclear waste story. For my informants, positive or negative reactor building decisions ultimately determined whether, how much, and what kinds of nuclear wastes would ultimately be produced too. These nuclear waste production conditions determined, among other things, the conditions that initiated Safety Case deep time-reckonings. Safety Case future-gazing was, in this way, inextricably linked to Finland's mankala circuitries and the flux ecologies of dreams, (mis)trusts, hopes, cooperations, cohesions, transparencies, and self-essentializing national cultural imaginaries alive in and around them. Posiva's renderings of far future worlds, materializing both in response to and simultaneously with Finland's mankala-contoured nuclear sector materializing, proceeded generatively from all of this and more.

The next chapter will similarly explore how nuclear professional worlds across Europe, North America, and beyond – and, by extension, across Finland's nuclear waste risk forecasting regime – were also grounded on efforts to stabilize multi-decade and centurial horizons of personnel succession, intergenerational knowledge-transfer, and project continuities. Just as this chapter's mankala circuit insiders iterated mankala to help endow their cooperative reactor financing futures with clearer pattern, Chapter 2's nuclear energy professionals iterate workplace role templates like recruit/retiree and junior/senior to endow cross-generational workflows with clearer pattern. I thus continue to explore how informants iterated and reiterated traces of what is familiar to them to orchestrate their movements forward in time and to endow their visions of tomorrow with more discernible features.

(Chapter 2) Regenerating Nuclear Energy: STEM Youth Aspirations & Workplace Peopling

Energy Insecurity

It was June 2013 and I was in Stockholm, sitting in an auditorium-style lecture hall at *Kungliga Tekniska högskolan* (Sweden's Royal Institute of Technology KTH). An elder nuclear energy industry leader from Northern Europe took the stage to speak to over three hundred ENYGF attendees. Her audience was mostly under thirty-five years old and drawn from nuclear energy professional worlds across Europe. She told us of the need to help "make nuclear cool again": to "make pro-nuclear art, songs and T-shirts," to "organize and participate in pro-nuclear events," and to always "bring cookies." In private conversations later that day, and then again at the WNA symposium[78] I attended in September 2013, nuclear energy insiders lamented how many educated young people in Western Europe and North America had grown up skeptical of nuclear energy's military-industrial origins. Some had been influenced by what they saw as doomsaying anti-nuclear environmental movements. Others had become wary of nuclear energy sectors' relatively slow paces of change. To them, tech-savvy youth fascinations seemed to have shifted away from hierarchical, centralized, big-industry projects like nuclear power plants and toward smaller-scale decentralized technology designs like smart phones, artificial intelligence, drone technology, biotechnology, computer software, wind/solar power, and so on. Where had the deep societal respects for nuclear scientists and space engineers gone? Had information and communications technology revolutions drawn innovations and media spotlights elsewhere?

[78] This is a yearly industry event held in London. The WNA has described itself as attracting "over 600 of the world's nuclear energy leaders who came together to discuss key topics: New Nuclear Build / Launch of the World Nuclear Association Nuclear Fuel Report / Novel Reactor Technologies / Back End Fuel Cycle and Decommissioning / Human Resources / Front End Fuel Cycle Developments / Leaders Perspectives on key nuclear issues / High Level Panel discussion" (WNA 2015).

Why, some wondered, would a society put, say, Mark Zuckerberg or Elon Musk on a pedestal while sidelining those following in the footsteps of nuclear legends like Hans Bethe, Glenn Seaborg, Enrico Fermi, or Marie Curie?

Many nuclear professionals lamented how big centralized state-funded technologies seemed, to educated youths, broadly old/past while smaller decentralized commercially produced technologies seemed broadly new/future. Others were concerned about whether nuclear could realistically attract the necessary "patient capital" – pricey investments when returns are not likely to result for at least another decade or two – in twenty-first century commercial frameworks (Eaves 2017: 34). Some professionals, insecure about nuclear energy's present potency, were defensive about perceptions of their industry's smallness and pastness. Few youths, they explained, entertained the starry-eyed post-WWII Atoms for Peace utopianism that inspired many in their parents' and grandparents' generations. Youths in the West – in contrast with those in emerging economies like China or India where nuclear was expanding – had grown up cool to the techno-optimist, nationalist, modernist, developmentalist dreams of countrywide wealth-maximization long associated with nuclear energy. Many university students interested in energy instead sought what they saw as more environmentally friendly and more subsidized careers in renewables, energy efficiency, or smart grids. In this context, seasoned nuclear higher-ups wondered: how could nuclear energy technology again win the hearts and minds of motivated younger STEM talent pools?[79] Would many of the best-and-brightest technical university students continue to steer away from nuclear and toward, say, careers in cybersecurity,

[79]The term "talent pools" refers to the hoards of university-level or early-career STEM techies who could potentially be drafted into nuclear careers. I borrow this category from informants at the ENYGF and WNA events and recursively deploy it to frame my analysis.

clean tech, nanotechnology, financial services, synthetic biology, or computer science? Or was a nuclear renaissance among the Millennials of North America and Western Europe nigh?

Waves of baby boom generation retirements added further uncertainties to questions about future nuclear professional demographics. A 2010 IAEA report had noted how, in the United States' nuclear energy worlds, just thirteen percent of engineers, fourteen percent of operations employees, six percent of maintenance employees, and four percent of radiation protection employees were younger than age thirty-three. It was advised to hire about five hundred trained graduates yearly to compensate for baby boomer attrition. Électricité de France (EDF) – which generated almost eighty-five percent of its energy output through nuclear – planned to see forty percent of its trained nuclear staff (more than four thousand professionals) retire in the next decade. It was advised to recruit about thirteen thousand PhD- or MS-level engineers and about ten thousand BS-level operators and technicians in that span. China's Eleventh National Plan called for recruiting over twenty thousand "high" professional or graduate employees even as it, "like some North American and European countries, face[d] challenges in attracting students into specialist nuclear power fields" (IAEA 2010: 3). In 2006, the U.S. NRC anticipated losing four thousand person-years of experience yearly due to increasing retirements in an agency where fifty percent of its staff had less than a half-decade of experience (Eng 2015). In 2009, the U.S. DOE responded to these challenges by establishing a program called Nuclear Energy University Programs (NEUP), which consolidated its funding for universities training young nuclear workforces. A 2012 Finnish government report noted how, as one-third of Finland's nuclear energy specialists reached retirement age, about 2,400 replacements would be needed by 2025. If one were to include the trained recruits needed for nuclear waste and proposed new reactor projects, the figure would rise to 4,500 new employees.

Yet these concerns were but momentary episodes in nuclear energy technologies' multi-decade and sometimes centurial project-lives. Nuclear reactors in Western Europe and North American could, at the time, operate for sixty to eighty years. This timeframe could be longer if reactor life extension updates were undertaken. Some nuclear professionals claimed there were incentives, in many locales, for keeping reactors in operation for as long as possible: once a plant's extremely high up-front R&D and construction costs had been paid off after a few decades, nuclear could, supposedly, produce ongoing emissions-free baseload energy more affordably later on.[80] Yet even plants shut down decades earlier than scheduled left behind spent nuclear fuel that had to cool in surface-level interim storage facilities, sometimes for forty or fifty years, before being entombed for millennia in underground repositories. These waste disposal projects commonly saw delays, as in the U.S. Yucca Mountain project context, due to political resistance, litigation, and scientific uncertainty.[81] Even repository programs that had proceeded more punctually – like in Sweden or Finland – had planning horizons exceeding one hundred forty years including R&D, construction, facility operation, and decommissioning phases. Nuclear energy as a whole thus necessitated long-term knowledge transmission, smooth cycles of recruitments and retirements, financial solvency, and coherent organizational continuity adapted across generations.[82]

To build a nuclear power plant was to establish a powerful path dependency to which near- and far-future generations had to adapt. This chapter explores nuclear professionals' work to endow

[80] Continual maintenance, life-extension updates, and safety updates adapted to changing regulations was still, of course, required for reactors.

[81] The Trump Administration has moved to try to restart the licensing review of the Yucca Mountain nuclear waste repository project. It thus may return as an option in the coming years. Still, even if the Yucca facility gets built, it would not be large enough to sequester all of the U.S.'s spent nuclear fuel. So it would not be a final solution for all of the country's spent nuclear fuel.

[82] This elicited much longer project continuity horizons than did, say, Silicon Valley software businesses, solar panel companies, or nanotech labs. Nuclear technologies' extended time horizons must be considered in any discussion of their distinctiveness or exceptionalism.

these paths with long-term continuities, to smooth intergenerational transitions, and to surmount human resource challenges. It shows how these horizons took shape in and around iterations and reiterations of *workplace role templates* temporalized, in part, by simple distinctions like "junior" versus "senior," "recruit" versus "retiree," "younger generation" versus "older generation," or "student" versus "pensioner." These indexed how nuclear insiders of many job profiles – technicians, managers, scientists, quality control staff, nuclear engineers, operators, environmental monitors, regulatory compliance professionals, and so on – were positioned in relative stages of career advancement and professional life-course vis-à-vis one another. To study them is to track how and why certain nuclear career expectations, life-projects, and personal aspirations had changed across the decades.

An Elder Explains His Management Philosophy to Younger Nuclear Professionals.

The chapter does not focus primarily on workplace "role" in the sense of, say, the differing responsibilities and disciplinary backgrounds between a "nuclear technician" versus a "nuclear engineer" versus an "accountant." While those are key parts of the story, the chapter emphasizes something more specific: how informants iterated distinctions like junior/senior, recruit/retiree, or student/pensioner to position themselves and others temporally within loosely coordinated career trajectory timelines, employee turnover horizons, and succession patterns. It examines how this helped coordinate distributions of responsibilities, layouts of duties, and taxonomies of specializations in their professional projects across time. This all shaped the *peopling* of nuclear professional worlds across the decades—channeling the flows of human capital into nuclear personnel succession role positions over the decades. Iterations of these familiar distinctions helped establish forward momentum in professional lives by endowing intergenerational time horizons with more discernible pattern.

Nuclear Energy Regeneration

Nuclear sectors across North America and Western Europe had, for years, developed projects to maintain knowledge continuities across incoming and outgoing generations of personnel. Some cultivated apprenticeship, mentoring, shadowing, or academic dissertation-advising relationships between seasoned insiders and fresh recruits. Others established projects to document, database, or audio-record aging insiders' stories, knowledge, and testaments. Some organizations had new recruits interview outgoing seniors for public communications projects. Certain retirees formally departed their workplaces and afterwards founded their own consulting businesses. Others traveled the world giving presentations at international organizations, universities, and new national nuclear energy programs. Some profited significantly from this work. Some nuclear energy organizations placed retirement-age experts in senior advisory roles, which a Swedish nuclear expert called "elephant graveyard" or "elder shelf" positions, reminiscent of academia's professor emeritus positions. NRC knowledge management expert Patricia Eng has called these elder-experts "rehired annuitants" and discussed "retention incentive" programs to prevent their full retirement. Some organizations have worked to ensure that certain difficult-to-replace professionals have on-the-job deputy-doubles ready to take over in case of unforeseen vacancies. Eng has called this technique double encumbering (2015).

Workplace role templates – temporalizing distinctions between junior/senior, youth/elder, student/pensioner, and recruit/retiree – greeted nuclear energy sector neophytes upon arrival. New recruits entered professional worlds in which they were always already positioned in relation to senior soon-to-be-gone experts who saw themselves as handing off their knowledge, roles, and wisdoms to inexperienced not-yet-theres. Elder nuclear experts were nudged toward going about the last decades of their professional lives with their own careers' endpoints in mind—toward self-closing their careers in ways enabling smooth successions.[83] This reminded them that their incumbencies their professional roles were not everlasting, but had to be handed-off to new occupants to help maintain patterned continuities across time.[84] Many inhabited a preexisting sociality of roles (Miyazaki 2007: 408; Riles 2010: 798) or template of workplace jural relations (Fortes 1961; 1965) that, unless intentionally redesigned, outlived any individual person's incumbency in them.[85] These matrices grounded nuclear professionals' thinking about their career trajectories and helped give form to futures and pasts. They iterated distinctions like these to rank and group themselves and others by chronological age, maturation stage, coming-of-age cohort, and status authorization. They iterated them to make judgments about colleagues' qualities, experiences, and talents. They iterated them as bases for narrating how nuclear energy worlds had experienced, were experiencing, or will experience change.

Positioning personnel temporally in generally agreed-upon constellations of roles, nuclear

[83] This revealed how elder working-retirement experts' insights were valued more highly than they perhaps would be from their counterparts in more rapidly changing industries (like Silicon Valley or ICT companies) in which information about how operations were conducted, say, thirty years ago would not be so integral to future business-as-usual—however interesting such details be from an oral history perspective.
[84] This reminded elders that, to borrow words from anthropologist Andrew Strathern, "death does not mean the ending of obligations, but their renewal and sometimes their amplification" (1981: 22).
[85] Given that these distinctions preceded and outlived informants' incumbencies in their workplace roles, they positioned them as part of what could be described anthropologically as a system with "replacement as a central mechanism" for steering the "life trajectories" of its constituent objects and individuals (Weiner 1980: 83). Workplace role templates could therefore be understood as loosely akin to what Fortes might have called a "matrix of social relations" that outlasts the human incumbents in them and thus persists across generations (1965).

professionals established formal grounds from which to tell stories of how various nuclear energy sector ideas, patterns, or conventions had emerged and maintained (or had failed to do so) across decades and centuries. They articulated intergenerational flows of human capital in ways reminiscent of how anthropologists elsewhere articulated issues of succession, social reproduction, or inheritance.[86] To borrow words from anthropologist Christopher Gregory, the nuclear programs aimed to create "conditions necessary for the self-replacement of both things and people" across generations (1982: 29). To borrow words from Annette Weiner, they sought a "dimension of reproductive potential" for nuclear energy's multi-decade and centurial horizons by facilitating the "regeneration of persons, objects, and relationships" through extensions of "social relations beyond one's own lifetime" (1980: 71-73, 79-80). While my informants used less arcane terms, they often self-reflected on how nuclear sector HR peopling, knowledge transfer, technologies, and professional roles entangled in patterned ways to form the ascent and descent relations that connected, but also differentiated, their roles across time. This individuated professional persons while collectivizing the nuclear sector as a sector.

Iterating role templates gave clearer form to how nuclear sector personnel regeneration proceeded across decades and centuries.[87] They became most visible when interpersonal frictions unfolded around, across, or within them. Biologically older insiders could, for example, feel miffed when biologically younger colleagues were promoted above them in workplace hierarchies. Fresh recruits or student interns could feel a certain accomplishment when they

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[86]See e.g. Cole & Durham 2007; Fortes 1961; 1967; Gusterson 2005; Kopytoff 1971; Lamb 2015; Wagner 1986; Weiner 1980. See also Curet's reflections on different "forms of transmission" – "succession," "inheritance," "descent" etc – for "passing down social or material resources from one generation to the next" (2002: 261).

[87] This intergenerational awareness unfolded in a way antipodal to what Woodburn has described as immediate-return hunter-gather socio-economic organizations (i.e. those he described among Africa's !Kung and Pygmy groups) in which inheritance, succession, and intergenerational property transmission mattered little (1982: 207). Unlike contemporary delayed-return societies – like those that harbored nuclear energy – immediate-return orientations showed "little concern with ensuring continuity of the human group itself" or the "replacement of its personnel" (Bloch & Parry 1982: 7).

discovered weaknesses in their more-educated, more-experienced superiors' work. Younger insiders could feel great jealousy when outperformed by even-younger colleagues. Some could react by gossiping childishly. Baby boom generation experts, not reared with today's advanced computer technology, could get frustrated when they struggled to adopt new programs that digital-native youths picked up with ease. Yet the dictates of physically older, more experienced, or higher-status professionals – maturity levels notwithstanding – were still heeded more readily than those of less-established counterparts.[88] At the same time, younger counterparts were more likely to be given second chances if mistakes were made.[89] Yet any nuclear professional could iterate these formal distinctions when engaging with workplace questions about the identities, relations, and hierarchies of nuclear colleagues, coworkers, employers, and employees across generations.

Focusing on these role templates, which had been iterated and reiterated over the decades, helped me track how nuclear organizations achieved coherence amidst uncertainties about nuclear professional worlds' future personnel demographics. Following them ethnographically revealed subtle quasi-anthropological commentaries on workplace aging, status, and succession already alive in nuclear worlds. It revealed, to borrow words from anthropologists Cole & Dunham, how "relationships across space and time are enabled" to impel "continuity across time" and a "regeneration" of nuclear energy sector worlds (2007: 3, 17). Nuclear professionals entered, occupied, and then retired from such widely agreed upon professional positions year in and year

[88] This was in part symptomatic of how old age is, in contemporary societies, "marked by declining physical and mental powers but very often counterbalanced by high generational status" (Fortes 1984: 107). Complaints of less-than-meticulous or forgetful older experts of high rank, for example, emerged in ethnographic encounters with certain Safety Case insiders.

[89] Most of these dynamics were not unique to the Finnish context or to even nuclear energy worlds. They could also resonate with events, for instance, in academic anthropologists' professional lives. They could thus be understood broadly as frictions that emerge from how "generational structure also expresses a continuum of authority" (Kopytoff 1971: 132).

out. Workplace role templates were conditions for the existence of – or prerequisites for, grounded foundations for, or constitutive elements of – nuclear professional life and, by extension, also the deep time-reckoning expertise engaged directly in Chapters 3 and 4. Exploring how informants thought in and about them, the next session explores ways their thinking patterns were inflected with terminologies from various sociological and management studies of tacit knowledge, organizational memory, and knowledge transfer that had been commissioned by nuclear institutions inside and outside Finland.[90] It argues that, amidst nuclear professional workforce hiring and retiring uncertainties, switching focus from tacit knowledge transfer to talent pool formation can become useful for social scientists.

From Tacit Knowledge To Talent Pools

Nuclear professionals tended to personnel regeneration patterns as logistical challenges, as human capital training challenges, and as human resource imperatives. In Finland, they were engaged through social scientific tacit knowledge rubrics showing how on-the-job mentoring relationships, face-to-face apprenticeships, documentation practices, and knowledge-sharing databases could bolster intergenerational professional workforce continuities (Hyttinen & Rintala 2004; Rintala & Kuronen 2006). The Finnish Research Programme on Nuclear Power Plant Safety (SAFIR), for example, developed pan-nuclear-sector projects on "managing safety culture throughout the lifecycle of nuclear plants" (See Oedewald & Gotcheva 2015), on "sustainable and future oriented expertise," and on "disseminating tacit knowledge and expertise in organizations" in its "Man, Organisation, and Society" projects (Ehrnstén 2014; Räty & Puska 2006: 323). As in many other nuclear energy professional contexts (e.g. Tipping 2010: 833), tacit knowledge had become so well established as a lens for analyzing intergenerational transition

[90] See e.g. Eng 2015; IAEA 2002; 2004; Lehtonen 2011; NEA 2012.

that it appeared both (a) as an etic category in academic social science literatures I could draw upon to frame my analysis and (b) as an emic category field informants deployed to conceptualize their own long-term knowledge transfer processes in nuclear energy sector reports. To simply apply the tacit knowledge concept to my field materials would generate redundant commentary preaching to at least these two choirs.

Finnish nuclear programs contracted with social scientists to better understand their organizational memory issues. They deployed the tacit knowledge concept. In a sense, this went full circle between social scientist and physical scientist worlds. When originally developing his notion of tacit knowledge more than a half century ago (2009 [1966]), Michael Polanyi drew upon his time as a physical chemist to critique philosophers of science preoccupied with method. Tacit knowledge is now a common STS analytic. Yet certain engineers, scientists, and managers I met were unsatisfied with how the social scientific reports simply presented information that was, as one nuclear waste expert put it, "already common knowledge." They were unimpressed when social scientists presented it to nuclear engineers or managers as, to use his words, a "scientific result." A Finnish KYT scientist once told me about the importance of *hiljainen tieto* ("quiet knowledge") in Safety Case projects. An PhD-holding SKB expert in her late twenties told me she had been suspicious of anthropologists' intelligence since she had to read a "pointless, simple, and obvious" Anthropology 101 textbook when in college in the U.S.[91] Other informants informally discussed embodied, experiential, unconscious knowledge in familiar ways. This revealed a reflexive mode of second-order knowledge practice key to how they navigated and articulated uncertainties.

[91]This SKB geologist also noted how "just writing the most liberal thing you can think of" was the best way to get an A in her Anthropology course. This, to her, detracted from its legitimacy as an academic field. She herself was on the left of the political spectrum too.

Most informants I asked agreed that the tacit knowledge concept had benefitted nuclear worlds overall. It had helped steer professionals toward auto-analyzing how nuclear knowhow can be best transferred through live, continuous, expert-to-expert instruction. It had helped them see what determined the successes or failures of projects to, say, replicate experimental results across laboratory settings (cf. Collins 1974) or disseminate technology designs within and across expert cultures and even enemy lines (cf. Vogel 2006). It had illustrated how nuclear knowledges can appear and disappear over time, depending on how they had been inscribed, maintained, and transferred between early- and late-career insiders across generations. It had shown how nuclear habits, intuitions, and understandings variably accumulated or eroded. It had called attention to how knowledge continuity problems can sprout up when nuclear institutions grow or shrink in scale, reorient in direction, or change their focus. It had underscored the importance of non-quantifiable non-verbalizable nuclear knowhow. This was all fruitful.

But tacit knowledge was simply not my informants' conundrum anymore. They already knew that problem well from their own workplace programs based on the concept, which were often inspired by past social scientific articles that had already been well-disseminated. What they needed were not diagnoses but cures: tools to optimize intergenerational continuities and strategies to cultivate pools of talented young STEM recruits.

I encountered even more negative sentiment when I returned to Cornell University in 2014. When I mentioned the tacit knowledge term to an American nuclear engineering professor, he responded that "yes, yes, yes… we know: experience matters." He associated tacit knowledge studies with "anti-nuke types." His exposure to tacit knowledge was not through workplace programs like SAFIR, but from encounters with critical STS scholars on campus. Those scholars were influenced by, for example, how Gusterson showed how U.S. nuclear weapons expertise "simultaneously matured and withered" across three generations as it "involuted" from a charismatic, informal, smaller-scale crew of young scientists making breakthroughs into a more formalized, bureaucratic, regimented institution making less-substantial incremental improvements (2005: 75). His analysis of how "neophyte weapons designers learn and elaborate their life's craft" (78) referenced tacit knowledge (87, 91, 97) and presented a vivid account of the changing organizational conditions experienced by nuclear weapons insiders over the generations. STS scholars had also been influenced by Donald MacKenzie and Graham Spinardi's work on how – even while textbook or written knowledge of nuclear expertise might endure across generations – the nuanced habits, skills, and tricks-of-the-trade needed to effectively build a working bomb might decay if not passed-down through continual practical application (1995). Analyzing how nuclear weapons knowledge "embodied in people rather than words, equations, or diagrams" waned during test bans and bomb design stoppages, they had provocatively asked whether nuclear weapons could, in some qualified sense, be uninvented (44).

Such studies have provided vital glimpses into how nuclear organizations and nuclear knowledges took shape across the decades. Many social scientists and nuclear organization intergenerational continuity programs have wisely followed their leads. But the tacit knowledge concept's influence came at a cost during fieldwork. For those associating it with critical scholarship, it could wedge distrust between ethnographer and informant. For those associating it with workplace programs, it could deflect attention from other crucial ways that nuclear energy personnel regeneration attained more intelligible pattern. The applied institutional studies the tacit knowledge concept inspired focused on knowledge transfer practices among *already hired* experts *already working* for already established nuclear organizations. In so doing, they took the cast of characters peopling the nuclear knowledge transfer contexts they studied as given. This could obscure (a) how, why, and from where STEM youths had initially been drawn to positions in nuclear sector role templates and (b) intergenerational realignments in the personal outlooks, industry incentives, and societal channels that drew STEM youths toward nuclear professional careers. The neophyte dispositions, ethoi, and personality profiles most attracted to, or most incentivized by, nuclear careers changed over time. This was key to nuclear energy insecurities about whether the best and brightest STEM students are really attracted to nuclear careers anymore.

Reaching too hastily for the tacit knowledge concept – and the comforts of its familiarity as an analytic – could obscure the subtle societal channels that fed nuclear sectors with human capital year-to-year. Ethnographically, these were accessible through conversations about informants' personal historical-biographical backstories. Their reflections resembled histories of the present (cf. Bunzl 2004): nuclear professionals fleshed out the historically contingent means through which knowledge transferers and transferees, and the institutions they inhabited, materialized. Doing so revealed how they initially came to people STEM talent pools. It revealed subtle nuclear energy regeneration patterns set in motion long before any expert even considered a nuclear career. Informants saw loosely grouped generational cohorts as diverging in their overall tendencies and personal predispositions. These auto-analyses were key to sculpting nuclear energy regeneration patterns' contours. Such questions piqued informants' interests more so than more familiar tacit knowledge questions about how organizational arrangements, pedagogical relationships, unconscious cues, interpersonal dynamics, or relations between institutions shaped knowledge transfer situations.[92]

An analytical switch from tacit knowledge transfer to talent pool formation backgrounded micro-scale interpersonal dynamics among already-arrived workplace role performers and foregrounded broader personnel regeneration patterns that helped constitute the pre-career persons who came to be fed into nuclear energy expert worlds as human capital in the first place. It offered an alternative route into nuclear sector intergenerational change attentive to (a) how the persons who came to inhabit nuclear expert worlds were influenced from birth by broader generationally shifting structures of feeling, ideologies, and sensibilities set in motion long before they even learned what nuclear energy was, (b) how these forces helped grow distinct-but-always-shifting arrays of young persons with particular tendencies, dreams, and aversions, and (c) how these propensities affected who ultimately came to pursue nuclear energy careers and why. Exploring these questions with Finnish nuclear professionals and ENYGF and WNA attendees revealed an unfortunate blind spot: tacit knowledge studies too often ignored how, why, and where nuclear professionals' pre-career personalities, aspirations, and political outlooks have changed, are changing, or will change over the decades. To miss the ways nuclear insiders' pre-career milieus had been reshuffled was to miss essential backdrops to present-day deflated youth enthusiasm for nuclear technologies and mass baby boomer retirements.

Analyzing talent pool formation and workplace peopling processes reveals nuclear energy personnel regeneration patterns' sensitivities to changing nuclear human capital conventions, changing personal sensibilities, changing recruitment/retirement patterns, changing political acceptability, changing population demographics, and changing industry human resource preference trends have shaped and reshaped nuclear sector talent pools across decades. In this

[92]Topics on this list comprise the academic foci of e.g. Collins 1974, 2001, 2010; Polanyi 2009 [1966]; Vogel 2006.

spirit, the following sections analyze nuclear insiders' backstories as routes into denaturalizing how nuclear professional role templates have been peopled with human capital across generations. It acknowledges how, if the world were to be set up differently, different people would become nuclear insiders and, consequently, different dynamics would steer nuclear knowledge transfer processes.[93] The next section explores these workplace peopling patterns by engaging with ENYGF and WNA event attendees' auto-analyses of the nuclear sector personnel regeneration challenges they faced.

Peopling Nuclear Energy Professional Worlds

At the time of 2013's ENYGF and WNA events, many universities in North America and Europe considered downsizing or even closing down nuclear energy-related degree programs. Some responded to reduced student demand, high instruction costs per student, decreased state funding, or concerns about liabilities associated with having nuclear materials on campus. Others simply wanted to withdraw from bulky pricey Big Science departments – like space science, plasma physics, or nuclear engineering – and move toward less expensive and more lucrative Information, Communication, or Computer Sciences departments more in line with the perceived societal demands of the times.[94] Still others were deterred by a sense that nuclear energy had become uneconomical in a neoliberal commercial framework.[95] Nuclear renaissance dreams

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[93]The spirit of this inquiry is thus, to channel Cole & Durham, to tap into the "mutually constitutive interplay between intergenerational relations and wider historical and social processes" (2007: 17).

[94] That being said, an American nuclear engineering professor once emphasized how undergraduate interest in nuclear had (a) rebounded greatly in the West since its post-Chernobyl early-1990s drop in favorability and (b) had never dropped as dramatically as it had among the university administrators that controlled nuclear academic programs' purse strings. The insight here is that that university administration support for nuclear programs and university student interest in nuclear programs are not always functions of one another. There can be skepticism among the former and zeal among the latter. Further, some campus research reactors were being revitalized like the TRIGA reactor program at University of Maryland.

[95] The worry was that it had become only tenable in places with strong sovereign support for military-style government reactor purchasing as in, for example, China. As one Areva USA insider put it, its difficult today for a

were being sapped. Yet some nuclear optimists remained warm to how, amidst all this, twenty-first century anti-nuclear students had become increasingly less likely to be dogmatic, nature-fundamentalist, deep-ecology-influenced environmental activists and more likely to oppose nuclear energy on more pragmatic, cost-benefit, risk-reward oriented grounds.

Young nuclear recruits were also increasingly gaining experience less at traditional universities and more at industry-funded private institutes linked to academia through, say, the World Nuclear University (WNU) network—formed by the WNA, the IAEA, the OECD Nuclear Energy Agency (NEA), and the World Association of Nuclear Operators (WANO).[96] This was part of a broader move away from government subsidized university training and toward privately sponsored training in many Western locales. Meanwhile, early-career professionals increasingly attended international networking and knowledge-sharing events like the biennial International Youth Nuclear Conference (IYNC).[97] National initiatives like the UK's Nucleargraduates, founded in response to how the "need for suitably skilled graduates from the UK is greater than ever," sought to attract talented young adults to nuclear energy careers. Industry education centers like these were increasingly where nuclear energy insider personhood was nurtured, where tricks-of-the-trade were inscribed, and where the conventions of

company to justify saying, "Lets invest in a new reactor design now, break even in forty years, and profit afterwards!" in an environment in which future state subsidy support cannot be assumed.

[96] WNU described itself as a "worldwide network of educational and research institutions engaged in peaceful uses of nuclear energy… WNU offers a range of unique nuclear educational and training programmes around the world, organised by the WNU Coordinating Centre in joint collaboration with members of the WNU network. By drawing on the support of industry, governments and academia, these programmes are designed to meet the training requirements of international nuclear professionals, particularly in the area nuclear leadership. As of June 2014, over 4000 participants from over 60 countries have attended WNU programmes" (WNU 2015).

[97] The IYNC described itself as a "global network of the future generation of professionals in the nuclear field… The primary purpose of the Congress is to transfer knowledge from the current generation of leading scientists and engineers to the next generation" (2015).

professional relating were learned, taught, and tweaked by the neophytes adopting them.[98] This formed STEM persons into personnel that fit more neatly into nuclear professional life-courses.

Other ENYGF and WNA event attendees pondered why STEM neophyte talent pools might be skeptical of twenty-first century nuclear careers. Some, they noted, rode shale gas and fracking hiring waves in the U.S. Others – in, for example, Sweden and Germany – had been deterred by past national nuclear energy phase-out decisions. Still others associated nuclear energy with nuclear weapons and, by extension, with a bygone Cold War past.[99] Indeed many across North America and Europe had come to see nuclear energy as more contemporary, on an imagined historical-modernization axis, with the developmental stages of emerging economies like India or China—which only recently saw nuclear energy surges akin to those service economies like the U.S., the U.K., South Korea, Japan, Germany, or France had seen in past techno-optimist macho-modernist heydays. Many youths dreamed not of stable, settled, long-term jobs as company man or company woman lifers at a single nuclear power facility, but rather of more globetrotting cosmopolitan careers working many different jobs in many different places. Today's personnel were seen as more likely to hop into, out of, and between various role positions in different facilities in different locales—sometimes in different countries. This was seen as a key cross-generational schism.

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[98] Nuclear education centers like these could be described anthropologically as sites where nuclear neophytes "constitute and dissemble themselves" through a "collective ascription and attenuation" of credentialed nuclear professional "personhood" (Kaufman & Morgan 2005: 318).

[99] Masco's work on the "technological cryogenics" and nuclear "weapons gerontology" work that emerged in the post-Cold War period usefully gets at the associations of oldness or pastness that have saturated nuclear technologies of many kinds: "Instead of continuing the evolution of the bomb through new warhead designs, weapons scientists have become gerontologists, involved in studying how nuclear weapons age… If the Cold War program speeded up time through constant production, as scientists rushed from one test to the next, the immediate post–Cold War project became to slow down time, to prevent nothing less than aging itself… a kind of technological cryogenics in which both bombs and the knowledge of bomb makers could be put into a deep freeze at 1992 levels, to be thawed in case of future nuclear emergency" (2004: 11).

A middle aged ENYGF speaker urged his colleagues to wise up to how young generations' lifestyles, aspirations, and values differed from those that came before them. He described how today's young talent want a "big paycheck," for their boss to tell them they are "the most famous expert in [their] field every day," to have flexible hours, and to be given smartphones and other gadgets. Few young professionals, he said, now "imagine staying in one position in one spot for thirty-four years" and prefer "rotation and movement" between work locations. They also, he smiled, "never sleep." They work hard, drink Red Bull energy drinks, play video games, and go salsa dancing late into the night. Responding to this tactfully could help improve "talent pools" during nuclear energy's current "public acceptance crisis." Young professionals from Europe or North America, he tried to make clear, are not as likely to be inspired by the static, stable, company-person, settled-down, lifer positions that are necessitated by nuclear power plants' multi-generational or centurial project horizons. STEM youths did not dream of finding themselves a spot in existing recruit roles and, from that spot, simply climbing to higher-status positions at the same facility or organization as years passed. Young recruits thus had to be baited by the cosmopolitan perks of attending international conferences, by possibilities to work at many different facilities throughout their lives, and by periodic technical tour trips to nuclear facilities in countries far and wide.

Young nuclear professionals at the 2013 ENYGF event in Stockholm.

Yet not all young professionals had to be lured into nuclear careers. Some – disheartened by, say, China's twenty-first century embrace of cheap polluting coal power or Germany's nuclear energy phase-out decision – were almost evangelical about nuclear energy's climate change mitigation potential. Companies like GE-Hitachi, Areva, Westinghouse and scientists at, for example, U.S. national laboratories dreamed of commercializing new breeder reactor designs. Others thought nuclear energy's appeal would return once energy demand recovered, in more locales, from the major electricity market collapse that followed the 2007-2008 global financial crisis. Some thought more governments would realize the advantages of subsidizing nuclear as a clean energy technology alongside hydro, wind, and solar. Others were enthused about Generation IV reactor technologies like SMRs, which – with their more decentralized, smaller-scale, flexible characters – seemed, to many nuclear youths, more in line with the times. Still others dreamed of future commercialized liquid-metal-cooled fast reactors, high temperature gas-cooled reactors, and molten salt reactors. Others lauded nuclear's power to combat energy poverty: "the state of not being able to charge a phone, study by lamplight, or refrigerate a vaccine" (Eaves 2017: 27).

At the 2013 WNA Symposium in London.

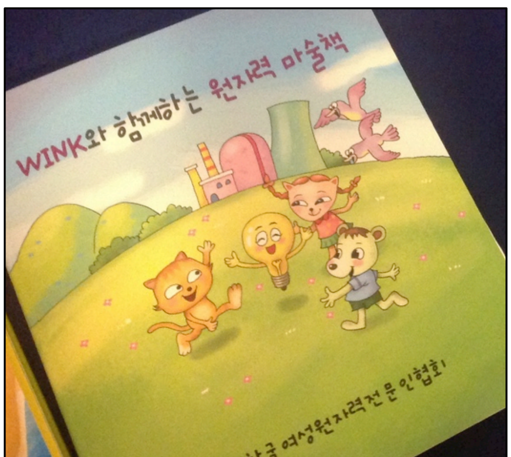
Such energetic advocates inhabited an industry with a "weird generation gap" in which there were few mid-career nuclear engineers: few across North America and Western Europe had pursued nuclear careers between the 1980s and early 2000s when new reactor projects were often haulted or failed to take off.

Insiders spoke of a “missing generation” (Eaves 2017: 28). Many elders saw more optimistic nuclear neophytes – especially when ambitious, enthusiastic, and talented – as the key to peopling sharp twenty-first century nuclear energy talent pools. Some advocated recruiting more outgoing, personable, energetic young technicians, engineers, and scientists. Doing so, a nuclear youth exclaimed in an ENYGF Q&A session, could “inspire a generation.” Another hoped, in a similar vein, that more of his peers would “come out of the closet” by projecting “pride” in their nuclear work among skeptical friends, family, and acquaintances. The figure of the young extroverted nuclear recruit – framed in opposition to the eccentric, lab-coat wearing, aloof nuclear insider stereotype of past generations – was heralded at ENYGF and elsewhere. It indexed a team-playing disposition to which senior nuclear experts, managers, and human resource professionals increasingly gave preference in hiring decisions. Such young blood was thought to enchant nuclear energy with a lively twenty-first century flair at a moment when it was increasingly relegated in public minds to backwards Cold War military-industrial complex pasts.[100]

At the London WNA symposium, I met two such twenty- or thirty-something, outgoing, jet-setting, pro-nuclear nuclear youths. They had recently visited UK elementary schools to educate students about nuclear technologies. They aimed to push back against teachers and parents who tell kids that nuclear energy is “somehow bad.” They and the children made paper models of

[100] Such valuation of extroverted expertise paralleled what a fifty-something Finnish nuclear waste expert once told me about the growing emphasis on “people skills” and “leadership skills” growing among hard science hirers in Europe and elsewhere. This phenomenon is likely not confined to nuclear energy worlds alone. In his words: “To make it in science these days you really have to be more of an extrovert. You’ve got to talk more. Once you could be the eccentric mad scientist who does things nobody understands. Now it doesn’t work like that. You cannot hide in your tower of expertise. You have to get funding. You have to know how to talk to the bosses who are, increasingly, not scientists. You have to understand their buzzwords, their code words, know their vocabulary, and use their dictionary. You must use the words they love in order to get funding. But, still, the gap between the scientists and the bosses is real. If you start using the terminology of the bosses too often, you might lose your credibility in your field among more competent scientists” (Ialenti 2014b).

nuclear power plants with tiny spinning mirrors in the reactor area representing particles darting about. I then met Suzy, the twenty-something daughter of an American nuclear engineer. Suzy had been touring and reporting with zeal on nuclear facilities around the world in her industry-sponsored *Diary of a Nuclear Tourist* blog. She told the London audience about "art as a tool for social engagement" to forward pro-nuclear causes. She also discussed her *Nuclear Literacy Project*: an industry-sponsored "outreach initiative geared towards reaching young, non-technical audiences with information about nuclear energy" (Hobbs-Baker 2013; Nuclear Literacy Project 2015). In London I also learned of WNU's 2011 International Nuclear Olympiad—which was, according to a print-out, a "contest for university students around the world to research and develop a plan for gaining public acceptance of nuclear energy in their country" and to "test messages that will help overcome adverse opinions."



South Korean Pro-Nuclear Children's Book "The Magic Book for Nuclear Power" at 2013 WNA Symposium in London.

Such charismatic early-career professionals were seen as catalysts for instilling pro-nuclear sentiment in even younger generations. They therefore became agents of a broader, global intergenerational promotion initiative with message discipline reinforced in gatherings like the WNA and ENYGF events. This was seen as a way of taming intergenerational recruitment and succession uncertainties. I encountered material artifacts of such initiatives in London, Stockholm, Finland, and elsewhere. One example was a Korean pro-nuclear book for children. On its cover were friendly animals dancing around a light bulb in front of a nuclear power plant. Another example was the brightly colored French-language nuclear trivia cards reminiscent of the English-language nuclear power plant trading cards I saw previously in Finland. The early-life encounters with science, technology, and nuclear energy that these promotion tools facilitated were thought to subtly affect certain youths' future openness or closedness to nuclear energy careers. This openness versus closedness played an important role in forming the talent pools that impelled nuclear energy regeneration.

The ENYGF and WNA events showed how youths' life aspirations, ideas about nuclear energy's promises and perils, and political sensibilities helped determine who came to be steered toward nuclear energy careers and why. These personnel regeneration forces determined who ultimately came to sit down at the nuclear knowledge transfer tables analyzed by social scientists and nuclear sector insiders alike. With this in view, the next section examines the particularities of Finland's nuclear energy talent pool formation dynamics—the processes that have peopled workplace role templates year in and year out. It does so by tapping into how generational shifts in hiring/retirement demographics, neophyte ambitions and lifestyles, relations between professionals at different career stages, and human resource approaches took shape. This accounts for how perceived differences within and between Finland's generation cohorts' outlooks, sensibilities, and personalities were thought to affect peopling processes impelling nuclear power generation. That is, it looks at how the typical profile of someone who came to inhabit Finland's nuclear workplace role templates had changed over the decades amidst shifting population, societal, and nuclear energy enthusiasm patterns.

Peopling Finland's Nuclear Energy Professional Worlds

Finland began its foray into nuclear energy in the 1970s. Posiva's nuclear waste repository was, at the time of my fieldwork, slated for decommissioning in 2120. That necessitated project continuities that extended more than one hundred forty years after Finland's first nuclear energy projects began. To put this into perspective: one hundred forty years before, Finland was a Grand Duchy of the Russian Empire. It had since seen its independence and birth as a nation-state, a vicious civil war, two world wars, Soviet Union offensives seizing territory Finland claimed as its own, difficult economic recessions, and the rise and fall of the global ICT giant Nokia. As with elsewhere in Europe, one hundred forty straight years of peace, prosperity, and stability would, for Finland, be difficult to come by. Yet societal infrastructure steady enough to regenerate generation after generation of specialized nuclear professionals was, like elsewhere, required still.

On top of this, the profiles of workforces needed for reactor or repository projects' R&D phases, construction/licensing phases, operating phases, maintenance and retrofitting phases, and closure/decommissioning phases were not the same. Each phase required the enlistment of differently composed groups of technicians, managers, scientists, quality control staff, nuclear engineers, operators, environmental monitors, regulatory compliance professionals, and so on. Chapter 4, for example, briefly examines how Posiva's transition from its construction license application phase to its operating license application phase – a stepwise decision-making template that emanated from STUK's and TEM's requirements – necessitated a transition from Posiva acting mainly as a repository R&D company focused more on conceptual work to a repository "implementer" company focused mainly on the logistics of building and maintaining the Olkiluoto facility. With that in view, some Safety Case experts noted how, once Posiva receives an operating license in the 2020s, the emphasis Posiva will place on revising the Safety Case every fifteen or so years will be lowered until the period leading up to the next major licensing phase: decommissioning circa 2120 (See Interlude section). Indeed, nuclear energy and waste facilities' long lifecycles and evolving life-courses required flexible workforces that could be re-composed over time. These timespans were lengthened by how Finland's four operating reactors' waste had to cool for forty years before final disposal. Olkiluoto 3's spent fuel would have to cool for roughly sixty years first before permanent burial.

Finland's nuclear energy companies, facilities, consulting firms, laboratories, agencies, associations, universities, and institutes implemented intergenerational continuity instruments in ways continuous with their correlates abroad. They, for one, participated in worldwide long-term failure analysis databases: collaborative catalogues of malfunctions, accidents, and incidents reported from nuclear facilities across the world to assist current and future generations informationally if related technical problems are to arise. Companies such as Posiva set up knowledge management systems in which data, reports, findings were recorded, indexed, and archived digitally for the long-term. KYT experts developed knowledge transfer initiatives cultivating mentoring and collaboration relationships between fresh recruits and outgoing seniors. Elder Finnish professionals were nudged toward keeping their own mortality horizons in view—toward planning for their own eventual departures, replacements, or erasures.[101] This aimed to instill in later-career experts ethics of guided career self-closure. It also aimed to instill in neophytes openness to their senior counterparts' guidance.[102] In so doing, it endowed complex nuclear energy regeneration with more predictable pattern.

Yet Finland's nuclear professional worlds were rife with idiosyncrasies mediating how its STEM

[101] This could be described anthropologically as effectuating long-term relations "produced and reproduced in anticipation of an inevitable end"—in this case, of an end of one's own career and life. Continuity was achieved by forging an intergenerational professional ethic "opposed" to death and the "consumption and extinction of relationships" (Wagner 1986a: 177).

[102] An anthropologist might interpret these continuity techniques as opposing, transcending, or mitigating expert deaths' or retirements' adverse effects. Indeed they were, in some sense, about achieving ongoing intergenerational "renewal of life" through a "denial of individual death" (Bloch & Parry 1982: 36). Chapter 5 addresses this in greater depth.

youth talent pools coalesced and how, when, and why its senior insiders entered retirement. Finland's workplace role template distinctions between younger/older, senior/junior, recruit/retiree, student/pensioner were, for example, made distinctly explicit at *Suomen Atomiteknillinen Seura* ("Finnish Nuclear Society" or ATS) events. ATS' Young Generation Working Group organized activities for "young people (under 35 years of age) who are interested in [or already members of] the nuclear field" to "ensure the knowledge transfer between the generations and to promote networking between young people" (ATS 2011). It worked to "motivate, educate and unite the young professionals and to ensure continuation of the nuclear field in Finland." It pursued this by, for example, co-organizing joint mixer events with its counterpart ATS Seniors Working Group. It also set up playful annual Summer Sporting events – with lively, satirical, sometimes-edgy social games toying with imageries of Finnish national culture and nuclear risk – to facilitate networking among Finland's younger nuclear energy insiders (Ialenti 2015). Meanwhile, workplace hierarchies and generational positions appeared to flatten temporarily at ATS general meetings held for members of all career stages. As a Finnish nuclear waste canister expert in his sixties once told me, ATS general body events were where Finnish nuclear workers socialized as "relative equals": where distinctions between employer/employee, student/pensioner, senior/junior, or recruit/retiree could dilute into what anthropologist Victor Turner might have called the communitás (1966: 96-97) of collective camaraderie. This subtly smoothed the cross-generational workplace relations upon which effective knowledge transfer was grounded. It helped form persons into personnel inhabiting professional roles laid out according to accepted constellations of professional duty distinctions.

Finnish nuclear insiders' intra- and intergenerational bonds were also tightened by their similar enculturations as *teekkarit* (techies) when undergraduates at Finland's technical universities. The *teekkari* notion evoked, for informants young and old, imageries of intoxicated students wearing brightly colored overalls – their colors representing their respective technical fields – celebrating boisterously in Helsinki's streets during Finland's May Day celebration *Vappu*. Related imageries pertained to *teekkarihuumori* (techie humor), to good-natured *jäynä* pranks reminiscent of what MIT tech student tricksters might call “hacks,” or to the irreverent – if not downright politically incorrect – contents of *Äpy*: Finnish tech students' irreverent Vappu publication.[103] Others associated *teekkari* culture with the collective, often mildly embarrassing, initiatory hazing rites that greeted flocks of first-year *fuksit* upon entering university. A Finnish nuclear expert’s time as a *teekkari* was his or her gateway into nuclear expert neophyte personhood—a formative rite of passage into a nuclear workplace role position.

***Teekkarit* on Vappu (Walpurgis Day) in 2014.**

Shared past *teekkari* identifications could also foster amities transcending generational divides. This was evident when a fifty-something physicist and engineer spoke nostalgically of how he and his fellow *teekkarit* had devised clever ways of brewing, storing, and distributing moonshine and wine in their student living quarters decades ago. A sixty-something Posiva manager likewise spoke nostalgically of raucous Saturday-night parties held upstairs in the Helsinki pub-restaurant Manala in the 1970s. Informants of many ages relayed how 1960s Finnish *teekkarit*, aware of plans to raise the sunken seventeenth century Swedish warship Vasa

[103] Such *teekkari* tricksterism, often laden with silly but technically literate themes, must always – I was often reminded – be harmless and never mean-spirited.

from the Baltic, placed a statue of legendary Finnish track athlete Paavo Nurmi on the submerged ship. This surprised spectators, in a *jäynä* mode, when the ship was lifted from the sea. A retired Finnish nuclear expert told this story to nuclear youths from across Europe in an ENYGF banquet speech. Such lighthearted elder-storytelling bolstered community sentiment across *teekkari* generational divides.

Teekkarit often defined themselves in opposition to *humanistit* ("humanists"). This boundary-work and Othering was thought to tighten their cohesiveness of the group. This worked both ways. Certain Finnish humanists and social scientists I knew, for example, rolled their eyes at elements of *teekkari* culture. One described them as "smart in the sense of being able to work with what they have, but lacking in terms of flexible, independent intelligence." She noted how being cloistered into insular *teekkari* communities cultivated narrow worldviews and the sense that "everyone is envious of them." A thirty-something sociologist saw *teekkarit*'s many traditions, penchants for collective affiliations, and socializing requirements as enforcing a normalizing uniformity – "discipline in the Foucauldian sense" – with little room for deviance. A humanist described how, after a few intimate encounters with *teekkari* types, she came to expect from them "efficient but unimaginative sex." Others nodded sarcastically to the corporate sponsor logos, some from nuclear companies like TVO or Fennovoima, emblazoned on Vappu overalls' colorful patches. Still others emphasized how *teekkari* culture's rule-bound insularity – as well as Finnish society's broadly positive or neutral outlook on it – bolstered nuclear energy's efficiency, stability, and popularity. Many Finnish *humanistit* observed astutely how *teekkari* traditions' obdurate, uniform, homogenizing spirits helped inscribe in nuclear neophytes shared modes of relating amenable to working in groups in highly technical careers. It instilled in them outlooks amenable to understanding and fitting into their future workplace roles in ways continuous with generations before them.

Humanistit and *teekkarit* alike, however, would agree that polyphonies of unique perspectives peopled *teekkari* communities: of course, no two *teekkarit* were the same. They noted distinctions in sensibilities along disciplinary lines. A sixty-something Posiva insider described geologists and biologists as generally colder to nuclear energy and warmer to outdoorsy countryside living (nature). He saw engineers and physicists, in contrast, as generally warmer to nuclear energy as well as city life's amenities (culture). A young SKB geologist told me that she saw "scientist mentality" versus "engineer mentality" as the most essential nuclear waste professional rivalry. On top of this, different generation cohorts, however loosely defined they were, differentiated themselves politically. Some saw younger *teekkarit* as overall more apolitical, agnostic, or ambivalent. While more than a few *teekkari* I met indeed seemed comfortably uninformed or unimpassioned about world affairs – rarely were they activists – many had stronger global environmental ethics than did their predecessors. In contrast, many *suuret ikäluokat* ("big generation" baby boomers) Finns were once part of student movements or were *taistolaiset* (Taistoists): advocates of Taisto Sinisalo, a prominent voice in the leftist Finnish People's Democratic League.[104] Others recalled debating Soviet versus American Cold War political positions for years in workplace break rooms. Divergent cross-generational political sensibilities that could spark frictions in relations among established versus neophyte professionals.

[104] While positive associations with *taistolaiset* related to political engagement and interest in the wider world around them, more negative portrayals saw them as dogmatic, naïve followers, or politically manipulable youth.

The ways informants iterated generation cohort, disciplinary, or age differences helped contour nuclear intergenerational dynamics. Some, for instance, made distinctions between generations' intellects. A sixty-something Engineering professor portrayed many of his younger counterparts as overspecialized in their "safe little boxes of expertise" and as less interested in Literature, History, Philosophy, and big-picture thinking about the wider world. He worried that "we are losing civilization" because "we are losing generalists" as "education is getting so narrow": young experts "don't read books or even newspapers," but just "play computer games in spare time." He also worried that these youths would be more likely to be manipulated by irrational (anti-nuclear) political movements. Some retorted that this elder simply felt overwhelmed trying to keep up with changing technological, scientific, or software conventions and hence became defensively dismissive of youths being lazy, incompetent, or unqualified. A sixty-something physicist, as another example, portrayed his own generation as "more afraid that they're not doing what they're supposed to be doing" because they grew up when "punishment" was more common at home and at school. When nuclear professionals differentiated themselves in these ways, they iterated matrices of distinctions between generational cohorts that affected how successions had taken and were to take shape.

An Elder Nuclear Waste Expert's Office Shelves.

A fifty-something modeler told me how digital-native *teekkarit*, while better with mobile phones and computers, would rarely think by "drawing conceptual figures" on paper. They were also less adept at making calculations in their heads. This contrasted with his age cohort, which used "paper and ruler sticks" as schoolchildren. He noted how "the tools you have direct your way of thinking," an insight paralleling anthropological reflections that had been disseminated amongst his generation (e.g. Goody 1977). One of his colleagues concurred that their younger counterparts do not "process their knowledge in their own brains," but use "artificial" computer intelligence. He also saw seasoned experts as "better at thinking outside the box" because they are less apt to believe there are "higher forces" or "superior minds behind all the thinking" taught at university. Experience had revealed to them the tentativeness of scientific knowledge. They became less stubbornly dogmatic in turn. Such intellectual, educational, and political differences between generational cohorts were also thought to mediate relations between usually-older nuclear higher-ups and usually-younger nuclear neophytes. The age, status, and career-phase position distinctions that differentiated these differently minded experts were tools for articulating nuclear energy regeneration patterns among them.

Such differences were connected to divergent views on nuclear energy. Many younger Finns grew up associating their country's nuclear energy ambitions with the big-industry energy needs of "old" Finnish lumber, forestry products, and paper and pulp processing industries as opposed to those of the "new" Finnish ICT, gaming, or software companies that achieved international success from the mid-1990s. To some of them, nuclear seemed more old-fashioned/dystopian than progressive/utopian. Further, younger Finnish experts were seen as having adopted more cosmopolitan orientations than their predecessors. This was attributed to how younger *teekkarit* were far more likely to have lived abroad, especially through EU Erasmus Year university study abroad programs. Their supposed global-mindedness was also attributed to the influx in foreign students studying at Finland's universities that had been picking up speed ever since Finland's

1995 EU accession.[105] Finnish insiders also explained how nuclear sector hiring preferences had changed over time. Paralleling ENYGF and WNA auto-commentaries, an informant described Finnish hirers increasingly warm to hirees enthused to "work in a group, be social, and be a potential leader." They sought a "mixture of quite good grades and a likeable nature." Nuclear hirers, like elsewhere, would not seek out a status quo-questioning young expert averse to sitting down with lethargic, grumpy, or set-in-their-ways retirees for knowledge transfer instruction. Generational change, it was thought, must be kept in check to uphold the slow-moving, hierarchical, conservative currents central to nuclear energy regeneration role configurations across the decades.

When nuclear insiders relayed such auto-analyses to me, they revealed their senses of how Finland's different generation groups have had different sentiments toward nuclear energy's promises and perils, different intellectual orientations, and also different career and lifestyle aspirations.[106] They revealed how they saw generalizable differences between age cohorts – which they acknowledged as polyvocal constellations of unique people – that emerged from generational change, from shared experiences of historical events, and from particular techno-cultural transformations experienced while coming of age.[107] Such was thought to elicit what a social scientist might call a fresh contact (Mannheim 1952 [1927]: 293) and subsequent reinvention of nuclear insider heritage (cf. Wagner 1981). As in other fields, this channeled

[105] Some younger informants were quite proud of this trend. One late-twenties nuclear expert suggested that "foreigners" knew that studying and working in "Finland is a good nuclear credential": its strict regulations and safety culture required all to work "at the highest difficulty level."

[106] Informants, in this way, articulated generational differences between *teekkari* personalities, politics, and lifestyles in ways consonant with sociologist Pierre Bourdieu's sense of how differently minded generational cohorts – themselves variegated with internal differentiations – could be "produced by different modes of generation; that is by conditions of existence which, in imposing different definitions of the impossible, the possible, and the probable, cause one group to experience as natural or reasonable practices or aspirations which another group finds unthinkable or scandalous, and vice versa" (1977: 78).

[107] Informants' interpretations of generational difference thus jibed with sociologist Karl Mannheim's postulate that "mere chronological contemporaneity" among a demographic age-cohort alone could not produce unified generational consciousness (1952 [1927]: 297).

different sorts of STEM youths variably toward or away from entering nuclear neophyte talent pools.[108] It affected the peopling of nuclear professional worlds year in and year out, thereby shaping who would come to inhabit them.

The outcomes of changing nuclear energy generation cohort rosters – in feeding different sorts of neophytes into differently composed talent pools at different times – underpinned all workplace situations, relations, assumptions, and assumptions about one's colleagues' situations, relations, and assumptions. The cast of characters at any nuclear workplace was born of them. *These peopling processes were thus implicitly a pretext to all moments of knowledge transfer*.

Fortum HQ in Espoo, Finland.

In Finland, reflexive nuclear insiders saw these personnel regeneration processes as shaped by continuities and changes in *teekkari* culture, in parental disciplinary styles, in academic field personality difference tendencies, in Finland's socio-politico-economic landscapes, and in adoptions of new technologies. Informant auto-commentaries on these processes showed how forces active long before nuclear neophytes' births fashioned the very persons who would later become nuclear professionals. The next section explores how this mediated the grounds for knowledge transfer processes by examining the

[108] That being said, the intergenerational consciousness informants evoked was still weaker, more flexible, and less precise than that elsewhere. Anthropologists might recall renderings of certain East African groups' generation-set organizations in which the "generation model is extended so widely as to provide the basis for regulating social relationships in an entire society." In such societies, "generational ordering is highly formalized and elaborate" such that "[r]ituals, variations in dress, forms of speech, permitted behaviors, specialized tasks, and places of residence may sharply distinguish one generational group from another" (Lamb 2015: 855). In Finnish nuclear expert worlds, differences in generational character, ordering, and tendency were more open-ended, fluid, and less clearly demarcated.

backstory of Timo—a motivated Finnish radiological protection specialist in his late twenties. It explores how his early career approach to authority, success, and professionalism jibed with Finland's nuclear insiders' cross-generational learning, relating, and human resource conventions. It shows how Timo's openness to having nuclear knowledge continuities flow through him endowed him with upward mobility as a professional. Timo's story is thus set where knowledge transfer processes met neophyte talent pool regeneration processes: a nexus where a younger nuclear insider slipped comfortably into his workplace roles.

Conservative Energy

When I met Timo, he was a young, outgoing, pro-nuclear Fortum professional with leadership ambitions. He attended workplace parties, socialized with nuclear insiders outside of work, spoke up at international conferences, and took his professional responsibilities seriously. Timo had long been inspired by his father's pride in helping build Finland's Olkiluoto and Loviisa nuclear plants in the late 1970s and early 1980s. His father saw these projects as strengthening the welfare, economic viability, technological prowess, and "backbone" of Finland as a whole. He took pride in advancing an immensely complex technoscientific achievement in a country which had, as I was sometimes told, just "come out from the forest" and onto the global scene. Neither father nor son wanted Finland to return to the old days when, to borrow words from a former Fennovoima manager, Finns had to "chop their own biomass in their backyards" to keep warm. Indeed Timo had an almost anachronistic zeal for nuclear energy and Finnish national culture that stood out among many of his more ambivalent or skeptical university peers. His zeal was no discontented nostalgia for an industrial past of lost national solidarity. It was not the cruel optimism of a developmentalist dream. It was an excitement for what nuclear energy could become – as an energy source and as a climate solution – in the future.

In his late teens, Timo was inspired by a "passionate" and "next-level smart" Lappeenranta University of Technology (LUT) professor and her "cool" teaching assistants who "knew all the students' names after the first day." A few years later, Timo was taken under the wing of an extroverted professional in his late thirties who was "friends with everyone" and, warm to socializing and partying, always made sure those around him felt "comfortable." Timo's story was one in which senior role models became vectors of nuclear energy career trajectory path dependence. It indexed how nuclear neophyte career advancement was often predicated on the neophyte first admitting that he or she does not know everything and, second, immersing himself or herself in the worldviews of his or her superiors. Such father, professor, and senior colleague figures became, for a younger Timo, future-ideals for which to strive to become.[109] They endowed his ambitions with forward momentum. His broader disposition toward elders, authorities, or accomplished experts opened him to adopting the knowledge, skills, and habits they sought to inscribe in him. This is not to say Timo was unreflexive or allergic to critical thinking. Quite the contrary: he was a dynamic personality who enjoyed intellectual debate—especially about why he thought others should embrace nuclear energy. What was not present in Timo, however, was the filter of suspicion that nuclear professionals with less-trusting constitutions harbored toward lessons their superiors taught.

Timo's backstory and overall outlook was not unique. A Posiva boss in his sixties, for instance, described a "charismatic" former *lukio* teacher having drawn him from Literature and Language to Mathematics and Engineering decades ago. Other more highly trained informants had looked up to Masters or PhD dissertation advisors. Some had not. More commonly, they showed pride

[109] Timo's tale could be described anthropologically as a case in which the "spatiotemporal dimension of social relations" stretching across generational gaps effectuated "possibilities for the reproduction and regeneration of certain elements of value" (Weiner 1980: 83).

in their doctoral “opponent”: the senior scholar often invited to Finland from abroad to ritualistically play devil’s advocate at their public dissertation defense—serving afterwards as the guest of honor in a *karonkka* dinner alongside the new doctor’s friends, colleagues, and family. Many successful nuclear insiders expressed gratitude about being taken under the wings of respected workplace superiors. Sometimes they expressed this to me in simple spirits of humility: telling me of how their achievements were not theirs alone. Other times it was more about legitimizing their authority by linking their current prowess to past guidance from credentialed predecessors. Yet always it indexed how a tendency toward grateful reception of mentors’ knowledge could render neophytes more likely to achieve nuclear energy career advancement and thus render them more likely to occupy their high-ranking role positions later on. This shaped who came to people given workplace role positions and how.

Enthusiastic Timo was not ashamed to perform this respect for his predecessors and elders. His disposition smoothed cross-generational relations at work. Conversely, if one tended to be suspicious of workplace authority – often sticking his or her neck out or taking unauthorized vigilante actions at the office – he or she would soon realize that nuclear energy might not be his or her ideal career path. Fitting into one’s role position was doubly about knowing one’s place. These expectations sprung in part from the nature of nuclear energy technologies themselves. Nuclear facilities were hierarchical, bureaucratized, tightly regulated sociotechnical assemblages with complex divisions of labor and, therefore, required numerous trained employees to submit to these templates for it to function smoothly. Workplace norms enforcing pyramidal orderings were thus seen as essential. Regeneration relations of this sort, as Wagner has noted, proceed in “essentially conservative” ways (1986: 176)—regenerating defined hierarchies, carefully positioned specializations, and vast distributions of responsibilities comprising bureaucratic structures with quasi-military organizations.[110] Some have thus seen decentralized energy technologies like wind or hydro as more compatible with democratic egalitarian principles than centralized energy technologies like nuclear or fossil fuels (Winner 1986: 32).

Timo excelled by thriving inside workplace role templates that preceded and would likely outlive his incumbency in them. Yet not all insiders were warm to this common trajectory. Some interpreted incentives nudging neophytes toward mimicking their ostensible superiors as explicitly upholding a problematic status quo. A critical Swedish nuclear expert lamented how "conservative" nuclear sector elder shelf positions "keep younger people in line" and enable "myth transmission." A Finnish nuclear waste expert thought mentoring setups often taught young nuclear professionals to "make the same mistakes" their predecessors made. He saw this as especially troubling in today's aging nuclear worlds. His concerns resonated with Auguste Comte's worry that "increases in life span would slow down the tempo of social progress, because the conservative, restrictive influence of the older generation for a longer time" would thwart the "innovating instinct" of the young (Lamb 2015: 518). Too much deference to workplace authority could, in the eyes of skeptics, foster gerontocratic relations in aging industries just as it could in greying societies.[111] Indeed these dual demographic concerns converged for nuclear professionals in Finland's "silver economy" that was said to be aging faster than all EU countries aside from Italy and, worldwide, Japan (Lall 2008).[112]

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[110] Such conservative repetitions, for Wagner, are upheld by a "collective or integrative perspective in which responsibility is assumed for the tasks and replenishment of society at large" (1986a: 176).

[111] For a stimulating discussion of democracy, gerontocracy, and intergenerational issues in twenty-first century aging societies like Finland, see the Meridian 180 Forum Summary "Is Democracy Sustainable in an Aging Nation?" (Lee 2014).

[112] That being said, in nuclear, Finland's retirement age maximums and minimums still maintained (albeit with greater flexibility than in past decades) despite avenues for post-career nuclear experts to teach part-time at universities, work in elder-shelf positions, or do consulting work. This tempered, but did not extinguish, the great influence of elder Finnish nuclear professionals on younger counterparts like Timo. Yet this occurred in a broader context in which, across Europe, the "intergenerational contract devised by the welfare state, according to which the

One could rightly say that Timo excelled at work because he was optimistic, ambitious, personable, and eager to learn. Yet one could also rightly say that Timo climbed the ladder because he regularly performed his esteem for talented superiors. His almost-anachronistic zeal for nuclear power and national progress made him stand out among established elder insiders who felt similarly. Timo was in this way emblematic of a certain type of outgoing young professional – less hesitant to seeing currently established leaders as future selves – preferred in nuclear energy worlds across North America and Western Europe. Timo became this way in part through forces calibrated intergenerationally via changing socio-politico-economic sensibilities, family histories, hiring incentive structures, educational outlooks, and youth life aspirations. He was testament to how certain temperaments – undoubtedly emerging in part from subtle intersections of race, class, gender, and background – fit into nuclear workplace role positions better than others.

Yet Timo's disposition was not the only kind that facilitated the replication of established nuclear workplace conventions, role templates, or status quos. A number of insiders I met were not really energized by their work at all. Some were simply glad to have stable futures and comfortable salaries. Some were content with employment rather than impassioned by vocation. One informant attributed her entire nuclear career to a coincidental job opening that seemed like a good "fit for her degree." A STUK expert, as an undergraduate in the early 1990s, pursued nuclear because saw its post-Chernobyl unpopularity as an opportunity for higher-salary job prospects in a job market of decreased competition. Other informants did not really like their jobs. Some felt overworked and stressed. Others were just a bit bored by numbers, bureaucracy, and office banalities. Some stayed on the job because they felt both competent and comfortable

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elderly withdrew from formal-sector work in order to make way for the young who would support them" had been "breaking down" (Cole & Durham 2007: 20; Greenberg & Muehlenach 2007).

in their positions. Others simply needed the money to support themselves and their families. Mentalities like these upheld nuclear industry continuities by not evoking inspirations to push envelopes at work. A passionate nuclear waste repository Safety Case expert worried that Posiva's hiring patterns increasingly gave preference to unimaginative employee-experts like these. I return to that concern in this ethnography's Conclusion.

Such transmitted iterations of workplace role templates – problematic or positive, adopted by energetic pro-nuclear proselytizers or complacent employee-experts – gave more discernible form to nuclear sector regeneration processes by reproducing patterns of relating, workflow, and knowledge sharing. This made employee-experts feel like but cogs in a grand machine or like operators of big train that plodded forward through the generations—one in which individual experts hopped on or hopped off as decades went by. For Timo-type enthusiasts, however, it let them feel part of an exciting, inspiring, positive immortality project that exceeded one's and one's colleagues' life courses' ephemeralities—instilling in them feelings of being part of something greater than themselves. Yet for all, nuclear energy's larger-than-any-individual-life qualities combined with its individual-death-transcending continuities to uphold certain role templates, routines, and knowledge sharing conventions across generations.[113] This happened in an Atomic Age that (through the bomb) directed intergenerational attentions toward civilizations ending in an afternoon while simultaneously (through nuclear waste deep time-reckoning) toward civilizations lasting tens or hundreds of millennia into the future.

Yet the amount of buzz around, enthusiasm for, or utopianism surrounding nuclear energy – or

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[113] The way grander intergenerational continuities defied death nestled informants in something resembling a Freudian *causa sui* (Becker 1977: 109)—enabling them to inhabit a multiplex institution from which feelings of purposefully transcending human limitations were collectively self-generated.

fear of, anxiety about, or vocal opposition to nuclear energy – was not at all static. STEM talent pools' characteristics thus varied year-to-year. Further, sentiment was known to reverse radically after rupture-events like, say, the Fukushima or Chernobyl disasters. As a consequence, nuclear hirers had different amounts of youth applicant passion, positivity, and proficiency to work with at different places in different times. This set the stage for different professional dispositions, loosely drawn across generational cohort lines, at work. For example, finding inspiration in nuclear energy – something he shared with his father – enabled Timo to relate more easily to his elder workplace superiors and vice versa. Yet such cross-generational relatability challenges waxed and waned over time. To tap into this is to tap into how nuclear neophyte talent pools become peopled with specific outlooks, sensibilities, and aspirations with variable levels of receptivity to adopting knowledge transferred to them from seniors. Such critical distance, or lack thereof, thereby modulated insiders' tendencies toward warmth/coldness, respect/disrespect, openness/closedness toward their cross-generational counterparts. This could solidify or shake the relational foundations grounding smooth knowledge transfer.

Any knowledge management platform or workplace intergenerational continuity technique devised to improve, systematize, or streamline how knowledge was transferred was therefore always already in part at the mercy of different generations' shifting tendencies toward or away from political activism, status anxiety, personal ambition, discipline, comfort with hierarchy, trust in authority, likelihood to take risks, and propensities toward having more formal versus more informal professional comportments. Since these propensities are were in-the-making long before a neophyte entered the nuclear workforce, they were necessarily obscured when analysts focused disproportionately on workplace tacit knowledge transfer or organizational memory without delving into their subjects' pre-career backstories ethnographically. This section's ethnographic accounts have illuminated these blind spots through analysis of neophyte aspirations and STEM talent pool formation processes. The next section concludes by arguing that this analytical switch is especially timely amidst North American and Western European nuclear sectors' dual twenty-first century uncertainties about how to navigate mass baby-boomer retirements and deflated youth enthusiasm for nuclear energy.

Onwards

Juxtaposing perspectives from 2013 ENYGF and WNA event attendees with those of Finland-based nuclear professionals revealed how various post-WWII and post-Cold War changes in learned segments of European and North American societies have shaped nuclear energy insiders' unique personal histories, sensibilities, and worldviews. For example, early-career talent pools altered in composition when rupture-events like Fukushima or Chernobyl shook publics' and politicians' relative warmth to nuclear energy in different ways in different locales. Such generational shifts affected who embarked upon, who was selected for, and who became leaders in nuclear energy careers. It shaped and reshaped nuclear neophytes' intellectual, aspirational, and political predispositions in ways that mediated cross-generational workplace relations—the very grounds upon which knowledge transfer process took place. The chapter responded to this by switching focus from tacit knowledge to talent pools. This foregrounded more slowly unfolding workplace peopling and regeneration processes that transcended, yet were inextricable from, any given moment of knowledge transfer or any given nuclear energy professional world. It backgrounded institutional knowledge dynamics manifesting interpersonally by foregrounding demographic dispositional dynamics manifesting intergenerationally.[114]

This switch revealed intricate dramas surrounding the peopling of workplace role templates. These templates were legitimized by appeals to status and rank – ideally determined by education, experience, and to a lesser extent age – along junior/senior trajectories thought to index a nuclear expert's achievement over time. Generation cohort terminologies were, for nearly all informants, seen as meaningful categories. When they reiterated their reality as "generative formula" (Battaglia 1990: 11) or as "generative schema" (Munn 1992: 122), they submitted to and shaped relations of deference, attentiveness, duty, responsibility, decision-making power, and salary among themselves. The role positions they defined were as much a part of people as people were parts of them. In being but a part of one's total identity, role positions were less than any one person. In being generation-transcending templates in which one serves as a mere temporary incumbent, they were more than any person. Role templates were thus this within each informant, but also dwelling in relations between them. This doubleness was their power.

Assessing one's position in workplace role templates could make one feel ahead of the game or lagging behind when sizing oneself up to ideal-typical sequences of advancement. They established indices of one's distance from starting work at an organization to one's ending work in retirement or death. Being near the beginning of this lineal-sequential rubric meant the professional should, ideally, be ingesting more of the institution's knowhow. Being near the end meant the institution should, ideally, ingest more of the professional's accumulated wisdom. Feelings out of sync with role templates, ahead of them, or above them could alter workplaces'

[114] That is, it foregrounded "social and cosmological issues of reproduction and regeneration" that transcended or went "beyond ego-centered linkages" (Weiner 1980: 82).

ecologies of affects—infusing experts with anxieties, enthusiasms, self-confidences, or dreads. Their valences also, prospectively, established replicable trajectories forward while, retrospectively, establishing shared backdrop chronotopes for narrating one's professional history. Laying out how individual and institution ought to iterate with each other, they had a regulatory effect on professionals. As tools of sense-making, they endowed them with analytics. This was their "constraint of form" (Strathern 1988: 180-182).

Workplace role templates became guides for nuclear neophytes who might someday become nuclear energy sectors' upper echelons; compasses for how to adopt nuclear professional lifeways. Yet studying neophyte backstories revealed how they were always already fashioned by global alignments and realignments of broader nuclear energy regeneration patterns that had gained ground long before they came to people workplace knowledge transfer processes. For instance – while Finland's longstanding *teekkarit* conventions may have been homogenizing forces in forming STEM university students – the country's changing socio-politico-economic sensibilities formed different ethoi, mentalities, and values among those fed into these university programs year in and year out. This would later calibrate the complementarity, relatability, and working chemistry between junior/senior, youth/elder, student/pensioner, and recruit/retiree professionals by subtly mediating the amounts of mutual trust, esteem, respect, reverence, or suspicion that existed between knowledge transferers and transferees.[115] This shaped how they fit, or failed to fit, into workplace role templates.

Attuning to this complicates any crude image of more senior professionals unilaterally passing down their (tacit) knowledge to receptive younger protégés without many layers of contextual

[115] For example, informants helped me think through such working chemistry impasses via the figure of the young professional wary of nuclear sector intergenerational myth or status quo transmission.

backdrops wedged between them and mediating them. It shows how relations between nuclear workplace role inhabitants are always already haunted by past talent pool lineups comprised of those who wound up there via intersecting practical, aspirational, and financial circumstances of years past. Analyses inflected by the tacit knowledge concept have lucidly shown how nuclear projects', institutions', and expert teams' scales, agendas, organizational structures, mission statements, and reasons for existence have shifted across decades and how this has altered knowledge transfer conditions. But they have also taken nuclear workplaces as given by failing to account for how such personnel adopted their own distinct personalities, dreams, aspirations, characters, ambitions, ethics, sensibilities, motivations, and modes of relating to others inside and outside their generational cohorts in the first place. This chapter has corrected for this by denaturalizing a scene of nuclear workplace knowledge transfer by foregrounding backstories to its peopling.

Departing from Finland's nuclear workplaces and attending the ENYGF and WNA events – where many wondered why many of today's brightest young STEM graduates are less interested in pursuing nuclear careers – revealed the tacit knowledge concept's blind spots to be crucial. It did this by showing how nuclear energy sectors across North America, Western Europe, and beyond were grappling with mass retirements, greying baby boomer workforces, and looming deaths of indispensable experts. This revealed a rich space for ethnography of the neophyte professionals who will soon replace them and inhabit leadership positions in twenty-first century nuclear workplace role templates. Examining this personnel regeneration and peopling is now more exigent than continuing to build on already answered questions and already disseminated insights inflected by the tacit knowledge concept. I have emphasized this in reaction to how responses to well-identified knowledge management, organizational memory, and tacit knowledge transfer challenges are already the object of nuclear energy insiders' attentions globally. Attuning to talent pool peopling better syncs with the looming human resource, demographic, and generational changes I encountered among nuclear energy professionals in Finland, London, Stockholm, the United States and elsewhere. These changes, this chapter showed, can be seen in the uniformities upholding and dramas unfolding around nuclear workplace role templates iterated and reiterated by those who people them as well as those who wish to people them.

Interlude: Safe-Case Deep Time-Reckoning

This ethnography's Introduction described how my encounters with Safety Case experts' deep time-reckoning practices had a de-romanticizing effect that I experienced, in part, as an aesthetic shift. In Anthropology, this shift could be compared to the de-romanticization that can occur when, say, an aspiring archaeologist transitions from (a) reading about long-term archaeological history in books while imagining awe-inspiring deep horizons of rising and falling civilizations, of alien societies warring or trading, or of ancient customs shaped by semiotic systems foreign to one's own to (b) doing fieldwork in the muddy dirt among mosquitos with trowels, stratigraphic column graphs, GPS systems, boots, friendly and unfriendly colleagues, working according to short-term funding-constrained deadlines, and so on. In the field, deep time's aesthetics of horror, sublimity, and awe can become shallow. This deflationary trajectory was in motion when, for instance, I arrived in the field and noticed how many informants' imaginations were captured more by, say, the rapid-fire tempos of finance and politics (Chapter 1) and the multi-decade and centurial tempos of nuclear personnel succession (Chapter 2) than by the forbidding expanses of nuclear waste's deep time.

In this same spirit, Chapters 3 and 4 will examine nuclear waste deep time-reckoning – as artifacts of ordinary expert actions – by engaging with Safety Case experts directly. Doing so can deflate deep time's popular imageries for those who might overrate them. When searching for deep time in Chapter 3, I instead find entangled relations of familiar part/whole, input/output, iteration, and means-ends thought patterns orchestrating continuities across the Safety Case's immensely complex technical reports' minutia. In Chapter 4, I instead find ecologies of unique personalities, relationships, contingencies, insecurities, epistemic sensibilities, jealousies, computer technologies, health conditions, affects, and office politics. Both chapters aim to ground deep time's instantiations by recasting them as, in a large part, products of incessant iterations and reiterations of familiar patterns. To segue into those more conceptual explorations, I will now provide background information about how the Safety Case materialized in practice.

Making a Safety Case

The Safety Case was the central technical-evidentiary portfolio in the Preliminary Safety Analysis Report (PSAR-2012) supporting Posiva's Construction License Application (CLA) request to formally begin building an underground nuclear waste repository in Olkiluoto. It detailed technical designs, reported engineering principles and strategies, and contained numerous interwoven quantitative models and scenarios that forecasted the repository's potential fate over the coming hundreds of thousands of years. Its goal was to assess if and how radionuclides would later escape from the repository and enter Earth's living environment and what, if any, human exposures might result. For example, a key challenge was to determine how groundwaters – key vehicles for radionuclide migration if a canister were to breach – of various chemical compositions could flow through Olkiluoto's subsurface networks of crystalline granite rock fractures and how this could affect the repository's engineered components. To study this, some drilled boreholes from the surface and took samples, others conducted research deep in the Onkalo underground laboratory, others mixed waters and clays together in surface-level laboratories in Helsinki, others worked in offices computer-modeling the flows' repository safety implications, while still others developed Posiva's pdf and paper reports.

The Safety Case contained calculations of radiological consequences to future humans and other biota that were to conform to requirements in Finnish Government Decree 736/2008 and

STUK's YVL Guide D.5. Those guides established 0.1 mSv as the maximum allowable dose of radiation to the "most exposed" populations over whatever future span can be "assessed with sufficient reliability, and which shall extend, at a minimum, over several millennia" (Government Decree 736/2008, Sec 4). The Safety Case's most robust quantitative projections of far future radionuclide releases into Western Finland's surface-level ecologies focused on the ten thousand years following the repository's anticipated closure. Informants explained to me how this was roughly the amount of time since human habitation began in Finland after the previous Ice Age. Other analyses looked hundreds of thousands or even – in the case of the qualitative scenario "The Evolution of the Repository System Beyond A Million Years in the Future" (Posiva 2012: 197-200) – one million plus years ahead. The safety analysis models' key "reference period" for studying how the repository's physical architecture would evolve, however, was set at 250,000 years, so as to include at least one Ice Age cycle. Safety Case renderings of future worlds were circumscribed by regulatory prescriptions like these, which helped deep time appear more finite and calculable:

> The dose constraint for the most highly exposed individuals, 0.1 mSv per year, stands for the average individual dose in a self-sustaining family or small village community living in the environs of the disposal site, where the highest radiation exposure arises through different exposure pathways. In the living environment of this community, a small lake and a shallow water well, among other things, are assumed to exist… The average annual doses to larger groups of people living in the environs of a large lake or sea coast shall also be addressed.

One strategy for building confidence in Safety Case models involved overbuilding them with what informants called "conservative" assumptions. Experts modeling Western Finland's future ecosystems – or “biosphere,” as some termed it – assumed there would be six thousand or so people living in the Olkiluoto area eating only local food. Given the often dark and frigid environment there, it would, in practice, be unlikely or impossible that a population of that size could be sustained without importing food from elsewhere. Yet, the Safety Case argued, *even if* this unlikely conservative assumption were to hold, then Posiva’s repository’s radionuclide release potentials would still fall below STUK’s exposure maximums. As another example, the 2012 Safety Case “base scenario” assumed there would be an undetected but meaningful defect in one or a few of the KBS-3 canisters prior to disposition—a scenario that, in practice, was judged extremely likely.[116] Running models presuming this was thought to depict how a few defective and many non-defective canisters would interact with the “host” bedrock and Posiva’s engineered repository structures. The Safety Case argued that, *even if* a canister or two were to be significantly defective, then the repository would still pass regulatory muster.

The Safety Case’s “even if, then” epistemic orientation had parallels in the KBS-3 repository design itself, which, I was often reminded, was a “multi-barrier system” based on “robust system design objectives.” It was, for instance, argued that *even if*, say, copper or cast iron canister parts were to fail, the repository would still likely have its bentonite buffers, the granite bedrock itself, the ceramic state of the spent nuclear fuel itself, the materials used to backfill the repository after closure as barriers keeping the radionuclides amply isolated. That is, even if one or two or three aspects of the KBS-3 safety concept were to someday fail, then there still would be other barriers in place as backups. The Safety Case sought to build confidence in safety through appeals to redundancy such as these.

[116] Posiva ruled this highly unlikely (less than one percent) in light of expert judgments about canister welding techniques as well as non-destructive tests of the canisters’ durability.

To enhance what was called “process control,” the Safety Case’s development was overseen by Posiva’s Quality Management System – based on the International Organization for Standardization’s ISO 9001:2008 requirements – which aimed to ensure that Posiva was, along the way, efficiently meeting its own safety and productivity schedules in transparent and traceable conformity to regulatory requirements. Before the Safety Case was compiled and submitted to STUK for regulatory review in December 2012, it was first reviewed internally by Posiva’s subject matter experts and then externally by outside experts under contract with Posiva. A Quality Coordinator (QC) was responsible for facilitating reviews, for approving final versions of Posiva reports, and for auditing the Safety Case reportage production process. Posiva used knowledge management systems like the POTTI research data system (See Chapter 2), which facilitated experts’ access to commonly verified and accepted data.

The Safety Case developers had been receiving feedback from STUK since at least 2008. Meanwhile, STUK had been revising its YVL regulatory guides since the mid-2000s, and continued to do so into 2012. Some said this created confusions for Posiva experts unsure of what upcoming YVL revisions would be, despite being given rough drafts beforehand. Since the early 2000s, Posiva and STUK planned for the former to submit working Safety Case report drafts to the latter by 2009. STUK was to provide preliminary requests for further revisions and research development prior to Posiva submitting final CLA drafts in 2012. Some noted that STUK did not provide substantial feedback on certain reports until late in the game: when its preliminary licensing review report was released in June 2011. Yet communications between Posiva and STUK did shape the portfolio’s development. So too did ongoing dialogues with

SKB experts and their contractors. As SKB's work was the original source of most of Posiva's KBS-3 design, Finland's repository project evolved in close parallel with that of Sweden. See Vira 2017 for a detailed insider perspective on this.

As a legal technology, the Safety Case – evidence curated to persuade STUK and its stakeholders that Posiva had amply reduced potential environmental impacts and human exposure pathways – materialized in contexts always already constituted by clusters of laws like Finland's 1957 Atomic Energy Act, 1988 Nuclear Energy Decree, and 1994 Nuclear Energy Act. The 1994 Act, for example, mandated that all of Finland's spent nuclear fuel must be buried permanently within the Finland's own granite bedrock. It also required that it must not import and hence profit from neighboring countries that might wish to use Finland's nuclear waste disposal facilities to bury their own nuclear waste. This was not always Finland's policy. While Finland's nuclear community has been studying domestic final disposal options since the late 1970s – and conducting potential repository site characterization studies since the 1980s – Finland had, since a 1983 government decision, considered the irrecoverable export of spent nuclear fuel to the Soviet Union (later to Russia) as its preferred option. This was premised on a Finland-USSR agreement signed in 1969. Building a domestic geologic repository became Finland's backup plan.[117] Finland's handling of its spent nuclear fuel was, indeed, not immune to geopolitics. However, shipments of it to Russia had to cease in 1996 when the 1994 Law's export bans took force. It was then that Posiva, established in 1995 by TVO and Fortum (then Imatran Voima or "IVO"), became the key implementer of Finland's now ascendant geologic disposal strategy.

[117] In the 1970s, reprocessing of spent nuclear fuel seemed optimal, that plan was dropped in 1988 on economic and technical grounds.

The Safety Case was also, in part, an artifact of international bodies' determinations like, for example, those in SSR-5: the IAEA's "Safety Standards Guide for Disposal of Radioactive Waste," which was authorized by Article III of the IAEA's Statue. Previous years' standards – like the IAEA's 2006 "WS-R-4: Geological Disposal of Nuclear Waste (Safety Requirements)" – were jointly sponsored by the NEA, which was part of the OECD. The Safety Case's structure was organized in ways conforming with the NEA's 2012 "Methods for Safety Assessment of Geological Disposal Facilities for Radioactive Waste" and resembled that of SKB's SR Site safety assessment too. Posiva's methods and STUK's regulations were also influenced by widely circulated knowledge that emanated from the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the International Commission on Radiological Protection (ICRP). Finland's nuclear waste regime proceeded within the ambit of the EU's Radioactive Waste and Spent Fuel Management Directive too: in July 2011, the Community framework established by Council Directive 2011/70/Euratom formally described expectations for each EU country's handling of its waste.

Finland's first repository safety assessment was Esko Peltonen's 1985 "Safety Analysis of Disposal of Spent Nuclear Fuel: Normal & Disturbed Evolution Scenarios" report to the Nuclear Waste Commission of Finnish Power Companies, a progenitor of Posiva. Finland's next big safety analysis was TVO-92, which included studies of the country's Kivetty, Romuvaara, Olkiluoto, Veitsivaara, and Syyry areas as possible geologic repository sites. For more on how Posiva arrived at Olkiluoto as a final repository site, see Kojo 2009. Posiva built on these past studies to develop its major 1990s-era safety analyses, TILA-96 and TILA-99. After that, Posiva's safety analysis efforts began expanding, looking toward the Safety Case for PSAR-2012 for the CLA. Chapter 3 will cover these different "iterations" of the repository safety assessment in depth.

When I arrived in Finland, Posiva employed around ninety people and was headquartered in the municipality of Eurajoki. Its Safety Case work was often derived from contracts with experts from VTT, SROY, Pöyry, GTK, Aalto University and elsewhere. The repository project was forecasted to cost a total of three billion euros between 1988 and 2118. TVO and Fortum made provisions for the cost of nuclear waste management by making annual payments to Finland's State Nuclear Waste Management Fund, established in 1988 and overseen by TEM. Informants planned for this account to reach zero after post-2120 decommissioning.[118] The fund would then be dissolved and nuclear waste would be the responsibility of Finland's government—an entity that was assumed to have greater longevity than TVO, Fortum, STUK, Posiva, or any other company. Until then, the Safety Case would be positioned in phases in the following legal-procedural decision-making matrix, which my informants often kept in the backs of their minds:

1. <u>Stage 1: Decision-In-Principle (completed 2001)</u>: Finland's *Työ ja elinkeinotoimisto* (Ministry of Employment and Economy or "TEM") requested statements from local municipalities, from other agencies like the Ministry of Environment, and from STUK to gauge whether the Olkiluoto repository project was in the overall interest of society. Before this decision was made, the applicants published a description of the planned facility, its expected environmental impacts, and its expected safety. After the Posiva submitted its application, TEM held a public hearing and reported local opinions to the government. Once

[118] This was a centurial time horizon that, while certainly not deep time, evoked the horizons of contemporary climate change models or sea-level rise adaptation scenarios that looked decades ahead into the twenty-first century to envision potential human-ecological risks.

the Eurajoki local council approved the decision twenty votes to seven, the Finnish Government gave an affirmative Decision-In-Principle in 2000. This was ratified in May 2001 by Parliament, 159 votes to three. The positive Decision-In-Principle obviated the politics of *whether* the repository should be built and substituted it with a technocratic and administrative regime exploring *how* to best execute its construction.

2. <u>Stage 2: Construction License (in progress during my fieldwork)</u>: Posiva was scheduled to submit its CLA and Safety Case at the end of 2012. Some of the reports were delayed and remained works-in-progress throughout 2013. Safety Case experts did technical work exploring questions like: what parts of the repository will be exposed to what kinds of groundwater or seawater? How would the repository be affected by the coming Ice Age's glacial ice cover and the potential seismicity to occur when it retreats afterwards? At what rate will KBS-3 components like copper canisters or cast iron inserts corrode? At what rate will bentonite erode? What effects will future Ice Age permafrost have? What role will the decaying radioactive waste's heat play in this? With these issues in view, my informants worked on reports seeking permission to build the repository. Posiva's CLA and Safety Case passed STUK's review in February 2015. TEM granted Posiva a repository construction license in November 2015, making Posiva the first spent nuclear fuel repository initiative in the world to have been granted a construction permit by a national nuclear regulator.

3. <u>Operating License (~2018)</u>: After Posiva received a construction permit, it reorganized itself from being more of a research and design company to more of a KBS-3 repository implementation company (See Chapter 4). Some informants confided that they worried of a

looming brain drain at Posiva: an increasing lack of expert authority related to long-term safety matters combined with a rise of new business-oriented managers without rigorous technical backgrounds. Yet they still began working on another "iteration," to use the words of many, of the Safety Case. This time they sought permission from STUK to begin accepting waste at the repository facility. Questions of operational safety over the repository's multi-decade project-life were foregrounded. Originally the repository was slated to go into operation around 2020, but many informants, aware of possible delays, speculated that this could be a "floating" deadline. That said, many were optimistic that Finland's would accomplish the European Technology Platform for Implementation of Geological Repositories (IGDTP)'s vision, becoming the first EU country with a repository operating by 2025 (Vira 2017).

4. <u>Decommissioning License (~2120)</u>: Once a license to operate was granted, the repository would be open and accepting nuclear waste for one hundred or so years and would be decommissioned around 2120. A Decommissioning License Application (DLA) with a final Safety Case would need to be submitted to STUK at about that time. Revisions of the Safety Case were to be made every fifteen or so years between the OLA authorization and the DLA deadline. Yet many understood that the revisions made in this long interim period would not be as elaborate as those leading up to CLA, OLA, or DLA deadlines. They would consist mostly of updates to the Safety Case based on new best practices, new assessment techniques, or tweaks in the repository logistics most agreed were inevitable in the coming decades. At Posiva, the Safety Case project's prominence was planned fade more into the

background after the OLA, requiring fewer experts and personnel focusing their energies on it.

As an ethnographic artifact, Posiva's Safety Case appeared to me as a pile of physical documents or a digital folder of PDF files. It was a mammoth assemblage of reports containing datasets, models, scenarios, descriptions, diagrams, charts, forecasts, maps, documented findings, and much more. It was a legal instrument used to fill a knowledge gap demarcated by regulatory requirements, laws, domestic and international institutions, public pressures, scientific understandings, and more. Most agreed that it was very unlikely that STUK would, in the end, reject Posiva's application, though significant delays were presumed possible. Most agreed it would be nearly impossible that the Safety Case – an evidence-driven portfolio designed to persuade – would ever self-announce Posiva's repository as unsafe or unworthy of STUK's authorizing permits. Yet Posiva still had to perform this elaborate legal ritual of filling an evidentiary information-lack with something more than itself before it could be allowed to operate its repository. Through these entanglements, deep time auguries were collaboratively shaped into more discernible and disenchanted objects of bureaucratic, scientific, management, regulatory, and engineering knowledge within seemingly more tractable horizons of social, institutional, and historical time.

The Safety Case deep future renderings that Posiva personnel, STUK regulators, and observers abroad took most seriously were, by and large, its quantitative models. Yet, as the next section shows, Safety Case experts also developed what they saw as more speculative, qualitative, analogical extrapolations about Finland's distant tomorrows. Those projects were too premised on “even if, then” arguments informants described as supporting a “multiple lines of reasoning” approach. It was thought that, even if one does not have faith in Posiva’s quantitative models, then he or she could still turn to the Safety Case’s prose scenarios and/or archaeological and geological analogical projections. Even if one has no faith in Posiva’s formal efforts to project qualitatively or quantitatively about far futures altogether, then one could still turn to the its descriptions of the repository’s engineered features or, say, look at reports about the non-destructive testing of KBS-3 canisters. In short, the Safety Case experts developed arguments to persuade audiences of diverse epistemological sensibilities. With that in view, I now present Posiva’s so-called qualitative projections as further background examples of how Safety Case expert practices and thinking patterns materialized.

Deep Time Mudstone, Nails, Cannons, and Cadavers

Seventy-three million or so years ago, a meteorite slammed into what is today Southern Ostrobothnia, Finland. Serene Lake Lappajärvi now rests in the twenty-three kilometer wide crater made in the blast’s wake. When I was in the field, locals still enjoyed boating to Lappajärvi’s Kärnänsaari: a melt-rock island formed by the Cretaceous collision. Canoeing there was a brush with Finland’s landscape’s deep history’s physical features.

The crater-lake caught the attention of the Safety Case *natural analogue studies* experts who pored over research conducted on geological and ecological formations tens, hundreds, or thousands of kilometers from Posiva’s offices. These experts selected these formations because they were thought to harbor features like those they anticipated for distant future Olkiluoto. That is, they studied prehistoric places like the Lappajärvi crater-lake as stand-ins for far future repository parts, geological features, and environmental conditions. Safety Case experts explained how Lappajärvi kept its form across many past Ice Age glaciation and de-glaciation events. Their reports told of "fairly stable conditions and slow surface processes" over millions of years (Posiva 2012: 197-200). They reasoned that Olkiluoto could expect only limited landmass movement and erosion in multimillion-year futures. Making comparisons across space and time, Lappajärvi's distant past physical features gave Safety Case experts glimpses into Olkiluoto's far future physical features. As in each chapter in this ethnography, futures were made with recourse to familiar formations. On these grounds, Safety Case experts argued that Posiva's repository could, like Lappajärvi's crater, hold up reasonably well throughout the retreating and advancing of coming Ice Ages' ice sheets.

Safety Case experts likewise enrolled a prehistoric Littleham mudstone in Devon, England as a deep time-reckoning device. There, copper was found encased in sedimentary rock that maintained for one hundred seventy million years without succumbing to corrosion. Safety Case experts foresaw a similar future for Posiva's large copper KBS-3 nuclear waste canisters, proposing that – as Littleham mudstone was more abrasive to copper than is the bentonite clay to surround Posiva's canisters – the canister copper might see even rosier futures. As in any natural analogue study, drawing analogies between physical formations across time (reckoning long futures through long pasts) and space (extrapolating across faraway regions sometimes thousands of kilometers apart) was a technique for reckoning far future worlds. In Littleham and Lappajärvi, deep time was reckoned through

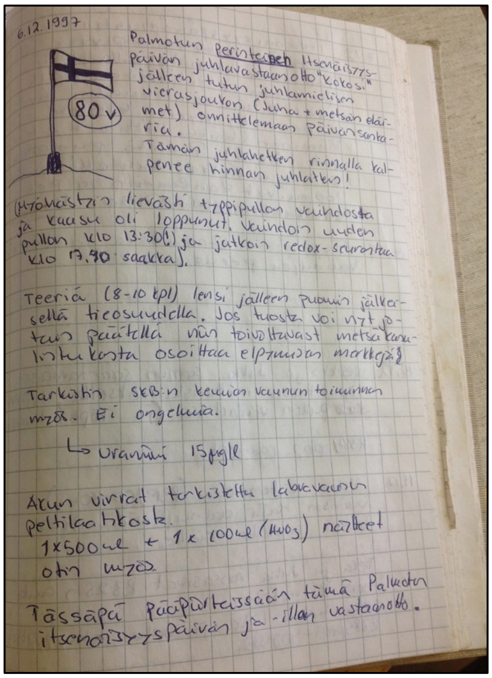
Joining a Field Informant for a Trip to the Hyrkkölä Uranium-Native Copper Deposit Analogue Site.

analogies made between Earth formations past, present, and future. Futures never emerged *ex nihilo* or from any world-outside-the-world. They were always derived from familiar devices derived from still others. Each was born of past traces and could be pregnant with seeds of future ones. Taking this derivativeness seriously – and how informants iterated and reiterated past and present familiarites to achieve it – can help one better understand the spirit of Safety Case deep time-reckoning.

An Ice Sheet Analogue Studied Near Kangerlussuaq, Greenland (Photo Credit: Nuria Marcos).

Still other Safety Case experts made research trips to a huge ice sheet near Kangerlussuaq, Greenland to study the local permafrost, ice, and groundwater as analogues for Sweden's, Canada's, and Finland's coming Ice Age conditions fifty or sixty thousand years hence. Some visited Southern Finland's Palmottu uranium deposit to examine groundwater flow patterns, how nearby radionuclides had traveled, and evidences of past chemical reactions at the site to clarify how Posiva's nuclear waste's radionuclides might travel there in futures near and distant. Making analogies between far-flung locales and far future Olkiluoto required imagination. But this was not the seemingly individualistic imagination of a solitary daydreamer, an artist at an easel painting solo, a neurotic novelist staying up late writing furiously alone, or a poet beneath a tree webbing together words. It was a deeply collaborative, collective, and interpersonal imagination relation that emerged among different kinds of experts, landscapes, future visions, and technologies. This too only became actionable through incessant iterations of the familiar: taming uncertainties in a future right-here by reiterating near-certainties about a past over-there. In analogue studies, the past could be seen as a perspective on the future only after experts in the present developed patterned perspectives on the past. That is, a present view on pasts had to become familiar before futures became thinkable.

Safety Case archaeological analogue experts worked similarly. They examined human artifacts' present and past physical features as analogues for future repository parts. For example, they studied a bronze cannon from the seventeenth century Swedish warship *Kronan*, long submerged in the Baltic Sea's southern rim, as an analogue for Posiva's copper canisters far future conditions. The cannon was chosen due to its high copper content, its nearly three centuries spent resting in abrasive seawater, and how it was long partially encased by seafloor clay reminiscent of KBS-3's bentonite buffers.



Field Notes Written by an Informant While Conducting Analogue Field Research.

They studied a 2,100-year-old, non-mummified corpse discovered alongside wood, vegetables, silk, and meat in China to see how the clay's capacities to preserve the body and artifacts could illuminate a KBS-3 repository's buffers' capacities to preserve radioactive waste for millennia.[119] The Safety Case also cited Switzerland's National Cooperative for the Disposal of Radioactive Waste (NAGRA)'s analogue research on two-thousand-year-old Roman iron nails dug up in Scotland. It pointed to how the nails, resting in conditions said to be more abrasive than those beneath Olkiluoto, saw limited corrosion across

[119]The Safety Case says the cadaver was "found to be well-preserved, with the skin complete and retaining some of its elasticity whilst the abdominal organs were intact and some of the joints were partially movable." The artifacts exhibited an "equally good state of preservation, the meat and vegetables showing only partial decomposition, and this has been attributed to the thick clay layer around the coffin…providing an air-tight seal" (Posiva 2012: 107).

millennia. From this, experts made forecasts about the multi-millennial endurance of the cast iron inserts Posiva would use to hold nuclear waste in place inside copper canisters.

Yet analogue studies comprised only a small part of the large Safety Case portfolio. Safety Case experts presented these more speculative, qualitative, imaginative techniques in their portfolio's *Complementary Considerations* (CC) report (Posiva 2012). CC was a hodgepodge of PR information and technical evidence made to persuade especially non-technical lay audiences of the repository's strengths. It played a secondary, sideline, or supporting role in Posiva's broader safety argument. Aimed at filling gaps that calculation alone could not fill, it included "less quantifiable types of evidence and arguments" lying "outside the scope of the other reports of the quantitative safety assessment" (Posiva 2012: 1). Thinking in an "even if, then" mode, informants saw these qualitative or analogical arguments as "back-ups" to step-in where calculation, engineering logics, or modeling evidences broke down. They were seen as less objective, less scientific, more notional. Hence, Safety Case experts relegated analogue studies in their guiding hierarchies of knowledge, letting the engineering and quantitative modeling calculations I explore in Chapters 3 and 4 overshadow them.

But, from a broader perspective, there were many similarities between the Safety Case's qualitative analogue studies and its quantitative models of how Posiva's repository might endure or degrade in its local environment's extreme long-term. All aimed to give form to uncertain futures, with recourse to traces of the familiar, amidst relatively shallow professional time horizons. Like analogue studies, quantitative modelers forecasted futures by synthesizing extant information drawn widely from across time and space. Analogue studies experts – just like corporate cooperators with their mankala model (Chapter 1) and nuclear energy professionals with devices such as recruit/retiree and junior/senior in tow (Chapter 2) – navigated uncertainties by iterating and reiterating more palpable traces of the familiar.[120]

Analogue research's multimillion-year futures were bound to today's conventions about what counts as an acceptable analogy and pre-formed notions about Earth's present and past features across deep time. Quantitative modelers' multimillion-year futures were bound to today's conventions about what is considered a credible or cutting-edge modeling technique. Both emerged from prescribed layouts of regulations, management practices, laws, and scientific logics. Indeed, all these deep time-reckoners – perhaps even like all humans and, by extension, all experts – participated in broader ecologies of iterations and reiterations of the familiar to attain momentum moving into tomorrows. Extreme cases like "The Evolution of the Repository System Beyond A Million Years in the Future" simply extended these temporal maneuvers into even deeper time horizons.[121] For all Safety Case experts, knowledge about present and past conditions was the key to developing knowledge about future ones. I now explore the abiding presentism to how the Safety Case was assembled in practice.

[120] As noted in the Conclusion section, this ethnography recursively replicates these distinctions by excising parts of informants' reasoning's endpoints and redeploying them as starting-points for my anthropological analysis.
[121] This is the section with featuring the Devon mudrock and Lappajärvi crater-lake analogue. These labors of deep time-reckoning and iteration could have, in theory, been extended further. But I did not observe that ethnographically. What was clear, however, was that when gaps in Safety Case mathematical models' credibilities were revealed, alternate deep time-reckoning techniques like those found in CC were devised to fill them. These were supplemented by even more longsighted deep time-reckonings, accomplished through prose scenarios, of Posiva's repository's future beyond the million-year mark.

(Chapter 3) Ants, Forests & Nazca Lines: Modeling Collaboration in a Self-Similar Safety Case

Inside STUK, Finland's Nuclear Regulatory Authority Reviewing Posiva's CLA.

Engaging with the farsighted Safety Case portfolio ethnographically, I witnessed first-hand how modeling expertise and professional collaborative relations co-created one another in Posiva's projects to reckon Western Finland's multi-millennial geological, ecological, and climatological futures. This chapter explores how models of deep time took form in a context of nuclear waste regulatory science.[122] Like Chapters 1 and 2, it does this by adopting informants' views of their work as starting points for ethnographic analysis,[123] redeploying some of their own familiar devices of orchestration as means for engaging with how they saw themselves modeling distant future Finlands.[124] What emerges is an account of how experts from a variety of fields and situated in a variety of positions in a broader Safety Case workplace ecosystem iterated and reiterated what they called "parts/wholes," "inputs/outputs," and "iteration" to endow their

[122] For more on "regulatory science," see Jasanoff 1990: 76-79.

[123] That is, this chapter aims to approach regulatory science's modeling knowledge from a slightly offset vantage—"learning how to see" (Strathern 2013) Safety Case modeling thinking from my informants' perspective.

[124]This, like other chapters' approaches, is inspired by Riles' approach to "borrowing" informants' own "forms and designs" to open up to analysis phenomena that seem "too familiar" for analysis (2000: 19, 21).

enormous portfolio with aesthetics of consistency. This chapter also explores how Safety Case insiders recast their own collaborations as "maps," "forests," and "Nazca Lines" to endow collaborative complexity with more discernible features. This helped them navigate their portfolio's great breadth and establish continuities across diversities of reports.

This analysis is less about models' epistemology, messy realities, or credibilities and more about the iterations of familiar layouts of professional roles and collaborative relations that served as conditions upon which Safety Case deep time-reckoning was contingent.[125] The sections to follow demonstrate how organizing patterns of continuity – which enabled coherent communication across difference – were attained across Safety Case scales, levels, and disciplinary divides.[126] They demonstrate what an anthropological analysis of form, aesthetics, and pattern can reveal about modeling practices in regulatory science contexts. They show how informants iterated and reiterated logical relations of merography, teleology, hierarchy, and self-similarity to ground the Safety Case's collaborative complexities. These familiar logical-relational devices were simple but essential to how informants achieved ambitious forward momentum in their projects. My approach complements STS-inflected approaches to regulatory science (e.g. Jasanoff 1990). Understanding how such logical-relational devices organize collaborations, I suggest, becomes crucial in uncertain twenty-first century expert worlds in which future-gazing modeling expertise pervasively governs lives, worlds, toxic materials, and

[125] That is, it proceeds by accepting as self-evident that models were rarefied products of epistemic simplifications, reductions, or distillations of complexity assembled amidst flux processes, messy realities, and extra-scientific imperatives.

[126] In other words, it reveals the ideational, relational, and contextual dynamics of how Safety Case experts collaboratively modeled distant future worlds. From this emerges a fresh model for analyzing regulatory science's predictive modeling practices—one informed by late modern anthropological work that, as I will show, focuses on many questions about form, scale, roles, epistemology, and logical/social relations that parallel key questions engaged by my late modern Safety Case modeler informants.

ecosystems. In response, I enter Safety Case futures' guiding logics ethnographically. This provides a window into the intellectual universe of Safety Case experts in particular and, to an extent, regulatory science in general.

Merographic Models

The Safety Case as a whole was composed of many interlocking parts that presented themselves, to the untrained eye of an outsider, as singular stand-alone technical reports. As a bound compendium of paper or pdf file documents, each report appeared as a discrete entity of its own. Yet, for informants, each was also but a "link" in elaborate "data chains" or "model chains" of "inputs" and "outputs" that looped in and out of each other to comprise a composite Safety Case. The resultant portfolio, as a whole made of parts, was construed as but a part of the broader 2012 CLA application. This logic of part-whole compartmentalization – a bit like what philosophers have called mereological relations or what Strathern has called "merographic" connections (1992a) – helped constitute the Safety Case's internal patterning. It rendered reports comprising the portfolio, as well as the portfolio itself, as discrete totalities (with multiplicities within themselves) and partial components (as pieces comprising multiplicities outside themselves). These interlocking skeins endowed the Safety Case with organizing self-congruencies.

Yet different Safety Case reports-as-parts contained information of disparate scales, temporal orientations, and methodologies. Some looked mainly at Earth's deeper geosphere; others at its less-deep biosphere. Some looked at potential future "near field" releases of radionuclides to occur at depth near the repository itself. Others looked at how escaped radionuclides might travel through future surface-level terrains and ecosystems. Some looked ten thousand years into the future; others hundreds of thousands of years. These diverse foci were studied via "multiple lines of reasoning." That is, some reports gauged "engineered barrier systems" (EBS) safety—referencing tests of repository components' structural integrities. Others developed simulated forecasts of distant future ecosystems or underground hydrological flows through quantitative modeling. The interface between the EBS and the biosphere-geosphere models – the central focus of this chapter – was the Safety Case's central evidentiary thrust. Relegated to supporting roles alongside quantitative models, however, were "Complementary Considerations" reports: qualitative, speculative, and analogical evidentiary appeals "outside the scope of the other reports of the quantitative safety assessment" that aimed to enhance "confidence in the outcomes of the safety assessment" and put them in a "broader perspective" (Complementary Considerations 2012: 14, 205).

The Safety Case was one evidentiary corpus with diverse epistemological sensibilities within. But this did not detract from how, if one zoomed in or out on nearly any region of it, one could describe what one sees through the lens of wholes-and-parts. Take, for example, the Biosphere Assessment Report (BSA)'s models. Informants noted how, with many models-within-models-within-models *et cetera* "feeding" it, the BSA was positioned at the tail end of the Safety Case "model chain." It contained five "sub-process" models, each with "outputs" that fed into it as "inputs." One such input-part was the Biosphere Description Report (BSD), which provided a "synthesis of knowledge about the *current* state of the surface environment and the main features of the past evolution of the site." A second was the Terrain and Ecosystems Development Model (TESM) that modeled the "development of topography, overburden, and hydrology at the site." A third was the Landscape Model Setup (LMS) that provided a "time-dependent and site specific radionuclide transport model." A fourth was the Radionuclide Transport (RNT) Report that analyzed the "fate of radionuclides released from the geosphere." And a fifth was the

Radionuclide Consequences Analysis (RCA) model that revealed the bottom-line final-result of the Safety Case endeavor by displaying the "potential radiological consequences to humans and other biota so they can be put in the context of regulatory requirements" (Hjerpe et al 2009: 14, 19).

The models wove together in gaps-and-slots logics[127] such that within the BSA's input-parts were still more models with their own input parts. Take, for example, the RNT model. The RNT was both (a) an input-part that made outputs-parts that fed into the BSA as a whole and (b) its own discrete whole that contained its own input-parts fed by yet other models' output-parts. The RNT first had to be fed, for instance, by both the Groundwater Flow Model (GFM) and a model of the repository's physical layout before it could generate its own output-parts to feed into the BSA. Hence, from the BSA's perspective, looking backward along the model chain toward the RNT, the RNT appeared as but a part in relation to the BSA as a whole: the BSA consumed a feeding-RNT as BSA-sustenance. Yet from the GFM's perspective looking forward in the model chain toward the RNT, the RNT appeared as an engulfing whole in relation to itself as a part: the RNT consumed a feeding-GSM as RNT-sustenance. Each model could thus be a context for, perspective on, or reference-point for each other model. Individual models like the RNT, the BSA, or the GSM were therefore both parts and wholes – both inputs and outputs – in a multi-leveled hierarchy of relations. They achieved significance through one another by each being both (a) a means to the Safety Case's ultimate end of demonstrating the Olkiluoto repository's safety and (b) a means (as feeding-part) and an end (as consuming-whole) in relation to its associated models.[128]

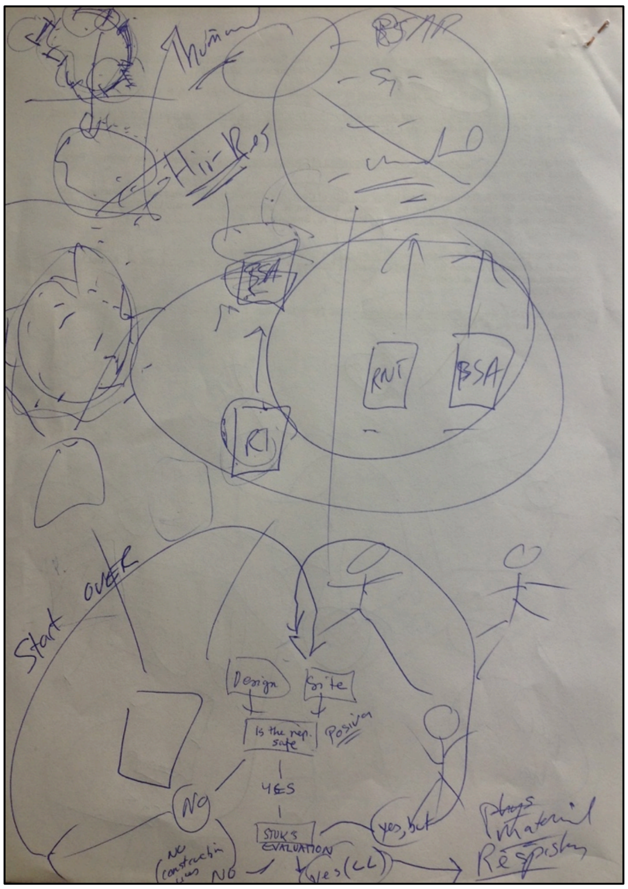
[127]To delve deeper into anthropological reflections on "logic of slots or internal gaps," see Riles 2000: 22.
[128]In the Safety Case, as elsewhere, "*mean*-ing (i.e. means-ends relations, significance, 'aboutness,' telos" was a "constitutive feature" (cf. Kohn 2013: 16).

Such formal patterns of inputs/outputs and parts/wholes, undergirded by instrumental relations of means/ends, existed throughout the Safety Case's model chains. A data-output from one model might have served as a data-input to another model, which might then have produced outputs that fed into, say, three other models, which were each fed into two other models, and so on. As with any individual report in the portfolio, any individual model in the model chain could be construed as both/either a whole-made-of-parts and/or a part-made-of-wholes. Informants sometimes described these patterned relations as "systems" with "subsystems" with "sub-subsystems" or "meta-models" with "models" with "sub-models."[129] The interlocking interiors and exteriors endowed modeled systems – which might have otherwise emerged as complex, formless, chaotic panoplies of disparate documentation – with a formal consistency. This portfolio congealed as a unit only through incessant iterations and reiterations of input/output, part/whole, and means/ends relations undertaken by Safety Case experts, reports, reviewers, computer programs, regulators, and other agents daily. Informants iterated these distinctions both to narrate professional autobiographies and to position themselves in broader workplace role templates that transcended any individual collaborator's field of vision. They said things like these:

> "My models are fed by that team's datasets. Their outputs are fed into both his report and her model." / "My dataset is part of models X and Y being developed at SROY" / "I started working here when Posiva was developing TILA-99 and will likely continue working here well into the OLA Safety Case iteration"

[129] These terminologies were hardly unique to Finland. Indeed they orchestrated many other Systems Analysis projects in many other sectors, countries, and times—such as, for example, the U.S. DOE's License Application models for its Yucca Mountain deep repository project (Ialenti 2014a).

The Safety Case as a portfolio could be analyzed remotely as a multi-scalar, multi-leveled, multi-dimensional artifact. The Safety Case experts' worlds could be analyzed ethnographically from within as an explorable milieu. In either case, if I as an anthropologist zoomed in on any particular model within any particular Safety Case report – opting to analyze it as a whole in itself – I saw a multiplicity of different parts feeding into the model as inputs. If I zoomed out and analyzed how any single model-containing report fit into the portfolio's broader ecology of interleaved reportage, the report would appear as but one part of a multiplicitous project-portfolio system. To see both of these views at once was to see information inputted into the Safety Case as both an external part of worlds-out-there and an internal part of worlds-in-a-model.[130] From this stereoscopic vantage, information was both/neither inside and/or outside its models. This revealed Safety Case models' inward-pointing and outward-pointing relations with one another.



An Artifact of Co-theorizing With A Safety Case Informant.

During fieldwork I could either (a) analytically background an individual model's or report's context within a broader model chain or portfolio whole and instead foreground the input-parts that constituted it or (b) analytically background the parts internally comprising the model or report itself and instead

[130]That is, taking a "double view" (Riles 2000: 90) in "binocular vision" (Bateson 1972: 79-80)

foreground its contextual position within a broader model chain or portfolio whole. These disparate approaches would produce disparate analyses. Both, however, revealed patterns of parts/wholes, inputs/outputs, and means/ends relations iterated and reiterated through and through. These repeating patterns loosely resembled fractal patterns in how they effectuated self-similarity across scale. [131] These self-similarities in formal arrangement appeared ethnographically as the Safety Case's DNA, skeleton, or connective tissue. In proliferating permutations of themselves, iterations of parts/wholes and inputs/outputs constrained and enabled expansions, partitionings, and branchings of the Safety Case's fanning complexity.[132] Linked by these self-similarities across difference, reports both extended beyond themselves and contained within themselves parts of other reports that extended beyond themselves. Put differently, one could view each either as an atomized, localizable, concrete unit or as a holistic, non-localizable, abstract parcel of patterned terrain.

Reports mutually completed one another. They could be construed as coordinative points-of-reference for positioning one another. Relations between reports could be seen as existing invisibly and abstractly between-but-outside reports and/or visibly and concretely within-but-spanning reports. Many informants, closely attuned to these issues of scale, had these forms deeply engrained in their psyches. Some extended parts/wholes and inputs/outputs form iterations beyond their conventional bounds as we riffed ideas back-and-forth in freewheeling

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[131] Holbraad & Pedersen have noted how Strathern's embrace of the "image of the fractal itself, with its 'not-quite replication' (p. xx)… generates a 'proliferation of forms' (p. xxi) inward and outward all the way" (2009: 376). Relations between the Safety Case portfolio's self-similar or fractal organization and the proliferation of the forms it impelled across iterations can be described using similar concepts. In different Safety Case role positions too, the "fractal" paradox of representation asserted that "no matter what the scale the degree of complexity stays constant" (378). For more anthropological analysis of fractal patterns, see Strathern 1991a; 1991b; Wagner 1991; 2000

[132] They thus indexed how, to borrow words from sociologist Dianne Vaughan, "taken-for-granted assumptions, predispositions, scripts, conventions, and classification schemes figure into goal-oriented behavior in a pre-rational, preconscious manner" in a contemporary regime of technoscience (1996: 405).

conversation.[133] One playfully cast the "output" of the total Safety Case portfolio itself as an "input" into STUK's regulatory guides. This expert thus enacted the entire construction licensing procedure as grounded on a tripartite adjudicatory template: Posiva's modeled "facts" were seen as inputs fed into STUK's radiological protection "rules" as means for outputting a "judgment" of the repository's safety.[134] The resultant judgment was then, in the informant's rendering, to be inputted back into Posiva to contour its own primary output: building a working nuclear waste repository compliant with STUK's regulations and Finland's laws. Another informant reflected on how the whole licensing procedure could be cast as but an input into the question "Is Posiva's repository safe enough?"

Field Research Undertaken at Palmottu Uranium Deposit in Finland (Photo Credit: Anonymous Informant).

Other informants downplayed input/output and part/whole patterns' significances. They did this by gesturing to individual reports' or models' multiplicities or idiosyncrasies. Indeed one model might have derived its inputs from *in situ* scientific observations at Olkiluoto's Onkalo underground laboratory, another from extant scientific publications on related topics, another from field study sites like Finland's Palmottu uranium deposit, and still another from the outputs of other models internal to the Safety Case. Reports and models thus ingested disparate forms of evidence, data,

133 In other words, some "scaled up" (Kirsch 2002: 293) or "extended" (cf. Miyazaki 2005; Wagner 1981: 27) input/output or part/whole devices to describe other surprising aspects of their work lives.
134 See Ialenti 2014a for more on how this tripartite adjudicatory formula has been reiterated to structure the United States' spent nuclear fuel disposal regime.

and knowledge from many temporal and geographic locales. From this emerged diversities of distinctive singular reports that contained diversities of other distinctive reports—entities at once objects and aggregates and thus, as anthropologist Roy Wagner might say, dividually "whole and part at once" (2001: 172). This revealed what Riles might call a "twin aesthetic of heterogeneity and system" (2000: 22) that contoured how diverse information forms were bricolaged together differently as a function of experts' distinct positions within Safety Case workplace role templates.[135] This twin aesthetic mediated the degrees of similarity and difference to exist between individual reports and models.

Yet in the live-action worlds of Safety Case collaboration, each multi-dimensional report was also a handoff object. Once a team assembled a model, they would hand it off to another team, which would then integrate it into their own model, which would then be handed off to still others for integration into a still-more-encompassing model, and so on. Each region of the Safety Case was thus construable as a part, a whole, an artifact, a milieu, a bundle, a piece of evidence, and a handoff. As such, the part/whole and input/output relations internal to models' technical interrelations steered how Safety Case experts, as collaborations-in-the-world, related to one another in constellations of roles defined vis-à-vis one another. To grasp how the Safety Case toed this line between perspectival multiplicity and logical consistency – constrained and enabled by basic devices of continuity coordinating both epistemological relations between models and role relations between people – is to grasp something essential about how the Safety Case became a unitary portfolio and a project. Yet this aesthetics of coherence had its limits. In fact, the Safety Case experts self-qualified their own work's epistemological plausibility by repeatedly asserting its partial, subject-to-change, or tentative character. They accomplished this

[135]For more on anthropological approaches to roles among experts, see work on "sociality of roles" (Miyazaki 2007: 408; Riles 2010: 798).

in part via a cyclical figuration that Safety Case experts called "iteration," which indexed the portfolio's progressive growths and mutations over time. The next section explores how iteration endowed the portfolio with generative incompleteness and futurity—endowing it with lineal teleology and progressive temporality.

Iteration Just in Time: Hockey, Buses, and Backpacks

Safety Case reportage increased in quantity and detail across what informants called iterations. After submitting the CLA Safety Case in 2012, they refocused on a "second iteration" of the Safety Case as part of Posiva's OLA to be submitted around 2018. Before the CLA came predecessor reports like TVO-92, TILA-96, and TILA-99 – published in 1992, in 1996, and in 1999 respectively – which an informant described as "thumbnail" iterations of contemporary "higher-res" CLA and OLA Safety Case iterations. Before those were early reports such as Esko Peltonen's 1985 "Safety Analysis of Disposal of Spent Nuclear Fuel: Normal & Disturbed Evolution Scenarios" report to the Nuclear Waste Commission of Finnish Power Companies, a progenitor to Posiva Oy. Each rendition was to depict the Olkiluoto area and repository's distant future fate with what the informant called successively "finer grain densities." Safety Case knowledge was to iterate over-and-over again cyclically, a bit like seasonal successions. It was to progress in a linear fashion integrating change positively, with decisions being made in incremental, stepwise ways.[136] These cycles were thought to fuse the short-term horizons of office, laboratory, and institutional life together with the multi-generational horizons that framed the project from the late 1970s until its anticipated closure around 2120.

[136] This temporality of integrating change intentionally is loosely resonant with what Lévi-Strauss called a "hot" society (1966: 233-4).

This positioned Safety Case reportage in time. All iterations beyond the first were to retool a past iteration in ways congruent with STUK's regulations and Finnish law's mandates. To quote an informant, STUK's mandated "enough" for TILA-99's quality was not as "big" as the "enough" mandated for CLA 2012 or the "bigger enough" mandated for OLA 2018.[137] The iteration device was enacted to index how the total Safety Case as well as specific models, reports, or datasets within it would grow and multiply incrementally over the three or four human generations of the repository's project-life. The final iteration was to support the DLA due to STUK around 2120. An updated Safety Case iteration was to appear every ten or fifteen years. Each report, model, or project at any position of the Safety Case could thus be seen as a member of a sequentially arranged iteration cohort.[138]

In the eyes of most informants, iteration's time passage was equated with proliferations of ever-higher-quality reports-in-the-world. Yet some enacted the iteration device more colloquially. STUK, as an informant put it, "iterated" back-and-forth with Posiva. An expert "iterated" back-and-forth with another expert, two teams "iterated" with two other teams, modelers "iterated" with scientists, the Safety Case models "iterated" with the repository design, the Finnish repository project "iterated" with the Swedish repository project, Nordic regulations "iterated" with international best practices, and so on. This was seen as essential to how the Safety Case's portfolio's characteristics were shaped and reshaped over the decades. Many of these reports contained models that were also described with the word "iteration." So-called "recursive" and "iterative" models ran algorithmic simulations of possible occurrences over-and-over, iteratively in varying combinations, to gauge future event probabilities.

[137] These demarcations, reframed in Vaughan's vocabulary, played a "powerful but invisible role by determining goals, setting deadlines, determining sanctions, and otherwise influencing the environment of decisions" (1996: 409).
[138] Seeing reports in iteration sequences made, to borrow words Strathern, aesthetics of "continuity" appear to make "change evident" over time such that the "stable and the transient coexist" (1992a: 1).

The iteration device's patterns' replications across Safety Case scale, level, and domain reinforced the portfolio's self-similarity. They did so by iterating with part/whole and input/output to channel the portfolio's emergence in specified directions. To zoom in on any section of the Safety Case was to reveal entanglements of inputs-and-outputs and parts-and-wholes retooled across successive iterations. To zoom out was, likewise, to reveal entanglements of inputs-and-outputs and parts-and-wholes retooled across successive iterations. Such repetitions were thought to effectuate the Safety Case's expansion, mushrooming far beyond the point at which a single human brain could encompass it in its totality. For instance, when models required more detail, many Safety Case experts felt compelled to integrate more inputs, more data, or more sub-process parts into each iterated version. This generated more reports, datasets, personnel, and research. Or when characterization of some detail about, say, a far future event that could compromise the EBS became too elaborate to be encompassed by a single report, many felt compelled to partition it into two or three leaner reports. This too generated more documentation and experts. Such partitive and additive logics made new inputs-and-outputs and parts-and-wholes appear to (a) effectuate finer grain densities via the portfolio's internal differentiation and (b) increase documentation quantity via the portfolio's external expansion. Iteration of these dual trajectories generated two "informational infinities" (See Riles 2000: 95): a multiplicative outward extension in the portfolio's size and a divisional inward splitting of its details.[139]

Each model, report, or datum could be (a) partible into fractions in a fragmentary-analytic mode or (b) stretched into breadth multiplicatively in an integrative-synthetic mode via further incorporation of a world-out-there. Expanding across iterations endowed each with what

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[139] Indeed, as anthropologist Dalton has noted, "any recursive self-replicating system… quickly leads one to infinities and fractal geometries" (2002: 55).

Strathern might call a "generative incompleteness" (1992b: 108) that, seeing lacks in the present, looked to promissory futures in iterations to come. These iterations summoned new generations of reports as years passed—setting constraints on how, when, and why the corpus of Safety Case knowledge grew across time. They fated the Safety Case to remain a work-in-progress for at least another century; and each report to always keep one foot in iteration's not-yet. The ways Posiva approached this not-yet diverged from what anthropologist Lucy Suchman critiqued as cognitive science's "planning" model (1987). That is, Posiva's iteration schedules did not establish a strict non-editable "sequence of actions designed to accomplish some preconceived end" that, ideally, would be fully recognized as rules and drawn upon by future Safety Case experts to coordinate their actions (28). Rather, it left openings for not-yet-known information, not-yet-discovered techniques, and not-yet-encountered challenges to appear before future Safety Case experts—allowing them to revise their research, data-collection, and problem-framing in *ad hoc* ways. A degree of adaptivity and revisability – premised on an acknowledgement of the unforeseen – was thus embedded in the Safety Case's path forward.

Some informants deflected criticisms of their portfolio's shortcomings by promising better iterations in the future. Iteration helped them do this by turning the Safety Case's unfilled knowledge gaps into gaps-to-be-filled at some later date. Appealing to these future fixes became a useful self-defense against regulatory, reviewer, or public criticism. Safety Case projections of potential ecosystems, geological change, and engineered systems millennia hence were, of course, easy targets for critique. Yet the iteration device allowed the Safety Case's information absences to point outside-and-beyond themselves to future information presences.[140] This progressive momentum was thought to move toward taming uncertainty, delimiting the

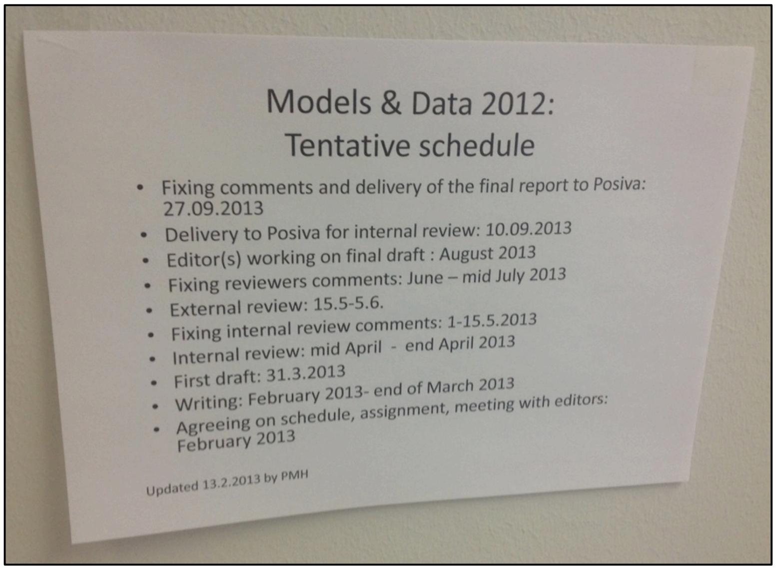
[140] These anticipations reminded Safety Case reviewers, critics, and insiders that – as Strathern would say – one's "field of vision" is not to be "*taken as all there is to see*" (1992a: 131).

boundaries of knowing and unknowing, hardening a series of unavoidably soft facts, and retooling absences of knowledge as knowledge of absences. By presenting Safety Case knowledge as subject-to-change, iteration helped the portfolio qualify and situate its knowledge claims in time. It did this by integrating Safety Case experts' auto-critiques, self-awareness, and reflexivities – and critical feedback from STUK and external reviewers – into the self-similar portfolio's production.

The iteration form helped tense the Safety Case project with sequence. Each iteration cycle contained countless interacting deadlines, schedules, phases, and workflow expectations. When there were delays, many experts rationalized, explained, or confessed reasons for their lacks of punctuality. They did this even while delays were, for repository projects globally, the norm not the exception. Punctuality was valorized in Finland's nuclear energy sector.[141] An informant from Southern Europe associated Finland's strict punctuality ethics with a commitment to respect, equality, and keeping one's word. She saw this commitment as key to how and why Posiva's projects proceeded from iteration to iteration without major delays. She explained this by evoking the common experience of waiting for a bus in Finland's cold winter:

> At the bus stop if you're 30 seconds late, they're gone. When it's -20°C and you're waiting for the bus you don't want to wait one minute longer. It is life or death! It is a respect thing too. Being late means I respect *my* time more than I respect *yours*. I actually like it this way because it's assumed that my time is not more important than your time. Why should I keep you waiting? You might have other stuff to do.

[141] Not a single informant was a no-show to my interviews. Not once did I feel it necessary to send a reminder email or text message to a Finnish informant to ensure his or her presence at a proposed time and place despite scheduling the meeting, say, a month or two in advance.



Schedule for Delayed Models & Data Report on an Informant's Wall.

Many non-Finnish observers of the Olkiluoto repository project were struck by how it plodded on on-schedule since the early 1980s with only minimal adjustment even to deadlines laid down decades before. The same could not be said of the U.S., German, UK, or French disposal projects. This remarkable punctuality emerged in part from commitments to prefigured iteration horizons. One consequence, however, was that the Safety Case expert worlds I studied were rife with workplace politics of lateness. Many noted how micro-delays had accumulated to make it so some reports positioned at the end of the CLA iteration schedule had to be submitted late. STUK and Posiva granted deadline extensions to the experts responsible for these reports, which were initially due at the end of 2012. One late report was the RNT. Another was the BSA. The BSA, as mentioned, engulfed many other models' outputs as its own inputs. It was therefore situated at the very end of the Safety Case workflow's model chain: the end of the CLA iteration. To use the forest heuristic's terms, the BSA, by encompassing a host of other models as its inputs, was situated in a very high branch in the Safety Case treetops. So the BSA had to be completed *last*, only after a host of other reports had been completed and then fed into it as inputs. A BSA expert complained about the time crunch this imposed on him:

> We've been discussing this a lot with a lot of biosphere assessment experts around the world. We always end up being the ones that people blame, saying we are late. Remember, the people two

> years ago were over half a year behind *their* schedule, but *that* is forgotten. So this goes for everybody who is working with a biosphere [model], the last link of the chain.

The RNT was logically and generatively prior to the BSA. One could have a complete RNT without having a complete BSA, but could not have a complete BSA without having a complete RNT. For the latter to be complete, it first had to engulf the former as its input. To be completing these reports was to be working close to an iteration cycle's endpoint. Yet from a project management angle, the RNT and BSA were developed simultaneously alongside one another. That is, all aspects of the BSA not contingent on the presence of the RNT ideally should have been fully developed by when the time came for the RNT experts to hand off their completed model to the BSA experts. So, even while the RNT preceded the more-encompassing BSA in logical succession in the model chain sequence, in practice the two models were developed at the same time, with, ideally, only a minor time lag between the two reports' completions.[142] Therefore, the RNT and BSA existed as before-and-after in relation to one another in one sense (as links in a sequential chain connecting reports), but parallel-and-simultaneous in relation to one another in another sense (in the living world of Safety Case expert workflows).

Yet some reports that preceded the BSA in the model chain – like the Site Description, the repository layout reports, or the RNT – were, over the past years, submitted late, awhile after the deadlines initially laid out for them. A BSA expert explained to me how delays accumulated at the end of the chain, placing added stress on RNT and BSA experts' workflows. They had to

[142] But temporal incongruities could challenges to the organization of workflows. Given that the completion of some reports were contingent upon the completion of other reports which themselves were contingent upon the completion of still other reports, delays could emerge if, say, the BSA model failed to work neatly with any given result from any of the five subprocess models that fed into it as inputs. Why, experts had to ask, are the two models not talking to one another correctly? How could this be remedied? How could the RNT experts and BSA experts iterate with one another to discern, in tandem, why the results churned out seem haywire?

complete their tasks with less and less breathing room between the start of their projects and the 2012 CLA submission deadline. These accumulations of lateness could, according the BSA informant, be compared to delays in a less-than-efficient public transport system. If a bus driver lagged behind schedule for just twenty seconds to chat with someone at each of the twenty-two stops on his or her route, tiny delays would accumulate to leave the bus patrons waiting at the final bus stop with a frustrating eleven-minute wait. This would be a harrowing span in which to be standing still outside in Finland's frigid winter.[143]

Another Safety Case expert described how accumulated delays could lag workflows by evoking the sorting process an inexperienced hiker might undertake when packing his or her backpack before, say, a month-long trek through the wilderness. When mulling over whether to put a certain item in his or her backpack, an experienced hiker knows that he or she must seriously ponder "is it worth shouldering this extra weight, however small, for this entire journey?" And, while an inexperienced hiker might be tempted to apply the additive logic of "well, item X hardly weighs anything, might as well take it!" again and again, the experienced hiker knows that doing so for item after item will make his or her backpack gradually accumulate weight. The backpack will ultimately end up too heavy to carry for long distances. Hence, when packing a trekking backpack or arranging workflows to keep tempo with Safety Case iterations, to repeat the same "a few more kilograms/weeks won't kill us" logic would throw one's organizing rhythm off kilter. This would create future stresses and risks.

Accumulations of lateness established a blame chain that flowed parallel to the model chain but in an opposite direction. The model chain – plotting a way forward toward an iteration deadline –

[143] This analogy was seen as apt in Finland, given Helsinki's strikingly efficient, orderly, and on-time public transport system—which is itself often held up as an emblem of Finland's punctuality ethics.

was successive and future oriented. The blame chain, starting at deadlines and flowing backward across chains of responsibilities, operated in reverse. For example, if a Posiva manager were to deride BSA experts for being late, the BSA experts could point to how sub-process models inputted into their model (like, say, the RNT) were handed off to them late. The RNT experts could then point to how inputs into their models (e.g. the repository layout model) were handed off to them late from experts in prior modeling chain positions. Those experts could then point to the delays caused by the revision of the repository's architecture when the since-abandoned OL4 new reactor building decision was being mulled, and so on. As one BSA expert put it, to blame only the experts at the end of a model chain would be like scapegoating a hockey goalie for the opposing team scoring a goal. Since the whole hockey team, typically, would have to fail a bit first to allow a goal-scoring situation to arise in the first place, to single out the goalie as blameworthy be would be to obscure whatever blame his or her teammates might rightly deserve.[144] The moral, my informant suggested, was that one must not scapegoat a single person as blameworthy while ignoring the webs of relations (the team supporting the person) that had to fail first in order to place the blameworthy individual in a bad situation in the first place.

Safety Case deep time-reckoning emerged only through iterations and reiterations of part/whole, input/output, and iteration – plus countless other formal devices I have not highlighted in my analysis – and the bundles of project tempos and time horizons that co-became along with them. This established temporal matrices in which informants' work was seen to persist into the future.

[144] This informant's "hockey goalie" heuristic is perhaps unsurprising given how many of my informants, like millions of other Finns, enjoyed hockey. When I was in the field, a *New York Times* article "Finnish Soul Is Reflected In Goalies" noted how a "country of 5.41 million people has produced more N.H.L. goalies than any other European country" and how "[o]n a more elemental level, goaltending is Finland's mirror, reflecting the strong, quiet and fiercely proud character of its people" (Crouse 2014). So, much like how Finnish informants have retooled forest imageries to explain to me the nature of the Safety Case projects, stereotypically Finnish imageries relating to hockey, efficient public transport systems, and punctuality too had been recast to explain why delays had arisen in the Safety Case model chain.

In these matrices, modeling techniques, while seen as generating fresh knowledge, were also seen as generating fresh non-knowledge over time. This showed how generating more certainties also generated more uncertainties (cf. Strathern 1996). As past iterations lapsed into present and future iterations, informants saw the project as having increasingly longer pasts and increasingly shorter futures. The now was seen as gravitating toward a future and away from a past. Informants saw these trajectories as essential to how Safety Case work's growing complexity elicited expanding personnel and reports over time. It also, as a formalization of informants' yearnings toward finer grain densities and higher-resolution futures, endowed models with teleologies of continual refinement. It endowed them with senses of what they had accomplished so far and what had to be accomplished in the future. The ever-presence of future-revision iterations took the weight off of their present knowledge's incompleteness.

Safety Case experts' ambitions relied on this positive forward inertia: if their knowledge could not get better or worse, they could feel like there was nothing to be gained or lost through good or bad work. This momentum was inseparable from delineated matrices of action that were inseparable from iterations and reiterations familiar distinctions like part/whole or input/output. Central to this was iteration as an evolutionary agent replicating parts-and-wholes and inputs-and-outputs progressively across time—imprinting the portfolio's formal self-similarity on each model. This all iterated with specifically defined workplace role templates (See Chapter 2): teams of Safety Case expert people organized in positions vis-à-vis one another's positions. These positions loosely mirrored the parts/wholes and inputs/outputs templates internal to the portfolio reportage. In these roles, experts iterated and reiterated these familiar devices to endow their project-worlds with pattern. With this in view, the next section explores how certain informants yearned to give the Safety Case's collaborative complexity even finer clarity by informally refiguring the portfolio as maps, the Nazca Lines, and a forest. These heuristics, I show, indexed informants' ongoing sensitivity to how their own knowledge's limits intersected with others' knowledge's limits. This attentiveness was, for insiders, essential to achieving the multi-perspectival, multi-scalar, multi-disciplinary vantage on the portfolio that the Safety Case collaboration needed to be drawn forward, by iteration, into the future.

Maps, Nazca Lines, and Forests

A Safety Case insider described input/output, part/whole, or iteration as working something like "You Are Here" signs on maps: they helped insiders navigate their vast and varied portfolio's partially signposted terrain by identifying their own work's coordinates within it. All projects could be positioned in particular parts, wholes, or iteration stages. Iterating these forms helped keep it together. It also helped STUK regulators and independent reviewers from abroad see how individual reports linked up with the portfolio's broader patchwork of projects. The maps heuristic was just one example of how, during fieldwork, some informants already had repertoires of tools they used to make their webs of interrelation more comprehensible to themselves, to one another, and to outsiders to Safety Case worlds like me. To quote one expert:

> No one person can describe how the whole system works based on what we know anymore… It is important to have the big picture, not just the details. But if you need to travel and go to a certain point on the map, you need the details. That is what STUK is going to do. So they need the details too so they can move around in these reports and see if they can actually find the destination or not… You have to have an opportunity to zoom in... That's why we have thousands of pages. If STUK wants to zoom in on something, it has to be there. It has to be all laid out.

The Safety Case's "all laid out" and "big picture" feel was grounded on continuities across parts. Traversing these tangles, like the wilderness backpacker described in the previous section, required skill in adopting multiple perspectives—toggling back-and-forth between different points on the broader project map. It also required careful attunement to matters of scale. Emphasizing this, a geologist informant named Taimi compared Safety Case experts' collaborations to those from which western Peru's Nazca Lines geoglyphs emerged between 400 and 600 AD. Taking a zoomed-in view from the ground, she noted, the Nazca Lines look like but long walls or arbitrary lines of stones. Taking a zoomed-out view from a helicopter, however, the Nazca Lines take form as images of hummingbirds, monkeys, lizards, and sharks. To create the Nazca Lines or a Safety Case, she reasoned, collaborators must understand how parts of one's own project will be scaled-up to feed into a bigger-picture:

> As for the Nazca Lines, flying above you can see that there are patterns. Nobody knows how they were made, but you can see their broader logic only from above on an airplane. They're unremarkable when you view them from the ground. To figure out what they represent on the ground, you would have to case the things and sketch it and make measurements. Looking at the Safety Case broadly like you're above in the canopy is like viewing the Nazca Lines from an airplane: you are not lost in the rainforest trying to understand the whole by tracing it out from a point or single report, a single part of the larger fabric.

Taimi – who was originally from Catalonia but was married to a Finn[145] – shared her university-age daughter's interest in Archaeology. Her Nazca Lines heuristic, like the map heuristic, helped Safety Case experts see their work – which could otherwise be received as a formless cacophony of diverse expertises, reports, projects, datasets, technologies, theories, and so on – as an interconnected collaborative. It did this by nudging one toward seeing one's own agencies inside a collaborative totality while also seeing a collaborative totality's agencies inside oneself. This

[145] She requested to be pseudonym-named "Taimi" but did not have a Finnish name.

challenged one to strain to see oneself as one would appear from a vantage outside oneself, as if positioned transcendently above oneself, seeing a collaborative totality all at once. It endowed experts' professional self-concepts with a better sense of their knowledge's incompleteness that many saw as more amenable to collaboration. The Nazca Lines and maps heuristics did this by pointing to gaps in individual experts' knowledge – gaps inextricable from their work's positions in the portfolio's internal part/whole and input/output relational templates – that appeared fillable only by working with other experts' knowledge and vice versa. From this, a Safety Case whole greater than the sum of its parts emerged. The iteration form asserted the Safety Case's changing knowledge's tentativeness across time. The Nazca Lines and maps heuristics qualified Safety Case experts' knowledge by asserting its perspectival incompleteness.

Another expert, in a similar spirit of pointing to Safety Case knowledge's inter-subjectivity, recast her workplace collaboration role templates as a *forest*. Laura was trained as a chemist and was originally from Italy. She had previously worked for nuclear waste projects in the U.S. She moved to Finland with her American husband, who did laboratory research on bentonite clay saturation for SROY's Olkiluoto repository projects. What Laura liked most about Finland was how her kids could play outside safely in the streets without crime worries. Laura was, among other things, responsible for discerning the big-picture of how Safety Case models and data interwove. Working in this coordinative role, she often topologized and taxonomized for me the different sorts of knowledge and experts from which the Safety Case portfolio emerged. She described the Safety Case collaboration's organization as follows.

Laura emphasized how some experts were to view the portfolio from the "treetops" by grasping the details of how myriad meta-level reports containing models-containing-models-containing-models and so on wove together. Others were to comprehend the portfolio's "roots" by grasping the details of how, say, how very specific datasets and models fit together. Still others were to comprehend the portfolio's "branches" composed of models that subsumed myriad other Safety Case models' outputs as inputs of their own, but still were not at the tail end of the data chain and hence produced outputs that fed into other more-encompassing meta-models at the portfolio's canopy. To quote Laura:

> In the Safety Case, you have the forest and the trees. The forest is the big overview; the trees are the details. That is a metaphor that is used commonly. When you say "you're looking at the trees, you're not looking at the forest" we mean "look at the big picture, don't get bogged down focusing on the details." And that's what we do. We try to look at the big picture. Try to keep in mind the whole ecosystem, not the individual details that can go very deep down to the roots. That's where the modelers work, to make sure that *everything* works. If you have only the top without knowing a little about the roots you have just this big green mass. And then if you have only the roots, you only see grass and brown stuff and you don't have the whole gamut. … Seeing both comes with experience and time… You cannot isolate one branch from the rest of the tree. It has to be *organic*. We need the food from the roots. And the roots need the treetops for light and life—for money to do their research.

The Safety-Case-As-Forest heuristic nudged collaborators toward acknowledging how their projects were nestled in specific roles within what Laura called the Safety Case's roots, branches, or treetops. It was enacted to suggest that project insiders should adopt more open-minded and holistic professional self-concepts. Sometimes it was enacted to discourage fellow Safety Case experts from getting bogged down in the details of their own projects. Like Nazca Lines and maps heuristics, it encouraged them to see their work in light of the Safety Case's big picture. It emphasized how one must keep in the back of one's mind how one's own projects scaled up to integrate into the broader forest of Safety Case reports that transcended any individual project team, expert brain, or workplace role position. This reminded Safety Case experts that they were but individual expert organisms inhabiting a broader collaborative ecosystem.[146] When I mentioned the forest heuristic to an expert working under Laura, he worried it was just another technique used to encourage deference to Posiva managers. He was concerned that it sought to put experts in their places by encouraging them to not speak out on behalf of themselves. He suggested the forest heuristic nudged experts toward submitting passively to the workplace role orderings – relational orderings that loosely mirrored the portfolio's part/whole and input/output logical orderings – laid down for them by their project managers. For him, Safety-Case-As-Forest simply aestheticized a formal workplace hierarchy and chain of command, verticalized high-versus-low,[147] with sylvan motifs.

Documents of Deep Time-Reckoning in a Safety Case Expert's Office.

[146] The Safety-Case-As-Forest heuristic's boreal aesthetics alluded also to how the Safety Case was literally alive: how it was an interdependent collective achievement in which the whole was sensitive to perturbations of the parts—perturbations like, for instance, an unanticipated death (Chapter 4). Indeed any event causing certain highly specialized living experts – in root, branch, or treetop positions – to cease to infuse their professional energies into the Safety Case collaboration could have put the portfolio's blossomings at risk of withering. To emphasioze this was to emphasize how the relatively short-term horizons of Safety Case experts' interdependencies, vitalities, and ideation were inextricable from the long-term horizons of the Safety Case's multi-decade and century-plus project lives.

[147] These high-versus-low relations permeated my field site: there were higher/lower level meetings, higher/lower level people, higher/lower levels of nuclear waste, higher/lower levels of modeling chain inputs/outputs, and higher/lower levels of data. Data inputs' highness/lowness of significance was gauged by what modelers called "sensitivity" levels. There were also higher/lower qualities of knowledge: with engineering expertise perceived to be on top, mathematical modeling a bit lower, qualitative/analogical work even lower than that, and informal *puskaradio/viidakkorumpu* gossip closer to the bottom.

The Safety Case collaboration looked very different from different role positions. Yet those who wielded heuristics like maps, Nazca Lines, and forest yearned to integrate all actors into unified frames of collaboration. Experts in project-management roles had incentive to temper the influence of particularly dogmatic or seemingly unbalanced expert dispositions in these interlocking chains of collaboration. This was seen, among certain coordinators in treetop positions, as key to maintaining fluid workflows. The heuristics helped them slot experts of divergent backgrounds, mentalities, and sensibilities into patterned role layouts established in light of experts' similarities and differences, and strengths and weaknesses, vis-à-vis one another. They encouraged Safety Case experts to attune to how their work refracted and diffracted relationally in and out of that of their colleagues. This nudged experts toward seeing themselves as inhabiting constellations of interrelated expert positions – each with relative perspectives constituted vis-à-vis one another's relative perspectives – within divisions of responsibilities.[148] This drew experts to commune regularly with the limits of their own specializations in ways enabling workable collaboration.[149] The maps, Nazca Lines, and forest heuristics gestured to the impossibility of any one person fully comprehending the intricacies of each and every part of the Safety Case – and the intricacies of how these parts wove together to form a whole portfolio – simultaneously.

The heuristics could broaden informants' horizons. Or they could enforce pyramidal workplace orderings. With this in view, the next section reflects on how maps, Nazca Lines, and forests

[148] Such could be seen as opening experts to continually revisiting their own professional self-concepts afresh in tandem with colleagues open to doing the same. That said, failure to achieve this sensibility put the expert at risk of descending into a disposition of defensiveness: receiving different sorts of experts' seemingly incompatible perspectives as threats to his or her own expertise's integrity.

[149] Cultivating adeptness at perspectivally shifting one's focus between root, branch, and treetop positions could be seen as having drawn Safety Case experts toward wider holisms—toward, to borrow ideals from a longtime Safety Case manager, embracing the collaboration's diversity of expertises by finding ongoing "intellectual pleasure in excursions to new areas of knowledge."

entangled with input/output, part/whole, and iteration to help Safety Case experts endow their mammoth portfolio with patterns that enabled intelligibility amidst uncertainties. This does more than show how Safety Case experts formally made models quantitatively while also informally modeling their own collaborations qualitatively. It reveals organizing relations of merography, teleology, hierarchy, and self-similarity that may have otherwise escaped analysis. This, I have suggested, is best apprehended through an anthropology of form, aesthetics, and pattern that backgrounds emphases on models' epistemologies or credibilities and foregrounds modeling projects' form and modelers' auto-analyses of their own workplace roles. This anthropological approach tapped into the essence of how Safety Case experts have related to themselves, have reflexively engaged their work, and have generated onward momentums into tomorrows. I conclude by reflecting on what this can offer social studies of future-gazing modeling practices in regulatory science contexts.

Devices Profoundly Simple Yet Simply Profound

When I first encountered Safety Case deep time models, my impulse was to try to upend their epistemic simplifications by untangling the networks of experts, machines, documents, instruments, ideas, and administrative infrastructures that were assembled to make them. This was very useful for understanding my field site. My training in Anthropology and STS had provided me with powerful tools for critiquing how modelers distilled a complex world into more quantifiable terms. Safety Case modelers did, after all, work on what a constructivist STS scholar might have called a "highly preconstructed artifactual reality" (Knorr-Cetina 1983:

119).[150] Their reports were artifacts of hyperconstructive work typical of scientific research dependent on simulations and modeling (Gusterson 2008: 559). Their models were grounded on scientific labors to order disorder[151] or to discernibly represent chaos—to quantify, regulate, or plan for unplannable in the face of risk (Beck 1992; Giddens 1990). Safety Case worlds were rife with examples of how a world-out-there's "background" can be "frozen and stripped away," "idealized," and purified to make phenomena scientifically intelligible or manipulable (Wynne 1987: 4). It was, right off the bat, clear to me that Safety Case models could be analyzed historically in a "how we came to know what we know" spirit like the one Paul Edwards developed in his study of global weather and climate knowledge infrastructures since the nineteenth century (2010: xiv).[152] They could be analyzed as susceptible to what anthropologist Kaushik Sunder Rajan had called epistemic fetishism (2006). They could be analyzed as what sociologist Andrew Lakoff had called "fictional experiences of the future in the present" (2008: 401).[153]

These lines of thinking could and can powerfully show how Safety Case models' epistemological statuses, in a variety of different ways, were always fated to be but pragmatic reductions of reality. So, in those first months of fieldwork, I took intense notes on how seemingly extra-scientific issues interwove with Safety Case models' production, reception, and

[150] Indeed, as Porter has noted, "any domain of quantified knowledge... is in a sense artificial," as "reality" itself "is constructed from artifice" (Porter 1995: 5). Porter's work on numbers and trust has influenced and been influenced by STS approaches to policy quantifications.

[151] See Vaughan's discussion of Star's work in Vaughan's thorough study of the Challenger space shuttle disaster for more on "transforming disorder into order" and representing "chaos in an orderly fashion" (Leigh Star cited in Vaughan 1996: 401).

[152]Edwards' work on climate models present other interesting analytical trajectories—for example, how "global data" is and "made global" or how "data friction" and "computational friction" can affect modeling work (2010:

[153]Related work by Barbara Adam explores how futures can be objectified, reified, or "commodified" (cf. Adam & Groves 2007: 8)

circulation.[154] My informants' portfolio was, like the ones Allison Macfarlane described in the U.S. Yucca Mountain nuclear waste repository project's construction licensing efforts, clearly "co-evolving" in a "feedback loop" with regulatory mandates such that its technical details could, to use her words, "not be separated from policy and vice versa" (2003: 784, 789). Safety Case models were parameterized by what Kristin Shrader-Frechette, analyzing nuclear waste disposal risk modeling practices in the United States, had called "methodological value judgments" (1993). I initially saw my field site as inviting analysis of how, to borrow words from Theodore Porter, "objectivity" can derive its "impetus, and also its shape and meaning, from cultural, including political, contexts" (1995: 90). I saw it as inviting scrutiny of how models can get caught up in sociotechnical imaginaries (Jasanoff & Kim 2009) or controversies in hybrid socio-technical forums (Callon et al. 2009). I therefore spent many hours pondering how models and politics interacted (cf. Edwards 2010: xxii) and how models achieved credibility, authority, or legitimacy (cf. Wynne 1987: 5, 8).

These initial analytical impulses, shaped by my recent social scientific training, were fruitful. They attuned me to how Safety Case models entangled with historical, political, socio-cultural, economic, and environmental imperatives. They drew my attention to how Safety Case models – presented as static representations in paper or electronic pdf reports – were products of flux processes, contingencies, and emergent complexities.[155] STS and Anthropology of Science teachings prepped me to avoid any naïve illusions of Safety Case models as decontextualized final Truth or unqualified universal knowledge. They inspired me to explore the (social)

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[154] As STS scholars have often observed, "the technical" is not a "clear-cut and simple world of facts insulated from politics" (Mackenzie 1990: 356).

[155] To borrow words from Brian Wynne, Safety Case models were developed in worlds an STS scholar might describe as "contingent, open, complex, hybrid and ambiguously… always non-completed… endemically in-the-making" (2005: 67). Such perspectives take seriously how "state of knowledge undergoes constant redefinition" (Jasanoff 1990: 80).

assembly, construction, coordination, materiality, and organization of the models' messy realities.[156] They led me to reflect on models' fragilities as tentative, context-dependent, manipulable, and open-ended reductions caught in the tangles of technicalities.

Yet, as my thirty-two-month field immersion progressed, I increasingly realized how my informants already had a strong sense of how they hyperconstructed their models in pragmatic-and-contextual, not universal-and-final, spirits.[157] This was in part due to STS's decades of success disseminating its perspectives among expert communities. Most saw themselves as simply responding, to the best of their abilities, to legal mandates requiring them to pursue deep time-reckonings that they all knew were ultimately impossible to attain. They were self-aware about the extra-technical dimensions of their work, the limits of data collection, and the vast extrapolations required to model events across deep timespans.[158] They knew all too well how interpersonal workplace disagreements could shape how futures were modeled. Many reminded me that they saw themselves as providing regulatory evidence rather than absolute scientific Truth.[159] Some even went so far as to program uncertainties about their knowledge's limitations into their models. The BSA, for example, integrated certainty- or uncertainty-tags that gauged

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[156] It is thus easy to understand why STS-inflected trajectories – from SSK to SCOT to ANT to the Strong Program and others – have deeply influenced ethnographies of technoscience (Fischer 2007; 2009).

[157] One informant lauded the ambiguating talent and multi-perspectival dynamism of many experienced scientists. This indexed how reflexivity, self-awareness, and nuance was valued among certain Safety Case experts. To quote him: "Scientific discussion works because scientists are 'are on one the hand, on the other hand' people. Scientists should not be one-handed: good scientists have a certain vagueness in expression so that the more experienced and the better a scientist, the less he or she is giving you straightforward opinions that are easy to digest… Young scientists in my team like making absolute statements, say, in their theses. My standard comment is, 'no, you must kind of dilute this, qualify it, say that this is so because we have this kind of evidence'... Whenever you talk to an experienced scientist, it is always such that you can never really get his or her neck in a loop. You can't nail him or her down."

[158] Safety Case modeling knowledge thus, as Riles might put it, proceeded "from an awareness of its limitations" (2010: 800).

[159] To address this in greater detail: informants knew well that, in producing technical evidence for Posiva, their aim was to – to borrow words from Strathern – "reduce, digest and otherwise summarise information in such a way [that] other information can be judged, proved, or verified" (2008: 22). That is, they knew it was their aim to reduce, digest and otherwise summarize prognostications about far future happenings to confront the repository and the region surrounding it such that the present-day facility's promise can be judged, proved, or verified.

the hardness or softness of models' inputs and outputs. In it, a scenario could be tagged a "what if case," a "sensitivity case," a "realistic" case, or a "most realistic" case (Hjerpe et al. 2009: 28, 30-33). The BSA also included a "Knowledge Quality Assessment" (KQA): a technical self-analysis, developed by the BSA's authors, that demarcated the incompleteness of their models' and scenarios' assumptions, inputs, and outputs.[160] KQA acknowledged how "large uncertainties in the knowledge base" created a "need for conceptual assumptions and simplified modeling" and for "communication of assumptions and uncertainties throughout the assessment chain in a systematic and comprehensive manner" (27, 141).[161] The aim was to enhance confidence in BSA knowledge by being forthright about the contours of its incompleteness. This aided experts in taking negative and critical knowledge ("we don't know x") and retooling it into positive, practical, instrumental knowledge ("we know that we don't know x, but we will outline its boundaries, and explain how this information gap relates to, say, variables y and z").

If I were to focus my ethnography primarily on these uncertainties – or on how radically futile it was to try to reduce distant future ecosystems to science's auras of objectivity – I would be preaching to two choirs.[162] The first would be the social scientists already steeped in rigorous STS-inflected work on expert knowledge. The second would be the Safety Case experts who already saw navigating entanglements, uncertainties, and contingencies as central to their

[160] Yet the KQA's transparency about Safety Case knowledge's incompleteness also served to deflect critique. Safety Case defenders thus benefitted from how, to quote anthropologist Rajan, the "beauty of a futuristic vision… is that it does not have to be true," nudging others toward gauging their knowledge's quality along a credibility/incredibility axis rather than a truth/falsity axis (2006: 114, 121).
[161] The BSA described itself as trying to maximize the "traceability of assumptions and data used in each calculation case" and pursuing "evaluation of comprehensiveness and the classification of cases according to their level of conservatism and degree of realism" (Hjerpe et al. 2009: 25).
[162] To rephrase and unpack this point a bit: to write an ethnographic account of Safety Case models' reduced, simplified, or pragmatic epistemological statuses – or to point to how their creation, reception, or credibility was entangled with social, cultural, or political contingencies – would, while accurate, also be in part replicative of auto-critique that was both native to my field site and internal to my informants' models. A way out of this analytical bind was to instead focus my analysis on aesthetics, pattern, and form.

expertise.[163] So I began turning my attention more to how Safety Case experts (a) reflectively self-scrutinized their work, (b) integrated uncertainties into their models' technical parameters, and (c) enacted second-order patterns like maps, Nazca Lines, forest, hockey goalie, or wilderness backpacker to better grasp how distributions of reports and distributions of collaborators took form vis-à-vis one another.[164] That is, I increasingly backgrounded construction/assembly/epistemology questions and foregrounded form/pattern/relations questions in my analysis. This revealed much about how Safety Case experts navigated uncertainties, pressed on toward impossible intellectual goals, and felt at home in worlds that far exceeded any person or computer's possibilities for comprehension. These classically anthropological questions helped me develop my inquiry into how informants introduced pattern into uncertain worlds to plot pathways between past, present, and future.

These patterns established baseline familiarities that helped Safety Case experts stretch their intellects into deep futures. The devices they iterated to generate them had one foot in reports' logical relations and another in experts' interpersonal relations.[165] "BSA," for example, referred to both a corpus of documents and a team of people. "RNT" did the same. Each portfolio segment generally corresponded with an expert group responsible for it. To see this was to see how experts' relations formed reports and how reports formed experts' relations.[166] When reality was reduced to create knowledge, it was also doubled to create knowledge relations and expert

[163]These forms, as discussed in the beginning of this chapter, captured the interest of late modern Safety Case modelers and late modern anthropologists in similar measure.

[164] This chapter's goal was not to merely prove that informants were reflexive: that was its starting point not its endpoint. Yet informants' nuanced self-scrutiny of present imperfections and goal-oriented pursuits of future ideals ought not be surprising given rich social scientific analyses of reflexivity as "an ordinary, unremarkable and unavoidable feature of action" (Lynch 2000) among "thinking subjects" (Miyazaki 2013: 6) or "creative subjects" (Holmes 2013: 179).

[165]This chapter's attunement to such conceptual divides renders it in part a study of modeler epistemology—but epistemologies that were always already relational and mediated by the organizing forms this chapter foregrounds.

[166]In one sense, then, they were what Star & Griesemer call "boundary objects" (1989) Safety Case collaborators shared to enable comprehensible cross-pollinations of ideas across disparate fields and subfields.

relations almost as mirror versions of one another.[167] At some level of generality this mirrored ethnographic knowledge in how it was both "relationally produced knowledge and knowledge productive of relationality, and this knowledge is the artifact of genuine struggle" (Riles 2016: 185). This struggle could not occur without experts – and their computers, reports, associates, administrative staffs, reports, and other agents – first synchronizing how they iterated grounding merographic and means/ends relations that spanned them all. Anthropological works about form, aesthetics, and pattern became essential to helping me articulate this. Doing so showed me how iterations of familiar devices and patterns wove together a shared real. This made deep time-reckoning's mundane, inter-subjective, black-boxed grounds appear profoundly simple yet simply profound in the complexities they organized.

Yet it was my informants who first helped me see how radically basic devices like input/output, part/whole, and iteration shaped relations between knowledge, documents, and people. Our conversations taught me how central iteration of the familiar has been to the culture, politics, epistemology, and history of future-gazing modeling knowledge in regulatory science. They revealed how modelers imprinted aesthetics of consistency on messy realities. They revealed how experts inscribed inter-linkages between teams, reports, and models with self-similar patterns to orchestrate collaborations in more airtight and hence more authoritative ways. They revealed shared ideascapes that enabled modelers to think, act, and elicit affirmations of credibility from others. They revealed how oft-neglected agencies of form enabled project

[167]Attuning to expert form iteration at this level of specificity can provincialize Safety Case modeling practices' late modern grounds as operating within what some anthropologists would call a perspectival-multicultural ontology – positing a plurality perspectives on a single open-to-interpretation Real – rather than, say, an Amazonian-Amerindian perspectival-multinatural ontology positing a plurality of perspective-generating worlds splitting off from a unitary primordial humanity-subjectivity (Vivieros de Castro 2004). It could provincialize modeling as unfolding in a late modern, not postmodern, reflexive intellectual settlement in which grounding relations of merography have not been cancelled and fidelities to scale relations maintain (Strathern 1992a). Such provincialization could, via comparison, reveal something essential about the intellectual habitus in which regulatory science modeling takes place.

continuities across time that enabled complex collaborations that enabled deep time-reckoning. They revealed how experts, reports, and models were cast as tentative works-in-progress that each anticipated improved versions of themselves in futures. These were the perks of focusing analysis more on informants' most basic thinking patterns and relations aesthetics and less on, say, the material networks or socio-technical infrastructures through which Safety Case models were, at first at least, most obviously assembled.

In sum, this chapter was testament to how iterating familiar devices like iteration, part/whole, input/output – reinforced by heuristics like Nazca Lines, forest, and maps – laid more stable plateaus for moving forward in Safety Case expert worlds. These momentums could spawn dreams, imagination, anticipations, and clever modes of articulating collaborative complexity. They showed how deep time visions emerged in shallow everyday time horizons. Yet forward inertia and stable project organization were not always readily apparent. The patterns this chapter addressed thrived in ordinary moments of routine. Amidst steady workflows, informants were apt to talk about their work in detached technical terms without emotions welling up, without appeals to workplace personality politics, and without opening up the black boxes of basic project organization formations. Informants were more open to riffing inventively about the Safety Case portfolio's fractal patterning in moments of non-crisis. However, the opposite was true in moments of workplace uncertainty, transition, instability, or time crunch. The next chapter explores the fallout of one such crisis: the unanticipated death of an influential Safety Case expert upon which many informants had closely relied. In contexts like those, the systematic formations chronicled in this chapter were backgrounded. Safety Case collaborations succumbed to a contingent accident's disorder. Surviving colleagues responded, Chapter 4 shows, by iterating and reiterating a deceased predecessor’s various figurations. They moved into the future by reinventing some lost figures from the past.

(Chapter 4) Specters of Seppo: The Afterlives of Safety Case Expertise

The Safety Case was a mammoth assemblage of reports containing datasets, models, scenarios, descriptions, diagrams, charts, forecasts, maps, documented findings, and much more. Yet Seppo, a key developer of its modeling approaches, had long been reputed for his intricate understanding of the portfolio's complexities. A leader in the project since the 1980s, Seppo was described to me as the Safety Case's former "dictator" who "pulled all the strings." One insider called him the project's Kekkonen—a reference to Urho Kekkonen, Finland's longtime former Prime Minister and President, who was in office from the 1950s to the 1980s. Seppo was known for his temper, sometimes-caustic personality, and acerbic straightforwardness. When he died suddenly in a mid-2000s bicycle accident, it dealt a serious blow to the Safety Case project—bringing it, to use one insider's words, to a temporary but "screeching halt." Surviving colleagues realized that their work had come to rely so heavily on Seppo that it, as one put it, had become sort of a "one-man-show." Rejuvenating Safety Case workflows and restoring project "equilibrium" once more took months. Seppo's death-event obviated how the uncertain time horizon of a single human life course cut short entangled with the everyday office horizons of Safety Case experts' projects to augur distant future worlds. To recover from these instabilities, Safety Case insiders found themselves summoning, conjuring, or channeling memories of the late Seppo, whose "specter" – as one put it – still "haunted" their expert community.

Recollections of Seppo's predecessor persona figurations were iterated and reiterated nostalgically in stories, referentially in technical troubleshooting moments, and anecdotally in discussions of project phases past (Ialenti 2017). This helped endow Safety Case projects with continuity from pasts into presents and futures. When experts summoned Seppo, they focused less on what knowledge disappeared when an expert's body died – or how it could have been preventatively backed-up or managed – and more on what was perceived to have lived on of the expert's thinking patterns in and through them. Ethnographic inquiry into how they thought with remembered renderings of Seppo's former thinking patterns revealed subtle afterlives of expertise that could be glossed over in nuclear sectors' own sociologically inflected knowledge management, expert loss, and intergenerational knowledge-transfer studies. This chapter presents an anthropological counterpoint to those studies that is more attentive to expert predecessor agencies and the intergenerational consciousness they foster. Becoming more sensitive to this, it argues, becomes essential amidst today's mass baby boomer retirements and intergenerational transitions in nuclear energy sectors across Europe, North America, and beyond (See Chapter 2).

The sections to follow present four key spirits in which surviving traces of Seppo's influence were channeled. I call them Seppo-As-Anecdotes, Seppo-As-Voids, Seppo-Being-Succeeded, and Seppo-As-Predecessor.[168] Each indexes a common mode through which Seppo's memory shaped my informants' professional worlds. Safety Case experts' fascinations with Seppo's postmortem influence broadly paralleled those of anthropologists who have studied haunting, death, and ancestor figures.[169] That scholarship has shown how the dead can "retain a functional

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[168]Informants did use the words "voids" and "predecessor" explicitly. That said, these four Seppo-As modes I describe are heuristics I have developed to organize my field materials and convey them more clearly. I do no present them as exhaustive lists of ways Seppo's expertise attained afterlives. Another ethnographer might categorize these differently or abstain from categorizing them at all. I posit these distinctions as devices for demonstrating general ways (a) through which Seppo was summoned postmortem and (b) that I suspect will be at play in other contexts of afterlives of expertise.

[169] I do not, however, use the term "ancestor" explicitly in this text. Instead I posit "predecessor," an actor-category. My hesitancy to posit "ancestor" is loosely inspired by Kopytoff's critique of how Fortes "does not take the final step of shedding the ethnoecentric connotations of the very term 'ancestor'" (1971: 137). I analyze a dead predecessor as an almost-ancestral past-in-a-present-looking-to-the-future, but do not mean to imply any literal *OED* structural-genealogical definition of "ancestor" as one "from whom a person is descended, either by the father or mother; a progenitor, a forefather" (2016): Seppo's story is not about kinship in any literal sense. And it also has little to do with (a) debates about evolutionary universals posited by past anthropological evolutionary studies of religion or (b) the definitional politics about when, where, and why an anthropologist can legitimately apply the concept of "ancestor" versus, say, "ghost" or "ascendant" or "spirit" or an indigenous category. But tapping into such predecessor references' nuances in an ancestor studies inflected way, I suggest, is essential to understanding nuclear waste expertise's peopling, succession, and intergenerational continuity processes—which, as Posiva's

role in the world of the living" (Kopytoff 1971), can "profoundly [inform] the social identity of the living" (Kaufman & Morgan 2005: 323), can retain "enormous social force long after they themselves have died" (Graeber 1995: 272), and can be "part and parcel of the everyday life of their descendents" (Fortes 1961: 184).[170] Pairing nuclear experts' and anthropologists' parallel interests in forebear figures can help develop fresh perspectives on nuclear sector knowledge continuity. This chapter pursues this just as those preceding it have: by analyzing how informants' unyielding iterations of the very familiar – in this case, to ongoing enactments of known predecessor figures in time – helped them find their way forward amidst unknown futures.

Managing Nuclear Knowledge

Expert loss challenges have been widely acknowledged in nuclear energy sectors' own reports, conferences, and discussions. They have been analyzed through rubrics of knowledge management, dissemination, transfer, and sharing (de Grosbois 2012; IAEA 2016). They have entered analyses of organizational learning and tacit, implicit, or experiential knowledge memory in nuclear energy generation (Chakraborty 2003) and nuclear waste disposal contexts (Ojovan 2010). These analyses have shown how abrupt unplanned-for retirement, outsourcing, downsizing, job transfer, death, or quitting events can stir up project-management instability when an expert with "valuable and unique knowledge" – a "go-to" person who "peers and management recognize as someone 'we can least afford to lose'" (IAEA 2006: 56-57) – is lost.

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repository is not scheduled for decommissioning until 2120, unfolded in Finland in multi-decade and centurial timespans unique to nuclear waste expertise.

[170] This chapter is also informed by humanistic work on haunting and specters that has shown how traces of past persons can persist agentively as presences or as absences (See Derrida 1994; Gordon 2008). To put this all in more anthropological terms, this chapter is about how Safety Case experts "invented" and "reinvented," often in incongruent ways, Seppo's left-behind "conventions" to do practical work in their everyday office lives (Wagner 1981).

Finland's Posiva embarked upon a self-described mission to "cross the generation gap" by replacing departing "experienced specialists" with "competent personnel" as it anticipated an expanded workforce of "110-120 employees from 2020 onwards" (Palmu 2008). Seppo's case could, from these perspectives, be taken as an episode in a broader "battle against knowledge loss" that nuclear sector insiders across North America, Western Europe, and beyond sought to combat with "knowledge management solutions" (Uj & Barat 2008). It could be taken as a case study about the "loss of knowledge" that can arise from "change in careers, retirement, death, industrial restructuring, etc" and how it can affect the "everyday experience" or "natural evolutionary process" of nuclear organizations (Chakraborty 2003).

Lessons drawn from Seppo's death and its aftermath could help optimize nuclear sector strategies to "best capture tacit knowledge and transfer it to successors" (IAEA 2006). As intergenerational knowledge management programs became more common in nuclear energy sectors, some informants nudged my analysis in that direction. They did so with advanced democracies' nuclear personnel demographic shifts and retirement waves in mind. They did so with repository projects' rarities, scales, and novelties relative to many other scenes of technocracy – and how such could make them exceptionally susceptible to overreliance on small teams of highly trained specialists – in mind. In these contexts, Seppo's story could be about the knowledge-loss risks associated with vital hyper-specialized[171] expertise being backed-up only in living expert brains rather than workplace reports, notes, or knowledge management platforms. If a crucial expert like Seppo were to die, so the thinking went, his or her knowledge could vanish

[171] A Safety Case insider in her late fifties described such hyper-specialization as follows: "Nuclear waste is such a specialized field. At least in Finland, you cannot get enough background information at any university or in any academic course. It is something that you have to learn at the workplace… The process takes five or ten years, depending on the kind of work. The youngest have been here for about four to six years. You can say that the one who has been here six years has fully learned one specialized kind of work. But to get them good enough do multiple types of jobs... ten years might be a good guess."

if too exposed to mortality's contingencies.[172] The death could obviate[173] how many workplace collaborations, workflows, and customs had been made from and through the departed expert when he or she was alive. This could throw projects into disarray. A KYT expert, bringing lessons-learned from a past expert loss event to bear on the Seppo story, put it this way:

> "We're extracting information from old-timers… This is a response to a risk that has been realized here a number of times. For example, there was some guy who was the only one here who knew how to use a computer code. He died. Nobody even tried to use it because he hadn't documented his work in such a way that an outsider could continue with it, so they abandoned the code completely and started with a new one. That was at least twenty years of experience wasted… Perhaps we should just set up some alcohol jars in the corridors and take their brains!"

Responding to these organization memory challenges, organizations like the IAEA cultivated globally mobile ways of thinking of nuclear projects as having "life cycles" lasting over one hundred years from "cradle to grave" (IAEA 2006). This raised awareness about how path dependent nuclear energy worlds can become if their multi-decade workflows are not reflexively auto-analyzed by insiders. It developed vocabularies for articulating knowledge preservation challenges. Some informants suggested that a role for Anthropology here could be that of a scribe documenting Seppo's death stories and presenting them in a lessons-learned, cautionary-tale, or teaching-moment spirit to help develop best practices. In such a study, nuclear sector wisdom on tacit knowledge transfer and knowledge management would provide the analytical framework; ethnographic fieldwork would provide the empirical case study data.

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[172]For more anthropological analysis of a mortal human life-course's "aleatory" sensitivity to "contingencies," see Bloch & Parry 1982: 12.
[173]See Wagner 1978 and 1986b for more on obviation processes.

But to defer to nuclear subjects' analytical suggestions in that way would risk reproducing, as the academic anthropologist's own analytic, STEM informants' amateur renditions of social scientific and management studies insights they encountered in their professional lives. It would also risk skewing research too heavily toward what nuclear information went to the grave with Seppo, obscuring how his postmortem persona retained influence in nuclear expert worlds even after his body departed. For all nuclear sectors' tacit knowledge transfer and knowledge management studies of expert loss can reveal about what expertise is *lost* when, say, a death-event imposes *absences* on nuclear expert workflows, they can easily fail to capture key ways memories of, insights from, and traces of the departed expert's agency remain *present* in surviving colleagues' lives postmortem on their own. This lapse can arise from focusing too squarely on how reified kernels of information can be recuperated and stored in, say, databases or archives. That trajectory can fail to capture how Safety Case experts, even without nudges from project managers, were quick to recount anecdotes about, comment on, and make ongoing references to their late colleague's recalled insights during troubleshooting moments and everyday chats. Seppo's contributions were immanent in them, living on in and through them. The next sections explore how surviving colleagues iterated and reiterated the lingering spirits of Seppo's personality and prowess. It does so in ways partially inspired by anthropologies of ancestors and ghosts.

Forebear Figuration: Seppo-As-Anecdotes

Seppo died six or seven years before my arrival in Finland. I never met him in person. Yet he, and the great Safety Case fluency he achieved over his three or so decades working on the project, remained on the tips of many informants' tongues. I engaged often with remembrances, documents, and traces he left behind. Seppo was, for me, unseen but not wholly unknown.

Remnants of his professional persona were inferred from anecdotes from colleagues who had worked closely with him and from those who had worked with those who had worked closely with him. This could never fully reveal the really real details of Seppo's life or death. His true heart and mind was inaccessible. Yet scouring my field site for anecdotes about him – as if I was a salvage anthropologist, a record-keeper, or a scribe preserving a memento account for institutional history or knowledge preservation purposes[174] – gave me a glimpse into Seppo's postmortem influence. It showed how Safety Case experts iterated and reiterated Seppo-As-Anecdotes, not still living but still living on, as a plurality of vaguely similar predecessor figures that shaped Safety Case experts' work lives.[175] While I never encountered Seppo's biological body, I engaged with what Hélène Mialet has called an expert's "extended body" (2012: 7).

The SROY Office in Kannelmäki, Helsinki. This was one spot where Safety Case deep time-reckoning took place.

Anecdotes about Seppo were many. One Safety Case informant told me how Seppo would fly off the handle at his secretaries and "directly devalue" his colleagues when he thought them to be underperforming. Always multi-tasking and looking busy, technical information was his

[174] This trajectory loosely paralleled, for example, Posiva's and STUK's own oral history book projects, completed a few years before my arrival. It also paralleled Sweden's SKB's technique of interviewing aging experts and managers to conserve their knowledge before they die. For more on intergenerational continuity techniques like these, see Chapter 2.
[175]Attending to this, this chapter explores the practical, logistical, and affective conundrums that Seppo's surviving colleagues experienced after his death. I therefore do not scrutinize death's existential, philosophical, or ontological dimensions: the object of my study is informant *post hoc* storytelling *about* a specific death event.

paramount concern. During meetings Seppo was often just half-following-along: reading through technical reports and only listening-in when he thought something interesting was being said. One informant told of how Seppo would sometimes storm out of a meeting room banging doors, only sometimes returning afterwards once he cooled down. Yet many spoke of Seppo's more jovial demeanor during sauna nights, workplace parties, or trips abroad. They noted how Seppo enjoyed cycling and traveling across the world for vacations. The workplace was where Seppo's stubbornness, irritability, and intellectual intensity manifested most acutely. But even this intensity was thought to have its upsides. One insider cast Seppo's intellect as brilliant and his straight-to-the-point personality as charismatic. Calling him a "skillful leader," one put it this way: what really angered people was that, even while being all of these ambiguous things, Seppo was at the same time "usually right." Cast as strong-willed and extremely intelligent, Seppo was said to have changed the very "environment" of the Safety Case project observable today. As Bateson once put it, "Socrates as bioenergetic individual is indeed dead. But much of him still lives as a component in the contemporary ecology of ideas" (2000 [1972]: 467). The same can be said of Seppo among his surviving colleagues.

Alongside Seppo had worked Gustav, with a background in Physics and Engineering, who some portrayed as Seppo's lackey, henchman, or sidekick. Describing their working relationship, one informant cast Seppo as the "tyrant" with the big-picture vision and Gustav as the "right-hand man" who focused more on nitty-gritty calculation labor delegated to him by his boss. An enraged Seppo fired Gustav twice. Others had similar stories. Seppo had once fired Rasmus, whose modeling expertise Seppo once allegedly denigrated as "like playing computer games." Both Rasmus and Gustav were promptly re-hired after Seppo cooled down. Gustav described Seppo as ambiguous: an "Angry Bird" who sometimes wore "raging bullhorns." He said he had learned to keep his "personal defense lines up" when around him. Yet he respected him and continued to value many of his mentor's insights long after his passing.

Seppo took his profession very seriously. Two insiders described his attitude toward Posiva as "more Popey than the Pope"—more pro-Posiva than Posiva itself. Gustav associated Seppo's dogmatism, formalism, and fundamentalism to the communist leanings of his youth. He explained how, even while Seppo had abandoned his political leftism long ago, his broader mentality toward life, work, and science was generally shaped by a more fundamentalist outlook. He noted how Seppo simply had the brains, will, and aggressiveness to get the job done. Many also recalled Seppo's status consciousness. Gustav once told me how Seppo once, drunk at a party, became deeply upset after receiving news that Rasmus had been promoted above him in Posiva's hierarchy. Seppo then, sadly and seriously, announced that, if Gustav were to ever be promoted above him, it would be the lowest point in his life. Gustav also recalled Seppo's envy when attractive female Swedish colleagues laughed more at Gustav's jokes and stories than Seppo's at a dinner at an international meeting. When I chatted with him, Gustav playfully mocked Seppo's reactions the time he, not Seppo, was selected to represent Posiva on a trip abroad. He joked that Posiva thought that the "handsome" charismatic Gustav would be a more diplomatic representative abroad than his standoffish domineering boss.

When informants described Seppo as meticulous and always bearing personal responsibility for his decisions, it was as though he yearned to, as Wagner might say, "be both individual and group" (1991: 162): to control and, to a certain extent, to *be* the face of Posiva's safety assessment projects. When they cast Seppo as powerful, competent, and reputable – yet also morally ambiguous and best kept at arms length – they alluded to his role, in life and in death, as what anthropologist Joel Robbins has called an *exemplar*: an individual a community holds up on a pedestal, allowing him or her to shape people's imaginations and how they live their lives (2014). Anecdotes about Seppo were rife with the "normally ambivalent" (Kopytoff 1971: 138) or "complex and ambivalent attitude toward authority" (Graeber 1995: 258) anthropologists have long reported from elsewhere where ancestors, forebears, or dead elders have had great influence.

Seppo was cast as always wanting to be on top of the heap. But he was never promoted to a Posiva management position. Seppo had many overlapping layers of authority above him—from Posiva's management to Finnish laws to STUK regulations to TEM oversight to international expectations from peers, reviewers, and agencies like the IAEA and NEA. He was thus left to assert his renown, constrained and enabled by his workplace role position in a broader nuclear waste regime, among those who had worked closely with him. He achieved this through a subtle form of localized charismatic authority. As Max Weber emphasized, charismatic authority's leader-follower relationships are fundamentally unstable if not routinized into rational-legal rules or traditions delineating how they are to be formally attained, upheld, and sanctioned (1978 [1922]). Without such routinization, the authority cannot survive death. Seppo, achieving only an informal cult of personality among only small circles of surviving colleagues, never saw his influence amply codified as management protocols. This made his loss all the more destabilizing.

When I chatted with Gustav years after Seppo's death, his past difficulties empathizing with Seppo were apparent. Yet he still missed him in a few regards. Today, he lamented, the Safety

Case community is "all about market economics and competition" – every scientist thinking that his or her own work is of the utmost importance – with "everyone" trying to "advertise" their expertise to "everyone else." That, he said, results in frequent conflicts between experts, money wasted on frivolous research, and excessive concern with the "cosmetics" of the Safety Case. In the 1980s, in contrast, the team felt more like a "big family"—a band of "crusaders" working toward a "good and honest safety assessment" and nothing else. He wanted to restore the Safety Case project to its past greatness. Gustav then joked to me that he sometimes imagines Seppo, sitting on a cloud in the sky, begging God to send him to Hell so he doesn't have to see the Safety Case "descend further into bullshit."[176]

Seppo was serious and intense about his scientific projects. He was said to be deeply competent. Seppo often worked late into the night. He rarely talked about his private life. One colleague called him a lonely rider and a lone ranger. Others noted his short physical stature. A Finnish modeler speculated that Seppo, discontent with the imperfections of the world around him, yearned to live in "the perfect world of his models." Some described a large visible tumor on Seppo's face. They explained how, prior to his death, it had been well known that Seppo had hemophilia and that, if the tumor were to rupture, Seppo could die. This was precisely what was said to have happened during Seppo's terminal mid-2000s accident.[177] But despite longstanding awareness of Seppo's vulnerable health conditions, his colleagues described his death as

[176]Note that there are less generous ways to interpret elder informants' complaints about the Safety Case's alleged declining quality or authenticity. One could easily see them as defensive fronts aiming to cover up anxious feelings of being increasingly outdated, irrelevant, or overwhelmed by new technologies, scientific norms, or computer programs that their younger counterparts pick up with ease. Many other informants, in contrast, saw earlier, simpler, more straightforward safety assessments like those Seppo spearheaded as archaic, crude, or based on outmoded assumptions. See Chapter 2 for more on these intergenerational frictions.

[177] Some said Seppo had been drinking—that his bike crash occurred as he was riding home from a house party. Others were uncertain whether this rumor was accurate. This indexed how anecdotes about Seppo did not always neatly align.

surprising, unexpected, untimely, and even unnatural. One informant attributed this to death denial: to how Safety Case insiders felt a cognitive tug away from thinking rationally about losing a colleague, friend, or mentor who figured so centrally in their lives. This happened even while his colleagues knew well that Seppo's death was possible in the short run and inevitable in the long run.

Seppo's powers to manage, guard, transmit, reveal, produce, or conceal Safety Case knowledge were evident in anecdotes about him pulling all the strings at work. This top-down oversight was central to his singularity.[178] It was testament to how a thought-leader's authoritative status can hinge on his or her control of socially valued expertises or exclusive possessions of special knowledges (cf. Lindstrom 1984; Rubel and Rosman 1979: 292). In tales of Seppo's guardedness, it was as though the social distance he maintained between himself and others enabled him to know without being known.[179] This enchanted him with a powerful relational force field of charismatic workplace authority. Yet Seppo was grooming few or no heirs. His failure to adequately document how he worked, along with his knowledge's power's reliance on others' non-knowledge, was obviated upon his abrupt death. Seppo's standoffish masculinity was seen as central to his chiefly personae—to the series of empowered figurations of him that exceeded his everyday person, influencing colleagues in turn.[180] His ambiguous comportment helped establish Seppo as a man set apart, standing out, or elevated above those working for

[178] The focus of informants' auto-analyses of how Seppo's local status was inextricable from his control over variable distributions of knowledge among those surrounding him resonated with Barth's focus on relations between secrecy, mystery, status, and differential social organizations of knowledge among Melanesia's Baktaman (1975; 1990).

[179] This is perhaps why certain informants spent so much energy trying to figure him out. In life, Seppo was received as sort of an enigma. Sometimes I found informants trying to talk out past experiences with Seppo in order to better know he who knew without being fully known. In so doing, they helped characterize their predecessor's persona postmortem.

[180] Fortes has discussed the elevation of one's persona to chiefly status in 1967: 12.

him.[181] This empowered him as having a seemingly higher-order level of meta-expertise to which only he was privy.[182]

The afterlives of Seppo's expertise were multivalent. Memories of his professional authority, personality traits, and technical work were iterated sometimes – to borrow words from anthropologist Fredrik Barth – as a "substantive corpus of assertions," other times as a "range of media of representation," and still other times as a workplace "social organization" (2002: 1, 3). Informants iterated Seppo-As-Anecdotes in historical-biographical modes to reflect on how a lost thought-leader controlled uneven allocations of Safety Case knowledge – and ignorance, knowledge's flipside (See Dilley 2010; Gross 2010) – to reinforce his office authority.[183] These iterations disaggregated the Safety Case's epistemologies and methodologies from the Safety Case experts' knowledge-practices' underlying webs of relations (cf. Crook 2009).

Yet informants singularized Seppo as a one-man-show[184] even while knowing all too well that his unitary form was grounded on many other men, women, technologies, and institutions that

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[181] In this regard, Seppo's figuration can be read alongside analyses of Melanesianist anthropologists' figurations of big men versus great men—chiefly figures of "prominence" who "stand out" as an "epitome" in various ways (Strathern 1991a: 197; Wagner 1991).

[182] Seppo's competence's perceived distance above that of others was achieved on multiple fronts. For example, the well-acknowledged competencies underlying his influence were powerful in influencing how his colleagues went about their own technical work. His thinking thus extending into that of others. On top of this, Seppo's ambiguous project-leader personality prevented those around him from getting close enough to him and his thinking to see all that he had in his mind.

[183] This switch resonated with anthropologist Tony Crook's turn away from the established Barthian focus on epistemology (viewed through the lens of "secrecy") and toward how knowledge is relationally exchanged and performatively enacted in informants' terms (2007). For more Crook's turn away from Barth's focus on how distributions of knowledge can generate diverse worldviews by "[configuring] and filter[ing] out individual human experience of the world around us" (Barth 2002: 1), see the way he disaggregated knowledge-practice and epistemology in Crook 2009.

[184] Seppo's intensity, importance, and attributes may appear especially pronounced in informants' – and, by extension, in my – "one-man-show" renderings because my field materials were derived from those who had worked closely with Seppo. Of course, if I had instead chatted with other nuclear waste insiders positioned differently in my field site's networks, Seppo would not have appeared as such a pronounced set of personae. I thus present the density of his personae – the centerpieces of this chapter – as emerging in part from my position as a researcher immersed among his close colleagues.

had bulwarked his position and exceptional aura.[185] Put differently, while Seppo was in practice composed of "many men" (cf. Strathern 1991a) and non-men, he was iterated as a single character in anecdotes.[186] Iterations of Seppo as a single entity were more products of narrative strategy than epistemological statements about Seppo's (inter)personal constitution. No Safety Case insider would refute that contributions from the diverse persons and non-persons Seppo meticulously oversaw – from the computers he worked with to the assistants who assisted him to the secretaries he devalued – fed his accomplishments and formed his personae. It was obvious to informants that Seppo's prowess, exceptionality, and prestige were not his alone. They were achievements of a broader expert community and an administrative infrastructure that upheld it. Seppo's internal multiplicities, composed of relational links that stretched outward toward others and vice versa, were impossible to overlook when his abrupt death left colleagues scrambling to revive shaken Safety Case workflows.

This forced Seppo's surviving colleagues to wrestle with the distributed character of expert personhood.[187] They had to come to grips with how Seppo was a part of them and how they were parts of Seppo—how Seppo was part of a scientific community and it was a part of him. For them, death obviated Seppo's expertise's distribution across wider fields of relations: making explicit his expert personhood as, to borrow words from anthropologist Alfred Gell, a "spread of biographical events and memories of events, and a dispersed category of material objects, traces, and leavings, which can be attributed to a person" (1998). STS scholars have addressed issues

[185] For a more substantive discussion of figure-ground relations like these, see Wagner 1986b.
[186] This resonated with how Strathern characterized past anthropological renderings of the Melanesian Hagen big man—which "presents a singular form" such that "whatever the heterogeneous relations of which he is composed, these are internal parts of a figure imagined as a unity" (1991a: 199).
[187]Anthropologists have wrestled with these questions too. Strathern, for example, has described Melanesians seeing themselves not as unitary individuals but as dividuals, or persons always already derived relationally from other persons (1991).

like these too. Mialet, for example, has shown how Stephen Hawking's great singularity is, perhaps counter-intuitively, owed to how he is widely collectivized, distributed, and connected across human, machine, and administrative networks—constituting what she has called a "distributed-centered subject" (2012: 192). Law and Callon, in dialogue with Latour, have noted how "Pastuer-the-great-researcher" never existed outside a wide actor-network of competencies that constituted his "body and mind" (1997: 169). Seppo's case, however, specifically calls attention to how singular expert-figures' surprise deaths can force bereaved colleagues to look the distributed character of expert personhood in the eye—challenging them to revisit the individual as, in many ways, himself or herself a collective.

Stories of Seppo were often reiterated to describe a latent project-management weakness that Seppo's death obviated: a critical overreliance on a single embodied expert who was not keen on documenting the methodological assumptions, boundary conditions, or conceptual presuppositions that grounded his scientific work. Yet even after Posiva corrected for its past overreliances on Seppo – and once Safety Case workflows flowed smoothly once more – Seppo's personae achieved no closure. In the years that followed, Seppo-As-Anecdotes' figurations altered and re-altered through survivors' rememberings and forgettings, exaggeratings and downplayings, eulogizings and disparagings, idealizings and criticizings. The affective intensity felt for the late Seppo decreased over time.[188] The spirits in which Seppo-As-Anecdotes manifested differed in the years before his death, immediately after his death, a

[188]Of course, similarly volatile workplace logistical turmoils may have ensued if Seppo had, rather than dying, simply quit work and suddenly permanently severed all ties with his colleagues. But the affective residues left behind by a tragic death-event versus those left behind by, say, an abrupt "I quit!" workplace abandonment would have inevitably filtered remembrances differently and hence differently mediated how, when, and why Seppo stories could be enacted to do work in various circumstances postmortem. His departure's affective aftermath – psychological and emotional fallouts entwined with stress-ridden project-management fallouts – was thus accentuated because death was involved.

decade after his death, and would continue to do so, say, three decades after his death. Anecdotes differed from informant-to-informant and circumstance-to-circumstance too. Seppo-As-Anecdotes could be channeled with solemnity, awe, respect, nostalgia, aversion, or warm friendliness for different reasons at different moments. Seppo's predecessor persona figures were reiterated as they had been for years: in ways plural and subject-to-change.[189] Predecessor personae thereby shifted and re-shifted as collaborations' spirits, scales, and compositions shifted and re-shifted.

Seppo-As-Anecdotes could be iterated sometimes like fables, other times like hagiographies, other times like nostalgic retrospectives, and still other times as but simple historical backstories. Sometimes they were iterated to reflect on how Seppo, a deceased forebear, might, if alive, wish to reorganize the lives of the living. This was on display in Gustav's imagining Seppo judging his peers from a cloud on high. Other times Seppo's predecessor personae were summoned to offer past perspectives on present practices. Sometimes they were iterated with quasi-mythic inflections, pioneer motifs, or forefather mystiques.

Seppo's surviving colleagues sometimes recalled their lost mentor's eccentric gruffness, great competence, and salty bluntness in ways that resemble how Lawrence Livermore National Laboratory scientists recall the quirks of prominent nuclear weapons designer Seymour Sack.

[189] It was also unclear whether, when Posiva's project concludes around 2120, Seppo would be remembered as anything but a textual citation, if at all. So too was it uncertain how year 2120 Safety Case experts will (mis)interpret Seppo's 120- to 140-year-old work. The extent to which my account of Seppo here or in Physics Today (2017) will be available and read in 2120 is unknown. It is an open question whether either will be received as authoritative. Both, however, will help endow Seppo's personae with continuity if read by future generations of Safety Case experts. Future receptions of present-day work will also be mediated by the extent to which present-day jargons or scientific terminologies are, in 2120, seen as antiquated. While most key Safety Case documents are published in English, niche reports' continuities may also be affected by whether, as another example, year 2120 inhabitants will still speak Finnish.

Like Seppo, Sack was not especially well known outside his own expert circles. Within them, he was elevated as a legendary mentor and brilliant thinker with a unique personality. In the 1990s Sack's mortality became a key focus in Livermore's work to archive indispensable insiders' knowledge before it was taken to the grave with them. Informants' recollections of Seppo also, at times, recalled how U.S. Navy insiders have reminisced about Hyman Rickover, developer of the USS Nautilus, the world's first nuclear submarine. Like Seppo, Rickover has been remembered for more than just his innovations and competence. He left behind a cult of personality and management philosophy that, years after his death, still pervade the projects he helped build. Many remember Rickover for his extremely high standards, crustiness, abrasiveness, aggressiveness, and sharp tongue. Although Seppo never achieved Rickover's great fame, or even Sack's notoriety, he did greatly influence Posiva's path-breaking repository project.

These historical-biographical iterations of Seppo-As-Anecdotes were but one spirit in which dead Seppo's personae were summoned, conjured, or channeled in uncertain presents moving toward uncertain futures. These were useful for providing backstories to Safety Case happenings, for endowing technical reports with socio-historical context, and for articulating how workplace interpersonal relations had tangled and untangled in the past. The next section explores another common spirit in which Seppo stories were iterated: quasi-social-scientific or quasi-functionalist thinking patterns that informants brought to bear on the workflow repair work that ensued in Seppo's death's aftermath. This was conjured up more in day-to-day troubleshooting work when Safety Case experts grappled with their technical knowledge's strengths and weaknesses. It was a more mechanistic, detached, professional way of narrating Seppo's death's left-behind voids' impacts. This Seppo-As-Voids way of iterating Seppo's predecessor personae was iterated side-by-side with the Seppo-As-Anecdotes spirit described in this section. Both were key to how Safety Case expertise took form as it moved into futures. Seppo-As-Voids, however, was more about thinking patterns informants iterated when describing Seppo's loss' organizational or logistical consequences on project-management.

Death's Disequilibria: Seppo-As-Voids

Inside a VTT Office in Espoo, Finland.

Projects to revive workflows after Seppo's death, to recover fragments of his lost thinking, to regenerate effective project organization, and to reestablish Safety Case project "equilibrium" – as one informant put it – took months. Insiders told stories of death-induced disequilibria in workflows in Seppo's death's aftermath. In their accounts, it was as though a part of their team, and hence a part of themselves as relational beings, had been amputated. Relations that once flowed in and out of Seppo when he was a living locus were left dangling unattached. Surviving colleagues recalled scrambling to reallocate the workplace roles left unfilled by his vacancy. Some searched folders in Seppo's computer for clues offering glimpses of his lost thinking. Others tried to interpret margin notes he had scribbled in earlier drafts of his reports. Posiva had to hire new personnel. When informants recounted these labors to me, it was clear how they saw themselves pursuing a re-balancing of workflows through various labors of rearrangement, substitution, restoration, reincorporation, reconsolidation, or rejuvenation.

Safety Case experts' aftermath stories were, at times, reminiscent of functionalist anthropological work on how death can induce a "partial destruction of social cohesion" that requires a bereaved community to "organize itself anew and reach a new condition of equilibrium" (Radcliffe-Brown 1933: 118).[190] They resembled what anthropologists have described as post-death imperatives toward "reintegration" of "shaken solidarity" or "re-establishment" of "morale" (Malinowski 1948: 53) accomplished through a "readjustment" or "reconstitution" of social relations postmortem (Gluckman 1950: 120). When informants described the "void" or "power vacuum" Seppo's death left behind, their auto-analyses resonated with how many anthropologists since Robert Hertz have focused on how survivors go about "restoring the social fabric after death has rent it" (Huntington & Metcalf 1979: 36).[191] Informants' void-filling work involved regenerative labors to master, transcend, oppose, negate, or triumph over a death-event's finality, abruptness, and resultant disruptions.[192] Seppo-As-Voids' power vacuum obviated for Safety Case experts how Seppo's bicycle accident biological death was not coterminous with his workplace social death (See Hertz 1960 [1907]). New challenges appeared before them: those of releasing an individual expert once vital to Safety Case work into the past while rekindling their workflows' momentums into the future.[193]

[190]This showed how "parallels between technocratic and anthropological or social scientific knowledge" can make "anthropological representations and the world they represent come together in certain shared practices of knowledge" (Riles 2004: 101).
[191] During fieldwork conversations I would sometimes recap informants' post-Seppo aftermath commentaries using anthropological functionalist terms back to them. They would often respond with a nod or just agree, assuming I was simply summing up points they had just made.
[192] This resonated with Bloch & Parry's description of "way in which death is transformed into regeneration by acting out a victory over (and thus giving recognition to) the finality and uncontrollability of death" (1982: 18).
[193] This mirrors functionalist reflections on death's dual-evocation of desires to both "maintain the tie" and "break the bond" with the departed (Malinowski 1948: 20).

“Equilibrium” and “void” were not the only terms that past functionalist social scientists and present Safety Case informants alike used to describe shaken post-death-event social relations.[194] As noted in Chapter 3, some informants also positioned themselves in what they called “data chains” or “modeling chains”: workflow sequences linking together various experts, teams, and projects. Social scientists such as Blauner have likewise described death, in a functionalist mode, as cutting a “break in the chain of interpersonal relationships" (Palgi & Abramovitch 1984: 397). The chain analogy was a useful explanatory device in both cases. Further, when informants associated the relatively large magnitude of postmortem void-filling work to the relatively small size of the workplace teams he departed, their auto-analyses resonated with functionalist social scientific renderings of how a death’s impact can be augmented when it unfolds in smaller more tight-knit communities.[195] When informants linked the depth, degree, and duration of Seppo-As-Voids’ postmortem power vacuum to his high status, their thinking patterns could likewise resemble those of Gluckman’s, Blauner’s, Van Gennep’s, Hertz’s, and Malinowski’s social scientific portrayals of how a death’s aftermath’s impact can be a function of the deceased’s stature’s scale.[196]

There were indeed many parallels between (a) the functionalisms of past anthropologists who inflected their cultural analyses with greater scientific pretense than today and (b) the amateurish quasi-functionalisms of certain STEM informants pausing from their Safety Case work to reflect

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[194] Sociologist Blauner, extending Malinowski’s 1925 commentaries on how death can disturb a community’s “equilibrium,” noted how death can create a “social vacuum” of a scale relative to the deceased’s relevance “for the functional activities and the moral outlook of the social order” (1977: 176).

[195] See Blauner 1977: 174 for an example of parallel thinking patterns in social science literature.

[196] Gluckman, for example, noted how death could forge a “different social situation according to the status, or manner of death, of the deceased” (1950: 124). Van Gennep noted how the deceased’s higher status could spell longer-term suspensions of social life among a greater number of bereaved (1960 [1909]: 148). Emile Durkheim’s student Robert Hertz noted how the “emotion aroused by death varies extremely in intensity according to the social status of the deceased” and how, at the “death of a chief, or of a man of high rank, a true panic sweeps over the group” (1960 [1907]: 76).

on their professional community's social relations with me, an ethnographer. This revealed how more mechanistic, systematic, functionalist ways of rationalizing human relationality made lots of sense among Finland's nuclear waste experts. This tendency to interpret one's own social matrix through rubrics of structure, order, scale, and function was not unique to death situations. Early-career Finnish nuclear energy professionals also iterated quasi-functionalist terms to describe how humor, satire, and games facilitated camaraderie, bonding, and stress-relief in their professional lives (Ialenti 2014c). Certain modelers, steeped in Chapter 3's logics of systems and subsystems, were more likely to draw upon systems, networks, or machine metaphors to articulate their interpersonal relations.[197]

Many of these informants' mechanistic thought tendencies derived from their STEM educations and their workplace exposures to management logics. They frequently extended their own technical metaphors of system, network, function, and machine to reflect on other domains of their lives. Yet informants also derived these tendencies from economistic or instrumentalist thought patterns that often served as default explanatory modes – even among those without much formal education – in the highly-industrialized knowledge-economies they inhabited. Indeed, a Finnish colleague once quipped to me that, when she teaches Introduction to Anthropology, her young students enter the classroom as functionalists. Her job, as she saw it, was to de-program them from the crude functionalist social thinking upon which they were raised—introducing to them other structuralist, interpretive, symbolic, feminist, or poststructuralist ways of viewing culture. Another third source of informant-enacted functionalisms was conditions in which well-disseminated social scientific ideas from past

[197] For more on the implications of different metaphors, imageries, or heuristics used to conceptualize organization and management, see Gareth Morgan's 1986 *Images of Organization*. Morgan explores the consequences of conceiving of organizations as organism versus machine versus brain versus culture motifs etc.

decades haunt contemporary thinking patterns. For some, this was reinforced by how certain Safety Case experts even read social scientific and philosophical books in their spare time. For example, a Posiva manager had read works by Mary Douglas, Ulrich Beck, Niklas Luhmann, and Bruno Latour. A Safety Case physicist was keen to reference economist Daniel Kahneman's *Thinking, Fast & Slow* and Nassim Taleb's *The Black Swan: The Impact of the Highly Improbable*. And a modeler referenced work by Wittgenstein and also Paul Feyerabend – which he encountered in a Philosophy of Science course in his university years – during our chats in his office.

The anthropological response to these parallels could not be one of uncritically re-applying functionalist anthropological insights (as academic theory) to informants' quasi-functionalist auto-analyses (as field data). That would generate redundant commentary. Nor could it be one of fully deferring to subjects' modes of knowing—adopting informants' analytics as the ethnographer's own. Doing so would risk reproducing amateur versions of outmoded functionalist social scientific analytics. Here the ethnographic challenge simply became one of understanding quasi-functionalist thinking patterns from the "native's point of view" (Malinowski 1922)—exploring the work they did in informants' professional lives.

Seppo-As-Voids underscored how Safety Case experts iterated amateurish quasi-functionalist explanatory devices to analyze workflows, optimize project management, and retool collaborative ties in a death's wake. They focused on professional obligations to restore Safety Case collaborative spirit to a sense of functioning like a well-oiled machine or an airtight system of systems. They did so always with an air of detachment: emotions, personality politics, and petty jealousies were restrained. Some spoke of workflow repair with monotone distance. Quasi-functionalist modes of articulation helped Safety Case experts speak as if from a narrative position above themselves—objectively assessing post-death circumstances as if outside of them. The clarity of systematic pattern, defending against an unsettling death event, fostered greater comfort and clear headedness amidst tragedy and unknown futures. Yet quasi-functionalist modes of articulation were not always deemed appropriate. Rarely was Seppo-As-Voids brought to bear, as Seppo-As-Anecdotes often was, on Seppo's extra-professional personal friendships or acquaintanceships.[198] Seppo-As-Voids was cordoned off by distinctions informants made between public/private roles, professional/personal lives, or colleague/friend relationships. It was seen as powerful for scrutinizing Seppo's loss' workplace logistical fallouts. Yet Seppo-As-Voids was seen as a weak, or even downright insensitive, means for expressing, say, the pain of mourning.

Attuning ethnographically to informants' Seppo-As-Anecdotes historical-biographical accounts revealed how, when technocratic routines failed, improvisational retooling of their workflows kicked in. Specific people, entities, and projects became gossip targets. Personality politics ramped up. Interpersonal relations were contested.[199] This was very different than Chapter 3's conditions of Safety Case project stability, which caused interpersonal politics to fade into the backdrop as more fluid, forward-looking, detached discussions of technical instruments took center stage. A veneer of emotionless Weberian iron cage rationality became easier for them to project. Amidst post-death-event project instability, predecessor politics were foregrounded.

[198]For example, it would not have been appropriate to eulogize Seppo in functionalist terms at his funeral. I should also note that some informants even saw discussing their late colleague with an ethnographer who might later write about the conversation as inappropriate in principle.
[199] Put differently, the "transparent matrix" (Bateson 1979) of thought that was steadily worked in and on in Chapter 3 was problematized.

Mechanistic input/output, part/whole, and iteration forms were backgrounded.[200] Amidst project stability, this figure-ground relation (See Wagner 1986b) was reversed.

Seppo-As-Anecdotes and Seppo-As-Voids were, as a coming section explores, iterated alongside a spirit of postmortem mentoring I call Seppo-As-Predecessor: when Seppo's past workplace prestige and scientific practices were channeled in moments of Safety Case technical troubleshooting. But active figurations of Seppo-As-Predecessor did not appear, as the next section shows, immediately or automatically upon Seppo's death. Much replacement, transition, and succession work had to be undertaken by surviving colleagues, supervisors, mentees, coworkers, and assistants first. The liminal interval[201] after Seppo died but before he was installed as a predecessor figure could be called Seppo-Being-Succeeded. This interregnum timeframe was formative. It spoke to calls for better "replacement" and "succession planning" at nuclear organizations far and wide (IAEA 2006: 58). It was aimed at achieving succession in Wagner's sense of the term: "human replacement within an apparently limited set of properties and privileges" (1986a: 177).[202] The next section explores the unstable interregnum that followed Seppo's vacancy but that preceded the installation of the "SafCa Group" team that replaced him. When this volatility was quelled, Seppo's postmortem personae were conferred active predecessorhoods in Safety Case expert worlds.

[200] That said, experts had to be especially inventive, improvisational, and creative with, say, the predecessor form when confronting, after Seppo's death, what Riles has called "failures of the network, the points of nonfit, miscommunication, dislocation, and nonportability" (2010: 799).
[201] See Turner 1966 for a classic anthropological analysis of liminality.
[202] Like Wagner, the IAEA report did not associate "succession" narrowly with kingly/dynastic power transfer. Unlike many kings/dynasties in the Western tradition, Seppo made no efforts to groom heirs or to control future succession outcomes. I also do not imply that Seppo's role-position was succeeded without being altered: in fact, this job once done by a single chiefly expert changed, after Seppo's death, in being done by a networked SafCa Group underlain by a larger corporate/bureaucratic infrastructure.

Interregnum: Seppo-Being-Succeeded

Much had changed in Safety Case expert worlds since Seppo's mid-2000s death. The Safety Case had become much larger, bringing together hundreds rather than dozens of experts. Many of these experts were subcontracted from other companies, institutes, universities, and consultancies outside Posiva. The project expanded in the years running up to Seppo's accident. The Safety Case intergenerational continuity patterns I observed in the field – shaped by knowledge management platforms, knowledge transfer techniques, and workplace role templates (See Chapter 2) – had already been retooled in response to lessons-learned from Seppo's abrupt absence. Seppo's loss had already made it clear that Posiva would not benefit from simply installing another Seppo-like project puppet master – certainly not one so focused on securing his own control and influence – in the voids his death was seen to have opened up. Seppo's vacancy was instead filled by a group of fewer than ten specialists called the SafCa Group: a more decentralized team overseen by Posiva managers and consultants from abroad.

Posiva experts consolidated and empowered the SafCa Group in the unstable interregnum following Seppo's death. It was derived from an inner circle of eligibles alongside fresh hires who had not worked as closely with Seppo. A SafCa Group member described the uneasy feeling of taking the reins so quickly when she inherited one of his former projects. Laura credited Seppo with paving the way for her own work.[203] Contingency plans, replacement strategies, or projects to back-up Seppo's wealth of expertise in anticipation of his potential departure had not been preemptively established. Many described how project-leading Seppo's lived presence's abrupt departure shook the Safety Case project epistemologically, temporally, and logistically.

[203] This resembled Goody's 1962 description of how, in LoDagaa holder-heir relationships, the successor/inheritor can feel uneasy guilt or a tug toward reciprocity given that he or she inherits a position only after the death of another. While Goody's informants reacted to this guilt by making sacrifices to ancestors, my informants reacted by expressing gratitude to a predecessor.

Seppo's death left his colleagues to face how – when singular nuclear waste experts die, leave work, or change career-paths abruptly – their workplace survivors' deep reliances on them can suddenly be problematized. It thus made challenges of "building, collecting, transferring, sharing, maintaining, preserving, and utilizing knowledge" (IAEA 2016) experience-near for Safety Case insiders.

When the SafCa Group adopted Seppo's former responsibilities and privileges, the Safety Case had already become so large that no single supervising expert, no matter how prolific, could wrap his or her mind around it in its totality. An insider suggested that something akin to this transition from single-expert to multiple-expert leadership was likely nigh even if Seppo had not died early. Another explained how Seppo's death-event accelerated[204] changes already occurring in Posiva's projects—changes that Seppo, in life, despised. For example, Safety Case experts increasingly had to write more detailed, "transparent," and "traceable" reports on their work. They had to exchange information about their projects more widely throughout more collaborative networks. Posiva placed more emphasis on "competence management" computer platforms (Palmu 2008). Some Safety Case experts used, for example, Posiva's POTTI research data system to facilitate their access to commonly verified and accepted data. Then there were more specific systems like the Rock Suitability Criteria (RSC) program, which defined "the performance targets for the host rock" and developed the "criteria for accepting certain rock volumes for disposal, including the acceptance criteria for the deposition holes" (Safety Case

[204] This happened because Seppo's workplace survivors, in the months and years after their colleague's death, retooled workflow norms to better prepare for future loss-induced replacements. As a human tragedy played out doubly as a project management calamity and as Posiva experts learned the hard way that Safety Case work cannot rely so much on a single mortal scientist, some worked to cultivate a professional ethic of making-oneself-more-replaceable. This professional ethic, nudging experts toward not behaving like Seppo, made the Safety Case less of a personality-project than it otherwise might have been. When I conducted fieldwork, the individuated mode of localized charismatic authority Seppo embodied was seen as an outmoded vestige of past project norms.

Plan 2008: 52). POTTI and RSC were knowledge management technologies thought to hedge against possible future information-loss events.

In response to the Safety Case project's growing scope and scale – and to lessons learned from Seppo's death – Posiva no longer empowered any one expert as its repository safety assessment work's chief organizing architect. It did this while upping its reliance on corporate bureaucracy, knowledge management, external peer review, auditing, and documentation. Such project-management reforms limited the sway any single expert could have over Safety Case decision-making. Many saw the project as increasingly run less by individuals and personalities and more by groups and systems. I was told that Seppo, whose highly localized prestige was in part a personality project, argued vehemently against such systematizations with certain VTT bosses in the months prior to his death. Informants noted how Seppo's death had occurred around the time he was moving his work base from the traditionally-state-run-but-increasingly-privatized VTT to the private underground engineering consulting firm SROY. When I began fieldwork, SROY had become the center of SafCa Group leadership.

Seppo-Being-Succeeded's liminal post-death but pre-replacement period would, it was thought, have been more stable had clearer expert replacement strategies been pre-drafted or had deputy experts been appointed to be on standby to take the reins in the case of his loss.[205] Such would have made the business of transition progress in a more fluid fashion. Smoother succession was said to have been achieved, however, when Posiva's Management Group was formally reorganized in early 2013. This planned leadership restructuring occurred once Posiva submitted

[205] Succession would have, to channel Fox reflecting on Radcliffe-Brown's work, been smoother if the process of transition" had greater predefined "clarity" (1993: 138). Seppo's position was what Goody might call a "unique and non-duplicating" position (1966: 2). There was, to use Goody's terms, no "co-rulership" in which "successor and incumbent hold office simultaneously" or any "dual paramountcy" in which "major roles are doubled up" (5) to militate against untimely vacancies.

its CLA and began looking toward 2018's planned OLA submission. This reorganization reflected Posiva's structural transition from a research and development firm (designing a repository) to an implementation and construction firm (building a repository). At this time, soon-to-retire managers were repositioned from department head roles to "senior advisor" or "elephant graveyard" roles. That is, their new focus was to assist, troubleshoot, and guide a new generation of managers into their leadership positions. Installing them in these roles was an intergenerational continuity technique akin to those elaborated in Chapter 2. Reorganization and replacement moved forward in this context, to quote a retiring manager, "naturally" without many "dramatics."[206]

The clarity in responsibilities turnover and years-in-advance preparation guiding Posiva's formal managerial succession in the 2010s – taking place without surprise vacancies – contrasted with the unclear suddenness of the more informal leadership of scientist Seppo's mid-2000s interregnum. The fluid preparedness of the former could be linked to how outgoing managers and pre-selected replacements participated actively in the handover process. On top of this, the Posiva Management Group transition unfolded among established offices delineated in a clear organizational template of command and deputation roles. The form these roles took reduced interregnum phase uncertainties. Their power was explicitly governed by corporate managerial customs. Seppo's power was, conversely, achieved informally through a quasi-cult of ambiguous volatile personality coupled with a reputation for competence among colleagues. Individual character, scientific prowess, and interpersonal relations – as opposed to a demarcated leadership position transcending whatever individual incumbents might occupy it – were what made Seppo

[206] Yet certain dissatisfactions with the transition were voiced. One Safety Case expert, for example, lauded two outgoing managers' more scientific backgrounds, more holistic takes on Posiva's vision, and more informal demeanors. He lamented a new boss' engineering background, preference for EBS projects, and less "outward" demeanor. He worried that greater business-and-engineering emphases would relegate Safety Case work's precedence.

a scarce human resource. Indeed social scientists have observed how succession, inheritance, replacement, installation, and descent can operate differently in different levels and segments of a society or an organization (See Curet 2002).

Most agreed that Safety Case continuities had, during and after the interregnum period, been amply readjusted to render them no longer sensitive to abrupt losses of highly specialized experts. However, many conceded, in hindsight, that much of Seppo's death's unstable fallout could have been avoided had latent weaknesses in project organization – which arose from putting so many eggs in the basket of one standoffish expert with vulnerable health – had been looked in the eye and prepared for earlier. Yet it took the lived experience of the death-event to fully obviate how the idiosyncratic expertise, local authority, and workplace personality project of a single expert took on a situated sovereignty of its own. This revealed the meaningfulness of a single expert's life-project amidst Safety Case deep time-reckoning's radical epistemic breadth. This was a sort of personal and intimate meaningfulness often overlooked in renderings of technocracy as a faceless, dehumanizing system of distributed, diluted responsibilities. It showed how Seppo, in his own little way, helped push history in certain directions by pushing a nuclear waste repository project in certain directions through his competence and ambiguous willpower. Seppo was, in life and death, a beacon of direction: he paved Safety Case experts' ways forward into unknowable futures. Iterating memories of him endowed their tomorrows with more discernible features.

Seppo-Being-Succeeded was another spirit in which informants iteratively endowed a dead Seppo's lingering personae with present agencies. Following it ethnographically revealed how lessons-learned in part from Seppo-As-Voids and Seppo-As-Anecdotes tales elicited new knowledge retention infrastructure and new workplace conventions. The succession aim was to facilitate more fluid, continuous, and clear expert replacement processes across generations. Anecdotes about the uncertain interregnum that followed Seppo's death were thus retooled as pedagogical stories to be retold in teaching moments or in cautionary tale genres. Iterations of Seppo-Being-Succeeded tales, like iterations of Seppo-As-Voids or Seppo-As-Anecdotes tales, helped establish stable grounds upon which Seppo could be channeled as a predecessor in presents looking to futures. With that in view, the next section examines how informants iterated Seppo-As-Predecessor tales to bring past scientific insights, expert intuitions, or technical strategies to bear on present troubleshooting—summoning renderings of past Safety Case practices, status quos, and conventions as perspectives on those of the present.[207]

Predecessor Parables: Seppo-As-Predecessor

One Safety Case informant mused that, even years after his death, Seppo's "specter" still lived on, "haunting" many aspects of the project. He said: "I've never met him, but everyone talks about him. Seppo would have said this, Seppo would have done that… What would Seppo do here?" His auto-analysis was almost hauntological (Derrida 1994) in spirit. Seppo-As-Predecessor was evoked as what an anthropologist might call an "active absence" or a constitutive "negative space" with postmortem "continuity of influence" (Battaglia 1990: 119; 196-8). Many past experts, in being forgotten or deemed irrelevant over time, failed to achieve ongoing reiteration as predecessor personae. But Seppo-As-Predecessor was iterated alongside Seppo-As-Andecdotes tales of his character, Seppo-As-Voids tales of his workplace function, and Seppo-Being-Succeed tales of his replacement and elevation to predecessorhood. Allusions to Seppo's past vision at times seemed like mythic enactments of a past status quo, precedent, or

[207] As Insoll (2011) has noted, ancestor-like figures come "as part of a multiple 'package' of phenomena, practices, and beliefs whose configuration can change over time" (1055). Focusing on Seppo-As-Predecessor shows how past phenomena, practices, and beliefs inextricable from his persona were recalled and retooled to serve present ends. For more on anthropology of ancestors, see Newell 1976.

authority. Other times Seppo's void elicited an almost spectral "something-to-be-done" (Gordon 2008: xvi): a "we should model this distant future hydrological flow this way" or a "this aspect of this dataset on Olkiluoto's ecosystems needs the be more like that." Recollected traces of what informants saw as Seppo's past thinking patterns were summoned in presents-looking-to-futures, adding newness or nowness to his predecessorhood.

Safety Case insiders approached certain workplace memories and artifacts Seppo left behind carefully. His old drafts, notes, and insights were seen as resources to be conserved to preserve memories of his past thinking. This was by no means a universal human response to death. Anthropologists have described how Navajo communities, for example, destroyed the deceased's possessions to evade ghost sickness (Wyman et al. 1943). Gluckman's accounts of afterlife among Africa's South-Eastern Bantu, as another example, described how one's possessions lost value when contaminated by their owner's death (1950: 123). But Seppo's workplace possessions' values spiked, eliciting care for them.[208] They had various degrees of interpretive flexibility. Seppo's protégés, successors, and mentees thus had wiggle room, perhaps unwittingly at times, for subtly editing Seppo's predecessor expertise when relating it to whatever workplace predicament was at hand. That was key to how living experts iterated and reiterated selected memories of Seppo's thinking on as-needed bases. It placed registers of Seppo's name's lingering sway, as well as authorship over lessons-to-be-learned from his loss, in the hands of a surviving inner circle.

Iterating Seppo-As-Predecessor also helped Safety Case insiders position their expertise in lineages of workplace forebears. It reminded them how, within and behind them, live(d) past

[208]Yet, as in Gluckman's account, Seppo's life-possessions' death-altered significances contoured his survivors' readjustments to living without him around.

experts gone. It reminded them how, ahead of and through them, are experts not-yet-become (See Bloch 1986: 11-13). It reintroduced past status quos into present negotiations. It made a late expert's life course accessible to new expert generations. Erasures and traces of a past no-longer – as present absences or absent presences – subtly entered into commerce with living Safety Case experts. Anthropologist Michael Jackson might put it this way: a figured "dead as object" (as a "thing-for-others") continued to assert predecessor agency by outliving a biological "dead as subject" (as a "person-for-himself") (1977: 287). This was achieved through referential conjurings and anecdotal channelings mediated by selective forgettings and remembrances that edited Seppo-As-Predecessor as an abridgement of deceased significances. Seppo had transformed from a person into personae, an individual into categories, an expert into emblems, a living subjectivity into biographical accounts, and a biological organism into remembered figures.[209] As in Strathern's reflections on English kinship, Seppo's installation as a predecessor was about a "social continuity" being "mapped on to biological discontinuity" (1992b: 75).

Seppo was dead: he could no longer know or not know. But his predecessorhood was something no more or less real than the distant futures worlds Safety Case experts forecasted. Seppo-As-Predecessor was also restless, never achieving full closure. It was multiple: iterated variably as a past personality, as a workplace role position, and as a prominent figure. Sometimes it was conjured as an ideal model according to which informants strove to conform. Other times it was conjured as emblematic of a backward mentality from project phases past from which Safety Case experts strove to diverge. Sometimes these channelings tightened group amity. Other times they were divisive, throwing disparate perspectives into relief. Sometimes experts associated

[209]However, it was also the case that, as Derrida once noted, a "man's life, as unique as his death, will always be more than a paradigm and something other than a symbol" (1994: xv).

themselves with Seppo-As-Predecessor to ennoble their own positions by linking them to those of a credentialed forebear. One informant reported feeling like Seppo's postmortem "voice" when he helped others interpret the late expert's reports and provided context for his projects.

Seppo-As-Predecessor figures seemed summoned from an almost timeless realm disconnected from transient unfoldings. As if channeled from a virtualized past-in-the-present, their presences ran through the backdrops of everyday office life. Yet Seppo-As-Predecessor belonged not only to a past, but also a present looking to a future. Seppo-As-Person was a being-already-been. Seppo-As-Position had been succeeded. But Seppo-As-Figure was agentive as a predecessor contemporary to all. Iterations of traces attributed to Seppo became vehicles for project memory not as a cognitive faculty, but as a performative act. Iterations of them could be at once prospective and retrospective. They could be aspirational or nostalgic. Predecessor personae were not resting in peace in the past, but restlessly making and unmaking expert worlds in the present. Safety Case experts experienced Seppo's death as a multifaceted loss. They registered it triply as a personal and interpersonal tragedy, as the loss of a non-substitutable embodiment of expertise, and as the loss of an ambiguous beacon of expert values. These multiplicities were incompatible with any idea of an expert's legacy being summed up and closed statically after his or her death. Their postmortem agencies complicated the common idea that only living experts can be contemporaries of living experts.[210]

Yet when Safety Case experts iterated and reiterated Seppo-As-Predecessor, it was not

[210]I say this partially inspired by Kopytoff's 1971 commentary, broaching Gluckman and Fortes' work on death and ancestors, on "communities of both the living and the dead" in Africa. Kopytoff argues against ethnocentrically imposing the living/dead binary on what his anthropologist peers might have otherwise interpreted as biologically dead ancestors.

necessarily figured, to borrow words from Fortes, in a "whole man" form. Much of Seppo's personal character was rarely, if ever, brought to bear on technical matters.[211] His expertise was most often iterated as a deposit of the past technical knowhow that had reinforced his past workplace jural status (cf. 1965).[212] That is, when what was presented as Seppo's past thinking was summoned, so was his past authority. Safety Case technical logics and Safety Case experts' professional relations therefore remained as tightly coupled (See Chapter 3) in death as in life.

Recalled as an exaggerated embodiment of a past professional ethos, Seppo-As-Predecessor had become a device through which professional and personal values were negotiated. At its worst, such could leave Safety Case experts mired in the will of a frozen idol or adversary from the past—encumbered by a pathological form of what Nietzsche called *ressentiment* (2003 [1887]). At its best, Seppo-As-Predecessor could be iterated in aphoristic spirits endowing experts with direction, ambition, and inspiration. At times Seppo-As-Predecessor served as a mentor to its contemporaries—serving in advisory roles postmortem. This showed how, even when death takes an expert, it may fail to extinguish his or her predecessorhood.[213] Seppo's Safety Case successors were thus fated to remain partially under its authority for as long as they continued to summon Seppo as such.[214] Iterations of Seppo helped shape a scene in which the transient horizons of a single human life course, the intergenerational horizons of personnel succession,

[211] As Fortes has noted, "Hence, not surprisingly, in such a developed system of ancestor worship as that of the Tallensi, the personality and character, the virtues or vices, success or failures, popularity or unpopularity, of a person during his lifetime makes no difference to his attainment of ancestorhood" (1965).
[212] This resonated with Fortes on how the "authority" of ancestors' "jural" roles can continue postmortem to regulate delimited groups of people who identified as being somehow related to or entangled with the deceased (1961: 182; 1965: 133). Chapter 2's sections on workplace role templates captured this well.
[213]This is a reference to Fortes in his discussions of ancestor worship noting how "death palpably removes fathers, but it is not assumed to extinguish fatherhood" (1961: 184).
[214] This parallels how Fortes noted how one "remains an ancestor only so long as his legitimate lineal successors survive" (1961: 180). Indeed there must be a delimited group of successors (as "living descendants of the right category") acknowledging a predecessor as such in order to endow the latter with power over the former (1965).

the multi-millennial horizons of nuclear waste risk, and the mundane horizons of office life converged. This was key to how phenomena often seen as larger-than-life, more-than-human, or overflowing ordinary comprehension – an exemplar's ambiguous authority, deep time's breadth, and death's mystery – converged. The next section concludes by arguing that becoming sensitive to these predecessor conjuring practices ethnographically can enrich current discussions of nuclear knowledge management, succession, and expert loss in a moment of intergenerational transition.

Afterlives of Expertise

This chapter explored four general spirits in which Safety Case experts iterated and reiterated recollections of a late colleague's influential thinking patterns. This helped them move forward into uncertain tomorrows by inflecting and re-inflecting futures with traces of the familiar. The recollections were iterated to describe, contextualize, refine, alter, or intervene in Safety Case happenings, collaborations, and workflows. With Seppo-As-Anecdotes, they were summoned in a narratological spirit to develop workplace historical-biographical awareness. With Seppo-As-Voids, they were summoned through terminologies of structure and function to reflect on project-management lessons learned. With Seppo-Being-Succeeded, they were summoned to chronicle a transition period from Seppo leadership to SafCa Group leadership: a time when surviving colleagues scrambled to install the former as a predecessor and the latter as a new sovereign. With Seppo-As-Predecessor, they were summoned to bring past expert perspectives to bear on present technical conundrums. Analyzing these afterlives of expertise can help critically revisit nuclear sector knowledge management studies.

Seppo was an irreplaceable expert who emerged from messy contexts in which experts were forged out of and through other experts and non-experts, living and dead. Safety Case experts, in relationally co-creating one another, could embody fragments, residues, or remnants of one another's comportments, intellects, and personalities. When a self in these relational tangles died, traces of his self-in-others did not evaporate, but persisted in surviving colleagues' memories, in databases, and in reports. That is, when an embodied locus of nuclear expertise became inert, the relational threads of the past person, still embodied in others, asserted their predecessor agencies in Safety Case worlds.[215] A biologically dead Seppo, installed as a predecessor and materializing as iterations of memories of him, was alive and changing—composed of shifting personae that altered in time as they were summoned forth by surviving colleagues almost a decade after his death. The ways this individuated Seppo as a predecessor while collectivizing a wider Safety Case community as a group were too subtle to be captured by corporate bureaucracy and documentation requirements alone. Nuclear organizations, and the social scientists studying or writing reports for them, can derive at least four lessons from anthropological reflection on this.

First, an abrupt expert death-event can compel surviving colleagues to wrestle with how distributed personhood grounds any corpus of expertise. This inevitably complicates any commonsense idea that one expert body embodies only one body of expertise. Merely interviewing a retiring expert to back-up his or her knowledge – a common recommendation in sociologically inflected nuclear knowledge management studies – will inevitably fall short of preserving a useful testament. Because assuming conventional individuated personhood will fail to do justice to an expert's relational constitution, dozens upon dozens of associated colleagues

[215] This showed how a nuclear expert brain can be construed as but a "subsystem" of larger circuitries, pathways, or channels of "mind" distributed across interleaved fields of habits, persons, technologies, media, institutions, ideas, and other entities (cf. Bateson 1972).

must be interviewed about the outgoing expert's thinking and impact for a nuclear organization to even scratch the surface of apprehending his or her lifetime impact. Without doing so, the countless incongruities, points of misfit, and contingent happenings layered between the many expert persons composing the retiring expert's expertise would go unmarked too. Blind spots like these can hinder nuclear organizations' institutional memories and obscure efforts to endow soon-to-retire experts with robust predecessor agencies.

Second, attuning to how predecessor figures get edited over time denies experts' legacies any semblance of closure. This is productive in how it rejects the pretense that an expert's impact can be "captured" by management programs (IAEA 2006). Nuclear professionals must better appreciate this lack of stasis. That can inspire experts to, in the wake of abrupt expert loss events, pause for a moment to reflect on what dimensions of a lost expert's knowledge lives on in them and their work. This practice repositions knowledge management as not primarily about the storage of predecessors' information in files or the codification of their methods in how-to manual reportage. It makes it more about enculturating experts to better attune to the open-endedness, tentativeness, and customizability of experts' postmortem figurations—a redefinition of nuclear expertise itself. This can encourage reflexive self-scrutiny of parts of oneself that might be permutations of, reflections of, contributions from, defense mechanisms against, or inspired by those of a lost colleague. This can help any expert better understand the predecessor insights he or she may already be conserving within—giving him or her a richer sense of how those insights can be most usefully channeled, conjured, or summoned in future troubleshooting moments. This can help ensure that an indispensible expert's thinking outlives his or her biological lifecycle – even nuclear facilities' lifecycles – which are often simplistically imagined as having endpoints that close at death or decommissioning, respectively.

Third, imperatives to instill richer predecessor preservation ethics raise the question of whether top-down “management” of objectified “knowledge” should really be nuclear sectors’ primary intergenerational knowledge continuity goal. Ground-up *stewardship* or *custodianship* of recollections of predecessor *thinking patterns* among surviving colleagues may better denote the everyday interpersonal work that must be undertaken to subtly conserve fragile forebear insights. Too elusive to be glossed as “everyday experience” (e.g. Chakraborty 2003), this eludes management itself. Yet this everyday expert labor – of inheriting what becomes construed as someone’s patterns of thought, taking responsibility for them, and taking over the dead’s intellectual estate in a gated community of professional relationships – is key to tending to predecessor agencies that can make organizations safer, more reflexive, and more stable. Stories of Seppo’s death are thus not mere case study data to be crunched. They area not empirical details to be abstracted out of executive summaries or internationally portable nuclear sector recommendation reports on knowledge transfer. Predecessor parables are key to warning against knowledge-losses that may occur if retiring nuclear experts fail to have their careers closed with care. These storytelling practices must be seen as performative acts of knowledge management in themselves.

Fourth, emphasizing predecessor-summoning practices complicates any crude portrait of a singular senior professional unilaterally passing down his or her tacit knowledge, tacit or otherwise, to receptive younger protégés. In this article, the latter were anything but passive. When making references to Seppo, they candidly reinterpreted his weaknesses in ways that revised his personae and rewrote his legacy. This generated lessons about how, for example, psychological tugs toward death denial can become real liabilities for organizations. Or how a fragile, standoffish, charismatic personality can attain a situated sovereignty of its own. Or how, once removed from a field of entangled relations, that sovereignty can create a vacuum, disrupting an organization's stability. This underscored how nuclear knowledge transfer pathways are always deeply mediated by countless contextual idiosyncracies wedged between knowledge transferers and transferees. For nuclear professionals, adaptively navigating ambiguous relations like these will become increasingly crucial as boomer nuclear expert attrition continues to ramp up across Western Europe, North America, East Asia, and beyond.

Deep Time-Reckoning: A Final Iteration

This ethnography showcased the work that informants' iterations of familiar devices like mankala, recruit/retiree, junior/senior, part/whole, input/output, and predecessor figures did to help Finland's nuclear sector worlds maintain continuities across the shallow horizons of politics and finance (Chapter 1), the multi-decade and centurial horizons of nuclear energy personnel regeneration (Chapter 2), the everyday office horizons of a one hundred twenty year project to model far future Finlands (Chapter 3), and the human life course horizons of Seppo's postmortem influence (Chapter 4). These devices helped Alaknam, Tuuli, Timo, Laura, Taimi, Gustav, and others feel more at home in the world by cutting through complexity to establish more recognizable coordinates for where to go next. When informants were "true" to the constrained forms devices such as these took (Keane 1997: 14 in Riles 2016: 186), they achieved what Kierkegaard called "recollection forwards" into the future (2009 [1843]).[216] Their iterations became both acts-in-the-world and acts of world-making, defining and redefining the contours of nuclear experts' "anticipatory consciousness" (Bloch 1986). Studying this revealed how key political, financial, succession, workplace-scheduling, geological, and human-biological time horizons – but a few among countless others – had to be simultaneously upheld for nuclear reactor projects, spent nuclear fuel management programs, and deep time-reckoning Safety Case work to attain auras of continuity into futures near and deep.[217]

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[216] Anthropologist Webb Keane showed how recognizability itself is about being "true to form," as any event, practice, or signal must take a knowable form in order to be intelligibly typified (1997: 14 in Riles 2016: 186). Kierkegaard explored how ongoing avowals of selfhood and faith have established "recollection forwards" into the future (2009 [1843]). This ethnography likewise tapped into how repetition and typification constitute lived experience and vice versa.

[217] Emphasizing this evoked a different kind of time depth—one about how any temporal now is deeply constituted not only by uncertainties, but also by cascading admixtures of interposed time horizons continually shaped and re-shaped by countless familiar devices of pattern being iterated and reiterated to uphold them. This focus backgrounded the notion of time's depth as about the quantity of time in an interval and, instead, foregrounded the notion of time's depth as about the qualities of a moment in time.

What emerged was an ethnographic approach of restraint: one that avoided getting mired in nuclear waste's deep time horizons' often sensationalized aesthetics of horror, sublimity, and awe by instead following how my informants made visions of distant future Finlands intelligible through familiar corporate, technocratic, regulatory, financial, and scientific practices amidst much shallower horizons. The stories I told were not about, as John Playfair put it in the early nineteenth century, how "the mind seem[s] to grow giddy by looking so far into the abyss of time" (1822 [1805]). They were not about how, when grappling with deep time, the "individual and the individual's system of relations disappears from view" (Bailey 2008: 21) such that the "individual, the community, nation, history, creed, institution, and religion all give way to the slow dissolution of the meta-level gaze from geological time" (Tomko 2004: 119). They were cloaked in "tropes of the aesthetic sublime" like those Charles Lyell, a father of modern Geology, drew upon in many a "rapturous passage on the contemplation of deep time" (2004: 119-120). They were about mundane short-terms, the pervasiveness of everyday devices of familiarity, and the cautious ethos of the meticulous knowledge-worker.

Inspired by my informants' iterations and reiterations of the familiar, I now conclude with a series of reiterations of my own.[218] First, I reiterate or "circle back" (Riles 2006a) to the Introduction's challenge of soberly depicting nuclear waste's deep future worlds—offering a more ethnographically grounded take on how it manifested at my field site. Next, I reiterate the Introduction's three opening questions about unknown twenty-first century expertise, environment, and nuclear energy futures. I respond to each with insights – about the *continuity*,

[218]This ethnography is itself structured as an iteration: questions are posed in the Introduction, addressed in the four body chapters, and revisited afresh in this Conclusion. This performative writing mode has many precedents in Anthropology. Martin Holbraad, for instance, performed the notion of "recursivity" in the structure of his ethnographic narrative while also taking the "recursive" knowledge trajectories of Cuban Ifá diviners as his object of analysis (2012: xx). Miyazaki likewise posited hope as his ethnographic object and replicated it as his method of analysis (2004).

thinkability, and *extensibility* of expert thought – derived from my reiteration of nuclear waste's deep time. These, I suggest, can help contemporary experts of many stripes scale the seemingly insurmountable uncertainties before them—becoming better uncertainty navigators by refocusing their intellects on how iterations and reiterations of the very familiar shape how tomorrows are envisioned.

What Was Deep Time?

Deep time was more than just a lot of time.[219] Deep time encompassed and subsumed many other shorter, already-formed time horizons upon which it was premised. That is, it took shape within and parallel to shorter horizons. That was its depth as encountered in my ethnographic immersion. When I was in the field, as durative time plodded forward, different experts iterated familiar devices like mankala, input/output, recruit/retiree, or predecessor figures in various time horizons simultaneously there are elsewhere.[220] This was testament to how the successful navigation of any deep time horizon had, as its prerequisite, the successful navigation of countless other time horizons. Deep time-reckonings thus hinged upon reckonings of myriad other time horizons too. If one such constituent, briefer, prior horizon had been sculpted differently, different renderings of deep futures could have taken shape in turn. For example, Posiva cutting a funding stream could have reduced the amount of project-time a Safety Case expert had to develop a model, which could, consequently, subtly alter the future worlds the model envisaged. An expert retiring five years earlier than anticipated could alter the course a modeling project took too.

[219]Deep time was more than an interval best represented as a space between two distant timepoints on a linear axis or geological timetable. It was more than just a projection extended out from an experiential present far forward and backward across time.

[220] The United States' Yucca Mountain nuclear waste repository project's license application experts, for example, iterated and reiterated modern Euro-American legal adjudication's rule-facts-judge template and legal personhood figures to reckon million-year horizons (Ialenti 2014a).

Deep time was always grounded on broad, familiar, black-boxed distinctions iterated widely across difference. For instance, when informants debated Safety Case technicalities, each implicitly affirmed an unquestioned international consensus about the "radioactive decay" and "half-life" notions from which the entire STUK-Posiva-TVO-Fortum-VTT-SROY-Aalto nuclear waste regime sprouted. Finland, like all nuclear countries, first had to naturalize and submit to a belief in radioactive decay's deep time horizons before it moved to build a repository.[221] These scientific time horizons were mostly uncontested. This was reinforced by international consensuses like those discussed in reports like the OECD-NEA's 2009 "Considering Timescales in the Post-closure Safety of Geological Disposal of Radioactive Waste." Nuclear waste could always be situated in a timepoint on a long path of becoming-pure that would culminate at a future horizon in which its hazardousness was to self-extinguish. Nuclear waste, by definition, could always be positionable somewhere between a starting-moment of its hazardousness and an ending-moment of its future purity. At that prefigured horizon, it would decay to what were called background radiation levels. It would de-differentiate itself, no longer requiring classification as waste.[222] Until then, waste management regimes interfaced directly with the deep teleologies that emerged from the waste's toxic materiality. Iterating and reiterating these half-lives' deep time – alongside horizons emerging from familiar devices like junior/senior or predecessor/successor – gave rise to an enormous ordeal of proving repository safety. Waste was in this way generative: from it bloomed visions of deep time.

[221]As Mary Douglas has noted, waste sequestration efforts often "depend on community-wide complicity" with regard to what is defined as waste (1966: xxii).

[222] Here I evoke Douglas' discussion of dirt, trash, and waste: "in this final stage of total disintegration, dirt is utterly undifferentiated. The cycle has been completed." She framed this in terms for form and formlessness: decomposing garbage moves "from a state of non-differentiation; all through the process of differentiating its role [is] to threaten the distinctions made; finally it returns to its true indiscriminable character. Formlessness is therefore an apt symbol of beginning and of growth as it is of decay" (1966: 198).

Deep time was in the now and vice versa. One was not more knowable than the other. They were both invented out of and in one another.[223] They both defied totalization. Sartre has described how the now can paradoxically be cast as either being or nothingness (Sartre 1943). Miyazaki has noted how trying accessing the present ethnographically evokes the challenge of apprehending "what is too close and too immediate" (2006a: 207). For my informants and me, deep time was an object of attention in our presents. When far futures were reckoned, momentary time and time immemorial, both ultimately inaccessible, converged. Safety Case experts chased these ever-receding horizons but, like the Introduction section's Sisyphean ants, never arrived. In deep time and the now alike, they encountered a complexity "overflow[ing] the thought that thinks it" to elicit what philosopher Emmanuel Levinas called *infinition*—the "overflowing of the idea by its ideatum" (1969: 41).[224] This required Safety Case experts to extend their intellects toward an infinity knowing all the while they would never grasp it fully. Reaching out to get closer to it, however, elicited ceaseless iteration of familiar devices such as predecessor, input/output, part/whole, mankala, recruit/retiree, junior/senior, and countless others I have not selected for analysis. Doing so inflected nows with semblances of pattern.

Deep time was polysemous. It was a time horizon that STUK experts required Safety Case experts to render into an object of legal, scientific, and policy expertise. It manifested sometimes as an idea-in-the-world, sometimes as a pile of documents, sometimes as geologic timescale poster on an informant's wall, sometimes as a computer file, sometimes as a prehistoric landscape feature and so on. It was artifacts of nuclear waste's toxic materiality. It was a representation of a timeframe contingent upon representations of many much-briefer timeframes.

[223] That is, one could "talk about one through the other" and vice versa to deprive each of their "perspectival completeness" (Strathern 1992a: 3, 8, 177). For anthropological commentary on relations invented "*out of each other* and *through each other,*" see Wagner 1981: 50; 1986: 9.

[224]Put similarly, deep time-reckoning left remainders, showing how the "capacity for conceptualization" can be "outrun by the concepts it produces" (Strathern 1991b: xiv-xv, xxi, xxix).

It was a philosophical concept that emerged in the eighteenth century in debates about, for example, Hutton's uniformitarian Geology. It could trump historical time and inspire species thinking.[225] It was a clickbait strategy for my online articles for National Public Radio (NPR), Physics Today, The Long Now Foundation, Nautilus Magazine and other outlets. It was a focus increasingly articulated through vocabularies of legalese, investment, the audit, administration, and research-funding applications in Northern European nuclear waste expert worlds. It was a chronotope for Anthropocene periodization and Big History storytelling. It was a wide horizon discernible only within short horizons, but it was not infinite time. It did not encompass what the theologians have called *pro chronon aionion*: the time before time started (Craig 2001: 19). It evoked what anthropologists have called distant time stories (Nelson 1983) in spans familiar to archaeologists and biological anthropologists. It was a natural-historical horizon in which we dwell. It was an old rock on the ground. It was a grabby pop science trope that evoked images of horror, sublimity, and sci-fi futures. It was gossip, emotions, and disputes (See Chapter 4).[226] It was many other things too.

Deep time emerged from inter-subjective webs of relations between experts with widely varying mentalities. Some informants, as a KYT expert once put it, had more "ancient Greek" mentalities

[225]This has also been said of nuclear risk itself. As Beck has noted, the "ascriptive quality of danger" of risk societies "transcends all social differentiations and inequalities" to drive the entire human species "into a *collective existence*" (Beck 1987: 154, 156). As anthropologist Lisa Yoneyama has said, "memories and testimonies of Hiroshima, and the state of the postcolonial, postnuclear age that they speak to, forbid virtually anyone from remaining external to this global condition." (1999: 39).

[226]I commonly encountered fractious gossip-disputes between experts. A nuclear energy company higher-up called mankala-opponent and Green MEP Satu Hassi a melon: Green on the outside but Red on the inside. Hassi, a proud idealist, retorted by telling me how her website asserts that, "in this job it helps if you've admired Pippi Longstocking when you were little." Another expert mocked the narrow stubbornness he associated with leftists in Finland. He told me the story of how Björn Wahlroos – then Chairman of the Board in financial company Sampo Group, Nordea Bank, and Finnish pulp, paper, and timber manufacturer UPM-Kymmene – evolved from being a radical communist in his youth to the arch capitalist he is today. Wahlroos now lives in a mansion in Salo, Finland and his son Thomas is a well-known poker player who has won almost $1.5m in tournaments. He ridiculed how a dogmatic communist hypocritically became a dogmatic capitalist. To him, all that was constant in such fundamentalists were their tendencies toward dogmatism. He then noted how Posiva had many former leftists in its highest ranks.

(compelled more by hard logical relations, data, calculation, syllogism) whereas others had more "ancient Mesopotamian" mentalities (compelled more by soft intuition, broader phenomena, and general patterns). Some were better at skating perfect figure eights (executing procedures perfectly or performing research with rigorous exactitude) than improvising like a jazz musician (the bricolage of drawing fragments of technique together in an ad hoc fashion on-the-spot). Some higher-ups could be good managers (organizing people, projects, knowledge, and things efficiently) but poor leaders (failing to inspire a team's ambitious morale or self-motivations). Some experts had a calm, sober, disciplined interior space enabling them to keep a cool head when things go wrong. Others became panicky and flailed under pressure. Some were eccentric, jumpy, or non-conformist ordinarily but became radically focused, serious, and dependable in crisis conditions. Some leaders, to use a distinction introduced to me by retired U.S. nuclear submarine engineer, could have leadership styles more like George Patton (a calculating tactician) or more like Dwight Eisenhower (bringing diverse groups of people together for a common cause). It took a village to make visions of deep time visible.[227] And an army of assorted expert voices to defend them and interpret them in various ways.[228]

Yet deep time was not eternity. It complicated the *Eternity* discussed in the Introduction section—that of Madsen's film *Into Eternity* (2011). Madsen's *Eternity* title seems imprecise when circling back to it after fieldwork, especially when one has philosophical and theological work on eternity in view. Deep time was not eternity because nuclear waste was not eternal. It had half-lives. Like this ethnography, it had starting-points and endpoints and inhabited an immanent not transcendent realm. Eternity does not end or start. Nuclear waste's deep time was things-in-worlds that did. Eternity is – if one has faith it – all that was in the beginning, is now, and ever shall be. From most philosophical or theological standpoints, then, Finland's newspaper obituaries iterated the eternity concept more correctly when they said, speaking of the dead entering Christianity's transcendent heaven, *tästä ikuisuudeen* ("from here to eternity").

[227] These personality differences can be demonstrated ethnographically. One informant alluded many times to his penchant for alcohol and cigarettes and spoke often of his divorce in the 1990s. Another, also with a reputation for having a strong personality, told me about how she once sent a colleague a joke email about him dying of lung cancer. One warm and hospitable Safety Case expert kindly invited me to her *kesämökki*. When there was an electricity blackout, remedied by candles, her friendly family playfully described the situation as resembling a spiritualist meeting. Once, when I was chatting with Gustav, he burst a blood vessel in his eye and then told me how everyone in the Safety Case project today listens too much to the young guys who smile a lot and how people today tend to lose track of the importance of rigorous mathematical calculation. One very accomplished nuclear waste disposal expert first introduced himself to me by telling me, warmly, "I like doing interviews because I am fat and old and have nothing better to do with my free time." This particular quip might not surprise an anthropologist of Finland: as an old adage put it, *mies se tulee räkänokastakin, muttei tyhjän naurajasta* ("even a snot-nose will become a man, but not someone who laughs at nothing"). A Finnish colleague reflected on that phrase as follows: "Of course I used this as an example of Finnish miserablism. The notion that frivolous merriment is suspect, and that one should be a serious person. Not talk unless one truly has something to say, and certainly not express trivial enjoyment. A lighthearted person cannot be relied upon, they do not take their responsibilities seriously. They do not feel the weight of the world. Surely there is something very gloomily Lutheran about this, the ennobling effect of suffering and humbly renouncing the material world, but it goes beyond that."

[228] Personalities and disposition affected how experts engaged with futures. For example, gestures of modesty, directness, humility, and self-deprecation were common in Finland. Some Safety Case experts derided others as perfectionists or nitpickers or, to use the Finnish terms, as *pilkunnussijat* ("comma-fuckers") or, more politely, *pilkunviilaajat* ("comma-filers"). Some saw themselves as more idealistic; others more pragmatic. Differences like these helped calibrate experts' relative optimisms versus pessimisms about the future. One informant, for example, used the phrase *pessimisti ei pety* ("pessimists don't get disappointed") when describing his personal philosophy of tomorrow.

Into Deep Time would have been a better film title. Sixth century philosopher Boethius (2001 [512])'s classic rendering of eternity can demonstrate why.[229] For Boethius, eternity was atemporal, timeless, or anti-temporal. It was situated omnisciently outside, beyond, and above the finite here and now.[230] No informants' iterations of deep time shared these pretenses of transcendence. Viewing the temporal world from on high, Boethius' eternity viewed all timebound nows as a *totum simul*: it could see the moment of the Lappajärvi meteor impact, Posiva experts' 2012-2014 work, and the far future Olkiluoto repository all-at-once. From an eternal standpoint, these three time-points were simultaneous. God, in seeing all moments at

[229]Boethian renderings of divine eternity posited it as "the complete possession all at once of illimitable life," as "the infinity of mobile time present," or as "the present instant 'standing still" (Stump & Kretzmann 1981: 430-434). It "owes much to the language of Neo-Platonism" (Helm 2001: 32) in assuming "two separate modes of real existence" (Stump & Kretzmann 1981: 434). Theologians asserting God's "absolute timelessness" or "atemporality" situate the transcendent Creator *outside* of the inferior creaturely realm (Helm 1988; 2001: 29; Leftow 1991; Stump & Kretzmann 1981: 450), and take God's immutability, perfection, impassability, self-sufficiency, fullness, or simplicity as indicators of divine transcendence (Craig 2001: 239; Helm 2001: 34-35, 39; Leftow 1991). Today, offshoot perspectives vie to supplant "absolute timelessness" as the dominant paradigm for conceptualizing eternity (See Ganssle 2001). Theologian Alan G. Padgett, for instance, argues for eternity's "relative timelessness" (2001) and for a God who is both "*conceptually prior* (in terms of ontological dependence) to eternity" and "immeasurable" in its infinity, as there is "no reason to assume" that "temporal metrics" which are "relative to inertial frames of reference… apply to God." Thus, God is timeless not intrinsically, but only "*relative to* the created time of our space-time universe" (2001: 105-107). Others, like analytic philosopher William Lane Craig, argue for God's "omnitemporality," the argument that "God was timeless without creation and temporal subsequent to creation" because "God is causally, but not temporally, prior to creation" (2001: 160, 186). Still others, like Nicholas Wolterstorff, posit God's "unqualified temporality," arguing that the A-Series' very existence negates the validity of an entirely B-Series divinity, and that Biblical data depicting God performing actions *in* time leave "absolute timelessness" adherents with a heavy burden of proof (2001).

[230] It thus encompassed "the whole fullness of unending life at once" from the standpoint of "a property particular to the Divine mind" which "embraces all things from some lofty height" (Boethius 524: VI). In contrast, "bodies endowed with sentiency" cannot "cope with the simplicity of divine foreknowledge" by claiming an "outlook [that] embraces all things as from some lofty height" as eternity does (524: V, IV),

once, was omniscient. Eternity, for those who believe in it, is seen as accomplishing the Safety Case ideal: a way of viewing distant-future worlds and present-day worlds as perspectives on one another in a single frame simultaneously.[231] But no informants thought they could, in life, achieve that meta-standpoint. Eternity, like deep time, often evokes reflection on the now. Kierkegaard called the now an atom of eternity (See Moltmann 2003: 88-89). Theologians have called it the *nunc aeternum* or eternal now (Tillich 1963). Goethe saw the now as eternity in immanence (See Moltmann 1964: 27).[232] But informants never posited deep time as any transcendent guarantor of, divine manifestation of, or metaphysical constituent of the now. It did not endow the now with *meaning* or *purpose* in the way eternity has been thought to. The deep time informants reckoned was mostly a mundane artifact of incessant iterations of the familiar.

A Geological Timetable on a Safety Case Geologist's Wall. This is One Form Deep Time-Reckoning Took in the Field.

Deep time never eluded or transcended the concrete world of formed knowledge. Even Chapter 3's Safety Case KQA reports on non-knowledge contained only formed worldly, not formless or otherworldly, knowledge. This ethnography did not emphasize the radical long-term that makes

[231] These deep time-reckoners sought to, to borrow words from Haraway, jump "out of the body and into a conquering gaze from nowhere" (cf. 1988: 581). Haraway rejects totalizations, in the hard sciences and in constructivist social science, "promising vision from everywhere and nowhere equally and fully" and advocates is "partial sight and limited voice" (1988: 584, 590). Safety Case experts did not believe they could attain anything like a Boethian eternal perspective—even when doing ambitious analogue studies that folded knowledge of present land formations into projections about multi-millennial past and future formations and vice versa. Religious and irreligious informants agreed that their mortal imaginations could extend material-temporal deep time but never divine-atemporal eternity. Yet, like this ethnography's Introduction's Sisyphean ants, they persisted nonetheless.

[232] It is as though the now and eternity serve to, to borrow words from Wagner, "'ground' each other, each being dependent on the other for the complement to its own effect" (1977: 392). In Wagner's terms, this could be because "each concept uses the extensive bias of the other as its symbol" (1981: 32).

deep time immediately titillating, but the endless subtle short-terms that make its real-world materializations captivating.[233] Attending to this can nudge one away from overemphasizing how nuclear waste temporalities can evoke distant future societies with alien semiotics (Benford 2000; Galison 2012) or repository sites' multi-millennial warning monuments (Bryan-Wilson 2003). It can prevent flashy questions of "imagining society 10,000 years from now" (Galison & Moss 2015) from distracting attentions from the sublime depths that a timebound now's convergent nexus of time horizons can reach. It can save one from getting mired in the gaudy aesthetics of apocalyptic time[234] or from feeling "abstracted out of significance" by deep time's breadth (Irvine 2014: 162).

Deep time, as an artifact of iterations of the familiar, was mundane but not boring. It could inspire awe just as common-but-profound things like life, the now, and form can inspire awe. Anthropologists Kohn and Deacon have gestured to how mundane attainments of form can be captivating. Kohn has shown how form is intrinsic to all life in that "patterns are harnessed, nurtured, and amplified by life" (2013: 20). Deacon has shown how all morphodynamic processes – which underpin any living and certain nonliving relations – require form to attain worldly regularities (2012). In that sense, deep time-reckoning, as a worldly knowledge-practice, is but one kind of these more basic living semiotic process that unite microorganisms,

[233] This ethnography affirmed Finland's Olkiluoto repository as an "incalculable, excessive object" that, like nuclear waste disposal projects elsewhere, evoked deep futures and stretched boundary making between concepts to its radical limits (Bloomfield & Vurdubakis 2005: 3). But it also made these deep futures shallow by analyzing them as but one extension of familiar iteration practices that grounded everyday office, laboratory, and institutional lives. It showed how hey they acquired form in and through situated (Suchman 1987) or ordinary (Lynch 1993) actions and entangled with the regulatory scientific forms that comprised Finland's nuclear waste regime. By this I mean the "set of integrated laws, organizations, and agencies, principles, norms, rules, and institutional procedures designed to regulate and coordinate action for the disposal and management of radioactive wastes" (Solomon 2009: 1012). These regimes' devices of coordination are not to be appreciated uncritically. As Beck wisely noted, to "categorize, classify and regulate everything in scientific-authoritarian-bureaucratic fashion belongs to the false logic of risk avoidance" (1987: 161).

[234] That is, to the bipolar "dialectical extremes" of "horror and hope, nightmare and dream, destruction and creation, dystopia and utopia" (Stewart & Harding 1999: 286, 291).

whirlpools, uncertainty navigators, shamans, dreamers, platypuses and countless others. That underscores how these agents all inhabit ecological, organismic, or inert general patterns always right under our noses. Being attentive to this can counter deep time's sublimity's capacity to overwhelm action and overspill thought. After all, form is, according to Deacon and Kohn – like the fractal relations that Chapter 3's input/output and part/whole forms generated – self-similarly present in and across endless scales and levels of (human) (expert) thought. It is as alive in deep time's novelties as it is in more familiar happenings like brushing one's teeth. That is part of its depth.

A goal of this ethnography was to scour nuclear expert worlds for trusty devices, concepts, and distinctions confidently iterated when unknowable futures, near and deep, have been reckoned.[235] Revisiting Finland's nuclear waste deep time-reckoners as but iterators of familiar patterns provided a useful limit case for underscoring key living processes through which far futures become thinkable. This was done not in a spirit of navel-gazing academic intellectualism. It was a pragmatic response to urgent crises. The current historical moment of political-epistemic uncertainty is too consequential for any expert to retreat into the safe boxes of one's technical expertise, to cloister inwardly in exclusive circles, or to cower before the magnitude of looming challenges. It requires nothing short of a re-thinking of expertise itself. As legal scholar Frank Pasquale has said:

> Technocratic cost-benefit analysis may be a useful guide in certain narrow, short-term contexts... But as the scope of time, space, and expense opens up, the method loses its mooring. The longer the term of our vision, the more basic ideals and values must come

[235] This included devices seemingly all about the past like Chapter 4's predecessor form or Chapter 3's Nazca Lines. The chapters on Safety Case expertise retooled *contexts* in which extremely long-term horizons entered practical policy, planning, or regulatory frameworks as *fieldsites* in which devices for creatively thinking the radical long-term could be found.

> to the fore. If we want a future somewhat recognizable to the world of today, we must buttress the institutions capable of inculcating certain habits of mind and character that respect intrinsically valuable aspects of our experience (Forthcoming).

In this spirit, I close by extracting from my encounters with deep time three lessons – about the continuity, thinkability, and extensibility of expert thought – that, I suggest, can help experts more thoughtfully navigate the unknown futures for expertise, environment, and nuclear technologies before them. My hope is that my informants' engagements with far future worlds can inspire other experts to reflect productively on the character of their thinking too.

Continuity: Navigating Expertise Futures

After I returned to the U.S. after fieldwork in 2014, spectacular denials of climate science, election polling, vaccine science, intelligence experts, crime and jobs statistics, and media fact-checks energized wide public blocs. Calculative rationality's social bases were regularly exposed in the media. Attacks on expertise writ large opened space for once-unlikely alliances between skeptical defense intellectuals, disillusioned deep state elites, left-liberal scholars, nuclear technocrats, scientists worried about climate denialism, Silicon Valley opponents of anti-immigration orders, and other communities of the highly trained.[236] This raised thorny questions about what Anthropology has to offer when nationalist-populist claims to political power are bolstered by moves to deny, refuse, mock, discredit, or refute technocratic wisdom. For example, what is the value of Foucauldian analysis – which assumed a close link between governing

[236] But these opportunities remain unlikely to be seized. For many, this suggests that what is needed now is confident, rigorous, thoughtful collaboration among experts willing to rethink how they can unite to counterbalance populist, nationalist, anti-expert fervor. Perhaps the time has come for expert cultures to embrace the identification of "expert" – really owning it as a badge of pride – and band together to counter attacks on their credibleness. Or perhaps today's political-epistemic turmoils are but brief episodes that will fail to meaningfully reroute nuclear sectors' deeply entrenched path dependencies.

power and expert knowledge – when the former becomes increasingly predicated on outright rejections of the latter?

Throughout the Cold War and the heydays of high finance that followed it, many social scientists sought to debunk uncritical views of science as universal, to question a powerful military-industrial-academic complex's quantitative auras of legitimacy, and to introduce alternative ways of knowing a world that seemed to be adopting a single, hegemonic, technoscientific worldview. That made sense. But alt-right critiques of technocracy have begun to parallel, often in unsettling ways, these same social scientific moves to deconstruct, criticize, or relativize expert knowledge. Anthropologists must now be cautious that their critiques of technocrats do not tacitly empower alt-right critiques of technocrats, affirm vulgar critiques of elites, give ammo to anti-climate science arguments, or help those in power defund STEM research. Yet there still lingers an impulse among many to undercut rational expert governance regimes by stressing their underlying contradictions.

Today, risk society theorists' once-apt advocacy of "self-criticism in all its forms" among experts (Beck 1987:165) seems off base. As this ethnography showed, few informants needed reminders of their and their colleagues' intellectual limits. All of them were familiar with failure, many were self-conscious about their knowledge's quality, and some felt they were growing less trusted by public blocs. Many knew their knowledge had been secured, as a risk society theorist might put it, through "rules of credibility" that can achieve only probable not absolute security (157). They did not need a social scientist to tell them of the close connection between public deference to their competences and their trusted statuses as civil servants, technocrats, or consulted experts.

Instead I advocate that scientists, engineers, technocrats, and other experts work to cultivate deeper appreciations of their expertise's *continuities* with – or ongoing interconnected "becoming-with" (Haraway 2008: 3) – wider ecologies of thought patterns and relational formations that ground, uphold, and establish the conditions of existence for their technical knowledge but that might, at first glance, seem impertinent to it. In this ethnography, broad and familiar devices like predecessor/successor, junior/senior, or input/output were iterated and reiterated in ways continuous with – intimately entwined or deeply connected with – even the most specialized nuclear science techniques and even the most farsighted deep time auguries. Appreciating these continuities between the widely-familiar and the deeply-specialized – becoming more sensitive to, appreciative of, or receptive to them[237] – can reveal how even the highest-level expertise is always, in part, an achievement of dense intersections of familiar figures, devices, and formations. It can reveal even the most counterintuitive finding as, in part, an artifact of countless familiar patterns – many strikingly simple and not specific to expert knowledge systems – mixing with other familiar patterns to produce other patterns that mix with still other patterns to produce still other patterns *ad nauseum.*[238]

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[237] This reflectiveness need not unfold in a self-criticizing spirit. Chapter 3's Nazca Lines, forest, and map figures were, for example, non-critical second-order self-reflections on technical input/output and part/whole distinctions. They were heuristics artifactual of becoming attentive to base-level devices upholding one's knowledge-practices—emerging more from thoughtfulness than self-critique. Indeed, Finland's nuclear experts ventured auto-commentary, auto-analysis, auto-critique, para-ethnography, self-condemnation, self-deprecating jokes, and amateur theorizing at different moments in response to shifting conditions of uncertainty versus certainty, crisis versus stability, unchecked technocracy versus populist anti-intellectualism.

[238] Bateson described the "enrichment of information that occurs when one description is combined with another" (1979: 84). He linked this enrichment with his inquiry into pattern: "First, any two patterns may, if appropriately combined, generate a third. Second, any two of these three patterns could serve as a base for a description of the third. Third, the whole problem of defining what is meant by the word pattern can be approached through these

Actively self-searching for how even the most arcane knowledge is continuous with countless circuitries of familiar patterns nestled within it and extending beyond it can help an expert achieve a wider, more holistic understanding of his or her knowledge. This does not necessarily mean reflexivity in a self-critical mode. It merely means opening up more to how one of the "key features of expertise is that it must exclude certain other forms of knowledge in order to define its own parameters" (Riles 2017: 14). Thinking beyond these exclusions and parameterizations could foster processes of expert self-formation more adaptive to political-epistemic contexts in which, in "many countries, the bargain between these experts and the public at large is rapidly unraveling" and in which "experts are increasingly skeptical about publics" (3). This mode of self-searching could be supported by what Pasquale has called an "ethical stance of attunement": an embrace of receptivity, sensitivity, appreciation of one's wider world over yearnings for mastery, escapism, and mechanistic thinking—a stance derived, in part, from Pope Francis' *Laudato Si'*s "sensitivity to time and speed" (Forthcoming).

Experts have lots to gain by adopting these anthropologically inspired sensibilities. They can help an expert avoid the hubristic trap of thinking he or she has, through esoteric learning, somehow transcended the concrete to adopt what Haraway calls scientific universalism's view from nowhere (1988). They can enrich one's sense of one's thinking's historical rootedness and deep humanity—obviating technical knowledge's foundations by unpeeling the countless prerequisite layers of familiar devices that have helped compose it. They can help experts see continuities between their knowledge-practices, those of peers, those of lay publics, and those of

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phenomena. Do we, in fact, carry around with us ... samples of various sorts of regularity against which we can try the information (news of regular differences) that comes in from outside?" (85).

alt-right extremists. Opening to these continuities can help one overcome inward-looking professional silos' ego-stroking lures to become a more responsive, understanding, open-minded expert when seemingly extra-scientific forces interrupt expert cultures' practices, values, and public support.

This openness can be described ethnographically. Jukka, a Safety Case expert in his fifties, was very attentive to continuities between his specialized expert knowledge and that which, at first blush, appeared exterior to it. He spoke thoughtfully about the layers upon layers upon layers of radically familiar thinking patterns that first had to be deposited from pasts and inscribed in presents for his complex professional world to become thinkable in the first place. From these grounds, he critiqued how the figure of an expert as "guardian of the best knowledge" was devolving into the figure of an expert as an extroverted, sophistic, personal pitchman.[239] He critiqued how expert career outlooks were increasingly more precarious, less stable, and less secure than those of their managers, funders, and administrators.[240] To see this, he first had to see how changes in how experts' positions realigned vis-à-vis other positions in society's broader constellations of role templates (See Chapter 2). This got him asking how, why, and by whom various familiar devices were or were not being iterated as uncertainties waxed and waned. Namely, he became skeptical of growing pressures to rearticulate his expert knowledge using vocabularies of legalese, investment, the audit, administration, and research funding applications.

[239] To quote Jukka at length: "Being a scientist you are normally quite humble in how you express yourself. Let your research do the talking. But, talking to those guys, you must abandon that. You must present yourself as on top of the world: 'I'm the owner of Europe and you are lucky to have the opportunity to talk to me'. Being, say, too modest is not seen as a virtue… In this case it might mean you get these extroverts who like to sit in coffee rooms, have small talk, and do nothing else. That's the danger. This is just an intuitive sense I have."

[240] Jukka grew concerned about how, while his employer recently laid off dozens upon dozens of experts, no administrators or managers saw the same fate. Though Jukka was heartened by a new rule that enabled managers to be laid off, he remained skeptical about whether coming waves of cost cutting would actually play out that way. He also became wary of how his team "wasted [so much time] begging for money" as there was "more and more this massive bureaucracy run by more business-oriented people counting money all the time."

Attuning to wider circuitries of iterating devices of familiarity underlying his expert position – putting his awareness in line with them – he was sensitive to how scientific ideas were increasingly packaged in non-scientist bosses' idioms of quality control and knowledge management.[241]

Jukka's attentiveness to these continuities was defined by his thoughtfulness about how interlocking patterns interwove with his technical knowledge, and how they were iterated differently when linked up to others, which were linked up to others upon others upon others, ad *nauseum*. This inspired an elaborate critique of public and private bureaucracy and the business-speak increasingly ascendant in science management.[242] Of course, not all experts shared his discontent with ways management, administration, finance, and capital logics were being iterated as ways of legitimizing scientific knowledge's credibility. Laura carefully followed this same re-packaging of Safety Case expertise. Yet she saw the accountabilities these bureaucratic practices fostered as quality-control improvements over past eras when experts hid behind their institutions' authority. Whether Jukka or Laura was correct is beside the point. What they shared was a self-searching ethos of awareness of the familiar devices they iterated and reiterated: a commitment to following the trails of entangled familiarities ever outward to discover more of the patterned coordinates that undergirded, transcended, and extended beyond their technical specializations. This helped them see how their expert thinking patterns could connect, un-

[241] As this informant put it: "You have to know how to talk to the bosses who are, increasingly, not scientists. You have to understand their buzzwords, their code words, know their vocabulary, and use their dictionary. You must use the words they love in order to get funding. But, still, the gap between the scientists and the bosses is real. If you start using the terminology of the bosses too often, you might lose your credibility in your field among more competent scientists."

[242] Jukka, like Gustav in Chapter 4, grew nostalgic for a time when Safety Case work was less about documenting his methods in Oxford English and on tidy Excel spreadsheets to meet growing traceability, transparency, and reporting requirements.

connect, or reconnect to other thought patterns of/in patterns of/in patterns of/in patterns, *ad nauseum*.

Adopting sensibilities like Laura's and Jukka's can help an expert open to continuities between specialized knowledge forms inside one's professional silo and knowledge forms not-specifically-for-experts inside, outside, and straddling one's silo. Anthropology can be instructive here too. Latour has made a distinction between reflexive anthropologies that give primacy to difference-making versus recursive anthropologies that give primacy to the consequences of sameness (2012). Taking the latter route, this ethnography emphasized how any (nuclear) (energy) expert is *united* with any other in their impulses to tame uncertainties with recourse to familiar patterns. It has therefore run counter to anthropologies of energopolitics (Boyer 2011), energopower (Boyer 2014), or cultures of energy (Strauss et al. 2013) that instead emphasize what makes specific kinds of energy contexts different from one another. In stressing the sameness that recursive Anthropology evokes, the goal was not to parse, say, how energopower, biopower, or what Povinelli (2016) calls geontopower *differ*. It was to become sensitive to continuities, at the level of form, between any given expert and billions of other expert and non-expert people across time and space.[243] With this in view, I advocate that other experts become more attentive to this sameness to help self-overcome how deeply-rooted devices of familiarity tend to deflect attention from themselves when buried under a moment's banal technicalities, frenzied politics, or contextual messiness. Doing so can cut through the chaos of uncertainty and difference and help an expert think beyond his or her professional silo-thinking.

[243] This evokes a very different kind of nuclear universalism—one not about global power politics and history writing (Yoneyama 1999: 21-24) but a weak qualified one about how basic modes of reification, cultural invention, knowledge-practice, and/or form harnessing can be construed as key to the deeper history of nuclear technical expertise. For more on reification, see Strathern 1988. For more on invention, see Wagner 1981. For more on knowledge-practice, see Riles 2011b: 10.

Anthropologists have also studied how such continuities manifest in the subtle but powerful roles that form and the familiar play in everyday life. They have shown how challenging it can be to analyze them. Kohn has linked the difficulty of becoming "better attuned to the strange ways in which form moves through us" to the usually-undetected "effortless" ways it organizes significance and engenders relations without conscious attention paid to it (2013: 19, 160, 227). Wagner has described how forms most familiar to us – from God to money – are "somehow mysteriously *in front* of things, too elemental for easy or ordinary comprehension" (1986: 3). Riles' aim was to turn institutional forms "too familiar" for immediate apprehension "inside out" to render them more visible to us in response to how, given that we are inside them and they are inside us, they lack a palpable otherness necessary for achieving analytical distance on them (2000: 21-22). In this ethnography too, informants iterated input/output, predecessor, part/whole, and junior/senior incessantly without thinking twice about doing so. Ubiquitous yet elusive, this was their power. Engaging with this opened the question of "how to apprehend what is too close and too immediate" (Miyazaki 2006a: 207).[244]

Anthropology also has rich traditions of becoming more aware of powerful formal devices in the field, absorbing them, finding their parallels in academic thought, and reiterating them as means for academic analysis. Strathern once absorbed and then borrowed mathematics' fractal form to develop her analysis (1991). Wagner borrowed the Daribi *habu* concept, situating his concept of invention within it (1972; 1981). Others have attuned to "plays of commonality and difference across academic and nonacademic forms of knowledge" (Miyazaki 2006b: 149). Riles

[244]Miyazaki's strategy for engaging with the problem of "how to apprehend what is too close and too immediate" involved juxtaposing an ethnographic analysis of a Fijian mortuary ritual's temporal form with philosophical questions about self-knowledge's and the temporal present's elusive immediacy (2006a: 207).

denaturalized, borrowed, and turned inside-out network, matrix, and bracket – formal devices all-too-familiar to her, her informants, and network theorists like Castells – to develop her analysis of institutional aesthetics (2000). Miyazaki did so with Fijian landowners' hope, positing it as both his object of and method for academic analysis, scouting parallels between it and social theorist Ernst Bloch's concept of hope (2004). These works demonstrate how one can attune to a pattern, device, or formation – that is, get in touch with it and carefully follow how it effectuates thinking – to track its effects across broader circuitries of significance. This anthropological skillset has lots to offer experts seeking to become shrewder uncertainty navigators as unknown futures weigh upon them.

In this ethnography, opening to continuities between experts' and others' knowledge-practices meant becoming sensitive to familiar devices iterated so effortlessly day-to-day that they appeared as innate backdrops of or naturalized contexts for specialized nuclear expertise—devices which, like part/whole or junior/senior, one would not necessarily associate with nuclear expertise right off the bat. The goal was to "literalize" these devices or make them more explicit (Strathern 1992): to amplify the "coordinates" or "conventional points of reference" for what is "otherwise taken for granted" about one's esoteric knowledge (174). This provincialized expert knowledge as but one more manifestation of much broader practices of iterating the familiar in response to unfamiliar conditions. When informants like Jukka or Laura exhibited sensibilities like these, it was clear they were skills not measurable, subsumable to analytics, or reducible to formal titles, certifications, or professional degree statuses. They could elude buzzwords and fail to produce deliverables. Those weak in such traits often, on paper, appear no less credentialed than those strong in them.[245] Yet they were differences that could make all the difference in resisting non-expert usurpations of control over technical knowledge.

Amid today's political-epistemic crises, complacent experts can, *en masse*, be as dangerous as any political demagogue. Off-the-cuff alt-right provocations compete with and often supersede the waning dominance of big data's ultra-rationalism. Anthropological critiques of neoliberalism's globalizing homogeneities have resonated oddly with new nationalist-populist calls for protectionism. Bureaucracy's Weberian iron cage of rationality has reappeared, for many, as an uncomfortably fruitful alternative to unhinged demagoguery. An expertise more attuned to its own situatedness in wider ecologies of patterned iterating familiarities is sorely needed.

Today it would be dangerous for any experts to go with the flows around them without being wary of the new forms their knowledge-practices take or the new geometries of their channels. Opening to continuities between technical and seemingly extra-technical knowledge patterns means becoming sensitive to one's specialized silo's broader circuitries of coordinates to better dispose oneself to adapt, critique, and retool the silo-world around oneself. To see the powerful role that iterations of familiar patterns played in envisaging deep time, my informants and I first had to literalize our backdrop familiarities to become more intimate with patterns already

[245] I hold Jukka and Laura up as exemplars of experts in touch with continuities extending outward from their specialized knowledge. But many informants simply did not care to reflect on organizational changes, their own historicity, or the conditions for their knowledge's existence. While they were often astute technicians or rigorous researchers, they did not have strong opinions, dreams, or frustrations regarding the way their expertise was, had been, or ought to be. They lacked in their propensities for reflectiveness, wit, imagination, thoughtfulness, creativity, and critical thinking. As in Malinowski's Trobriand Island fieldwork more than a century ago, I was acquainted too with "less intelligent or less patient informants" more "inclined to shrug their shoulders over such questions" rather than make "speculations, and produce extempore opinions, and ask your view, and just enter into a metaphysical discussion of a sort" (1916: 167). I similarly observed how variance in informants' capacities to think outside the box, make wise decisions on the fly, or reimagine their own worlds' possibilities.

radically close to ourselves. My goal in advocating that others do the same is not to nudge other expert fields toward having their own *Writing Culture* moment. It is to simply invite experts to attend more often to how patterns flow in and through selves as they navigate their crises of expertise and, in turn, redefine the expertise of the future. To encourage experts to attune to their own moment-by-moment "empathy" or aversion to "pattern" (Bateson 1979: 8) is to encourage an art of professional self-distancing that can help them refigure now they achieve their own senses of professional purpose in intensely uncertain times.

Thinkability: Navigating Environmental Futures

In the Humanities, questions about iteration have long been coupled with questions about temporality.[246] This ethnography built on these precedents, complementing them with an alternate analysis inspired by anthropologists' longstanding interests in form (See e.g. Bateson 1972; Kohn 2013; Leach 1970 [1954]; Lévi-Strauss 1960; Riles 2000; Strathern 1988) and helical, iterative, or recursive methods (e.g. Franklin 2013; Holbraad 2012). It posited academic anthropological notions of iteration as perspectives on Finland's nuclear professionals' notions iteration and vice versa. What emerged from these "parallels at the level of form" (Riles 2004: 400) were ethnographic accounts of how repetitious enactments, activations, or evocations of familiar devices established semblances of continuity between ever-elapsing nows. This happened even while, as Deleuze stressed, no two moments in which any given familiarity

[246] There are many similarities and differences between, say, how Derrida iterated "iterability," how Safety Case experts iterate "iteration" (Chapter 3), and how Kierkegaard or Deleuze iterated "repetition." Then there are "iterated functions" in mathematics, "iterative" pedagogical styles, "iterative design" approaches to prototyping products, and so on. Thoroughly comparing these many iterations of the broader iteration notion would be outside this study's scope. Yet I suggest that each can, in their own ways, help experts commune with how repetitions of the familiar establish semblances of discernibility through which futurity and memory can take shape.

instantiated were exactly the same.[247] It happened even while, as Derrida saw it, any iteration act became hostage to indeterminate future iteration acts: the repeatability of any one successful iteration depended on a recognizability that was itself parasitic upon other moments of iteration that might, at first glance, appear detached from the situation at hand (1988; Moati 2014).[248]

These flickers of similarity between moments endowed nuclear project-futures with auras of teleology, expert lives with meaningful directions forward, and collaborative teams with shared horizons of interpretation. This tapped into how futures became *thinkable*—a key problem-space with which experts must engage amidst unknown twenty-first century environmental futures.

In this ethnography, while no two visions of environmental futures were the same, none dwelled outside realms grounded, pushed forward, and held back by various mundane, familiar devices shared with others.[249] The nuclear professionals I studied were polyvocal. In their communities

[247]Deleuze (1968) discouraged one from assuming that any two (re)iteration events occur in two flat moments plotted on any fictive homogenous timeline with equal backdrop features. Time-point 1 and Time-point 2 could, for him, never be unified on a fully commensurable plane of identicalness. This was part of a broader discussion of how repetition aids the genesis of forms, the individuation of virtual Ideas, and the instantiation of the actual. Deleuze also examined how when repetition has been linked to circular time (e.g. seasonal change), it has been reduced to habit. When it has been linked to lineal time, it has been reduced to memory. He also insisted that repetitions of what differs from itself – that is, that which becomes – should be construed as time itself. He derived this idea from Nietzsche's notion of eternal return, which he qualified as being selective. Deleuze specifies that only what differs from itself can return. During fieldwork, I often noted how the primacy of the flux, difference, and incommensurability across time that my informants stressed during moments of intense change (e.g. when mankala optimisms deflated in Chapter 1) was broadly resonant with Deleuzean thought.
[248]Derrida emphasized the open-endedness of iteration events. For him, meaning is inevitably unfixed and language is inescapably citational. Even the first use of a specific turn of phrase is a repetition because the intertextual network of its enactment always already contains echoes of past similar turns of phrase. The singularity of a trace and its mechanical repeatableness are intimately entwined. More broadly, he saw the open-ended reuse, reiteration, citation, and re-performance of traces as at the heart of language and communication. Derrida explained how the repeatability of any form – such as, say, a signature – depends on a recognizability that is itself parasitic upon other moments of iteration that might, at first glance, appear detached from the situation at hand (1988). He called the minimal repeatableness of any trace "iterability."
[249]These devices could not be formless. Form was as alive in, say, Anthropocene visions of tomorrow as it is in any other realm of social life. Mary Douglas knew this well. While her sense of form was different than that of, say, Kohn's, Riles', or Deacon's, she once asserted that one way to "plot a map of powers and dangers," including toxic pollutions like nuclear waste, was to "underline the interplay of ideas of form and formlessness" (1966: 99). An

trafficked countless sentiments, dreams, regrets, affects, frustrations, kindnesses, aggressions, rivalries, and stories. Their personalities could be idiosyncratic; their daily dramas complex. Futures they envisioned varied and were often incompatible. Fieldwork confronted me with what was, in many ways, an insurmountably complex set of contexts.[250] Yet even amidst flux, key familiar devices – from junior/senior to mankala – enduringly avoided contestation and maintained their black-boxed statuses. Following them ethnographically cut through the intense difference these scenes imposed, revealing how competing visions of environmental futures emerged from the planes of stability that iterations of them deposited.

Many activists and Humanities colleagues, for example, envisaged apocalyptic Anthropocene futures of planetary degeneration. They foresaw a future dead Earth where death detached from life's regeneration. For them, nuclear power was a catastrophe risk to be lumped with a series of other catastrophe risks. They anxiously feared degenerated futures with melancholic despair. They linked nuclear energy with horrors and guilts about capitalism, modernity, privilege, and ecological collapse. They emphasized worst-case scenarios plausible in an age of nuclear weapons, population growth, mass extraction, biodiversity loss, environmental destruction, and fears of asteroid impacts and pandemic illness. Certain Earth Sciences informants flirted with these views too. In stark contrast, young ecomodernist informants like Timo, proudly rejecting

expert submitted to form's finiteness, ubiquity, and elusiveness while being enabled by form's effortless efficacy, permutability, and extensibility when crafting their own visions of environmental futures.

[250]Many sections of this ethnography gestured to this unknowableness by unpacking some of these endless empirical details descriptively. In such sections, ethnographic aesthetics of boundless complexity were foregrounded. The narrative of mankala cohesions disintegrating in Chapter 1 or the post-death fallouts in Chapter 4 are examples of this. Insights about the contingency and fragility of expert knowledge were gleaned. For example, Chapter 4 showed how ecologies of diverse expert persons and chance events like bicycle accidents (a) made entire corpuses of future-oriented knowledge disappear suddenly and (b) fated a predecessor figure to be reiterated in the years ahead. Attuning to messy contexts of radical expert difference underscored – for anthropologist and nuclear expert alike – expert knowledge's contingency and mortality. In Chapters 1 and 4, for example, this enabled me to contextualize mankala politics and predecessor death instabilities in ways that generated ethnographic aesthetics depicting seemingly endless complexity.

Anthropocene melancholy, saw nuclear energy as a climate change solution. They touted optimisms for innovation, open futures, technology, incremental progress, human agency, and achieving common political ground across ideological lines. They anticipated, with hopeful enthusiasm, futures of planetary generation (Ialenti 2016). For many members of *Suomen Ekomodernistit ry* (Ecomodernist Society of Finland), nuclear was an energy/climate technology to be lumped with other energy/climate technologies. Key engineer and manager informants flirted with these visions of the future.

While pro-nuke ecomodernist futures and critical Anthropocene futures seemed worlds apart, they were both similarly grounded – as conditions for their existence – on ongoing iterations and reiterations of familiar divides between generation/degeneration, life/death, life/nonlife, and collapse/progress.[251] These devices were posited as fundaments around which diverse environmental future visions pivoted. When future-gazing, a pro-nuclear radiological protection specialist could iterate them just as easily as could, say, an anti-nuclear sociologist. An anthropologist could reiterate them to pursue recursive analysis. Depending on the spirit of their iterator, they could be cloaked in anything from banal office aesthetics to the sci-fi-esque degenerated-Earth aesthetics of post-Sixth Extinction (Kolbert 2014), *World Without Us* (Weisman 2007), or future-Earth-as-present-day-Mars imageries (e.g. Jones 2012).[252] This ethnography demonstrated the same for input/output, part/whole, recruit/retiree, and so on. This showed the great power in, to quote Riles, how a "thin form can accommodate remarkable

[251] They were also both alter-ecologies (Ialenti, forthcoming): means for envisioning alternative ideal ecological futures, which both took flight from logics that have long been sidelined in dominant twentieth century secular-progressive environmentalisms.

[252]Radioactive contamination has also served as a means for imagining flourishing future worlds without humans (See Krupar 2011: 280).

diversity in an under-the-radar, mundane way, while standing for nothing in and of itself" (2016: 185).

This recasts expert renderings of environmental futures as, in part, fragile achievements of iterations of countless familiar devices that have already been remembered, forgotten, pushed onto, reshuffled, or impinged upon one another to comprise the repertoires of devices available for concocting a future vision in any given moment. An environmental forecast, even a deep time-reckoning Safety Case forecast, was in this sense continuous with countless other labors of prognostication elsewhere.[253]Attending to this provincializes any deep time vision of end-times "what if?" worst-case rumination by revisiting it as but another ordinary scene in which iteration of familiarities potentiates thinking itself. This can bring one down to Earth—distancing one's anxieties from popular hysterias enrapt with world-ending scenarios, financial collapses, and looming technological failures (See Crapanzano 2004: 179) by refocusing one's intellect on what black-boxed familiarities composed the visions in the first place. I therefore advocate experts become more sensitive to how they iterate the familiar to carve out boundaries between future certainties, uncertainties, known knowns, known unknowns, unknown unknowns, and unknown knowns.[254] This means attending thoughtfully to how futures are effects of patterns of knowledge and other formations, but are never situated outside knowledge or form itself (cf. Riles 2000: 21).

[253]Emphasizing these continuities runs counter to narratives that emphasize the "Nuclear Age" or "Atomic Age" as period of radical rupture from past practices (e.g. 1987: 154).

[254]These presentist groundings of thinkable versus unthinkable futures remains a crucial yet understudied nexus as, to use Beck's words, the "unthinkableness of a danger" is a growing threat (1987: 155). From this angle, mismatches between formed and formless futures were what allowed for failures of imagination enabling disasters like 9/11, climate change, the global financial crisis, or the Fukushima nuclear meltdown. To put this in Donald Rumsfeld's now commonly cited terms, environmental futures' known knowns and known unknowns can only be thought in and through form, its repetitions, and its frontiers.

When experts reflected thoughtfully on the familiar devices they iterated to compose prognostications, they scouted ways forward amidst political-epistemic flux and unknown planetary futures. Yet each time they reiterated, say, input/output, they did so in a unique temporal moment that implicitly evoked the familiarities of countless other past and potential future unique moments when input/output had been or had potential to be iterated elsewhere. These referential acts helped make what could otherwise appear as a punctuated spattering of disparate moments appear instead as a flowing stream of interconnected moments they saw themselves as inhabiting. They gave nows clarity by spanning them. Drawing past flickers of familiarity into presents-in-formation,[255] moments across time became associated together just as key "generative formula" (Battaglia 1990: 11) or "generative schema" (Munn 1992: 122) were enacted and upheld: act of iteration by act of iteration. Bridges of qualitative continuity allowed traffic between moments. Nows worlded together. Futures became more thinkable. Analyzing how devices like junior/senior or part/whole were iterated differentially across these moments meant performing a "double description" (Bateson 1972) that, in "recognizing the similarities and systematically comparing the differences" between iterations past and present, gave depth to how one's expertise changes (Kohn 2013: 98).

These familiar devices were rarely iterated as ends in themselves, but more to establish jumping-off points from which other more specialized, exigent, or seemingly interesting futurological operations could take flight. They were thus rarely innovated upon consciously as explicit objects of refinement. Construed as grounds in figure-ground relations (Wagner 1986b), they were often reiterated unconsciously as props for improvising one's way into futures-undergoing-

[255] And even the most common or familiar device can be enchanted with the freshness of improvisation when iterated and played out in new moments on novel terrains.

figuration. This ethnography literalized their quiet agencies by bringing them forward as figures of anthropological analysis. Tracking incessant reiterations of, say, mankala across diverse scenes revealed differences between the scenes. As Strathern once pointed out, foregrounding such continuities "makes change evident," allowing one to ask, "how much change has taken place?" (1992: 1). In this ethnography, doing so made relations of sequence, change, and mnemonic structure – as well as timepoint-crossing relations of momentum, trajectory, anticipation, fulfillment, circularity, departure, progress, nostalgia, and devolution – appear to pivot around, link between, or extend across nows.

With iteration's centrality to future-making in view, Safety Case reckonings of deep environmental futures appear as deposits of certain ways that interleaved relationships of iterating devices, experts, and ideas moved into the future at certain times at certain places. They were achievements of innumerable, entangled, episodic acts of iteration. As "elicitory triggers" (Strathern 1988: 181), these iteration acts could evoke, elicit, or lay ground for even more iterations, building alternative futures, or altering existing ones, as they went. In Chapter 1's analysis, for example, iterating the mankala cooperative corporation elicited subsequent iterations of its posited antithesis – the conventional LLC corporation – as a foil. That is, iterating the mankala elicited a wide but constrained set of potential analytical futures. During fieldwork for Chapter 4, similarly, discussing a predecessor figure could elicit a subsequent discussion of the predecessor's own predecessor—eliciting a reiteration of the figure as another figure's successor. The same could be done with the predecessor's predecessor, reiterating him or her as successor. Indeed, iterations could beget more iterations, summoning chains of associations and points of affinity between elapsed and unfolding moments. This could nudge iterators and those around them toward or away from various pathways forward.

The many ways these processes shape futures are underappreciated in thought on environmental risk. Beck, for example, famously emphasized how nuclear waste's ecological consequences elicited a radical extension of risk society's basic imperatives to impose order on disorder, quantify the unquantifiable, or plan for the unplannable (1987).[256] Yet, when doing so, he deemphasized many formal grounds for thinkability upon which such techniques of ordering, quantifying, and planning futures had first been predicated. He foregrounded new technologies and the novelties of a historical moment tactfully, setting the stage for his blockbuster works. But this analytical preference led him to abstract out how iterations of basic devices – including but certainly not limited to recruit/retiree, predecessor/successor, or part/whole – always already govern so many risk governance contexts. This ethnography recast them as differences that make differences. Their powers as grounds for future-gazing is, the next section shows, evident in their vast extensibility.

Extensibility: Navigating Nuclear Energy Futures

Nuclear energy futures remain deeply uncertain. One ethnographic response to this would be to flesh out these uncertainties descriptively. But this ethnography also sought to cut through this complexity by stressing how, in order for Atomic Age experts to harness fundamental aspects of the universe, they first had to achieve thinkable patterns by harnessing existing familiar devices of continuity in just the right ways. Chapter 2, for example, showed how, for one to ponder how an overexposure to radioactivity can have intergenerational health consequences,[257] one had to think with role templates like senior/junior or recruit/retiree upon which concepts of succession

[256] For Beck, this was because risk societies, ostensibly looking forward to contingency and innovation more than social reproduction and tradition, have unfixed futures (1992).
[257] Sociologist Kuletz has, for example, reflected on how these health consequences can be "passed on from generation to generation so that damage is rendered intergenerationally" (1998: 85),

and generations were contingent. They helped forge continuities across years, decades, and centuries. Chapter 3 demonstrated that even the most sophisticated computer-modeling programs were grounded on fundamental distinctions between input/output and part/whole. Informants iterated these, wittingly or unwittingly, to forge continuities across myriad Safety Case reports, models, projects, and datasets. I now reflect on how appreciating these deceptively simple devices' potentials for extensibility across time, space, and analytical terrain was key to appreciating their power and its limits.

Devices of continuity such as input/output took shape in referential ecologies extending across *space*: I have witnessed nuclear experts iterate the distinction not only in Finland, but also in Washington D.C., New Mexico, and elsewhere. Then also across *time*: I witnessed Finland's Safety Case experts iterate input/output in 2012, 2013, and 2014 and have also seen these same mereologics guide 1990s reports. Then also *analytical terrain*: I have reflected many times on how an ethnography of input/outputs could be done among nuclear waste facility modelers just as easily as it could be done among, say, plumbers, computer scientists, basket weavers, or electricians also iterating the distinction. This is not to say input-output is a unitary, transcendent, fixed ideal-type with a totally stable meaning that defies contexts. It existed only in its myriad instantiations in iteration acts that took place in specific, bounded, local points in time. It was a thin and simple form that, loosely speaking, effectuated roughly the same in-and-out relationships while being used to serve countless ends. Yet the ways it was so pervasively reiterated were so ubiquitous, adaptable, and tried-and-true that they appeared non-localizable. Part/whole or recruit/retiree, for example, had wide potentials for extensibility across diverse scenes of inquiry.

Anthropologists have shown how certain notions excel at perpetuating across difference. “Gift,” for example, has generated lively debates for decades about topics ranging from the global organ trade to financial institutions to the philosophical plausibility of pure gifts. As Miyazaki has shown, extensible notions like gift can “replicate” themselves across diverse “spheres of life,” eliminating differences as they go, but also serving as means for imagination, speculation, and creative work too (2013: 13). He analyzed how one extension of gift – Fijian gift-giving – was extended in (a) the Fijian Ministry of Tourism's mid-1990s initiatives to teach local souvenir dealers how to engage tourists in a more “Fijian” manner and in (b) Kelly & Kaplan’s academic analysis of a gift that Indo-Fijian cane farmers gave to a Fijian indigenous chief in 1944. In such works, gift’s extensibility potentials lie not only in its distinctiveness, but in its generative indistinction and productive ambiguity. The same can be said of how extremely broad devices like input/output or predecessor proliferate within immense technological feats like nuclear energy to help organize them.

These sensibilities can aid experts in achieving critical distance on their broadest thought tendencies. Take as an example how the extensibility of the thinking pattern *containing the nuclear* – iterated and reiterated by both nuclear insiders and the social scientists who study them – has shaped nuclear futures for both.

“Container” is a broad, common, and malleable term. STS scholars Sheila Jasanoff and Sang-Hyun Kim have examined the U.S. socio-technical imaginaries that seek containment of nuclear energy’s runaway hazards (2009: 119, 130). Galison & Moss named their nuclear waste documentary *Containment*. Cold War nuclear weapons strategists have spoken of containment policies toward the USSR. Historian Mary Mitchell, in her work on nuclear weapons testing in Micronesia, has discussed the 1940s North American Container geopolitical term (2016).

Nuclear reactors can have "containment" buildings made of steel, lead, or other materials. My informants used the word "container" when talking about Posiva's and SKB's KBS-3 copper "canisters" or, less often, "capsules." They iterated container when discussing Posiva's spent nuclear fuel encapsulation facility in Olkiluoto too. The significances "container" effectuates have varied widely across moments of iteration. It is not my question whether "container" is, metaphysically, a single centered form transformed onto multiple de-centered contexts or, rather, a de-centered multiplicity of enactments that, after reductive analysis, can appear as a singular entity. I am interested simply in the concrete effects of how, in one way or another, container roughly evokes very familiar patterns of separating-and-sealing-off, of enclosure, or of keeping-in-place each time that it is iterated in thinking about nuclear issues.

Yet the word "container" did not always need to be stated outright to elicit container-thinking patterns. Take, as an example, the enormous concrete and steel "sarcophagus" or "Shelter Object" (*Obyekt Ukrytiye*) built in 1986 to contain Chernobyl Reactor 4. There, container-thinking has evoked a sense of containment even as the overall Chernobyl disaster, uncontained, is ongoing.[258] Yet, by evoking a sealed-off cadaver, sarcophagus draws some to imagine total containment. When not iterated with care, appeals to container-thinking can evoke the finality of a mortuary ritual—enchanting Chernobyl with a premature past tensing and inaccurately relegating it to history. Attuning to how container-thinking in general, and the sarcophagus form specifically, have been extended to Chernobyl can unhinge the false closures with which they have endowed the disaster over the years. The same could be said of the container-thinking surrounding New Safe Confinement arch put over Chernobyl 4 in 2016. Both are examples of

[258]With huge victim compensation claims and cleanup costs, Chernobyl remains a financial disaster. With the Zone of Exclusion still in place, it remains an ecological disaster. Chernobyl, like Seppo, will still haunt the present and create the future despite being cast generally as a historical event of the past.

how container can be iterated into open futures differentially across geographies and toward various rhetorical ends.

Container, in its many extensions, has contoured nuclear futures. Nuclear professionals in Finland and the U.S. have, for example, both told me how an activist strategy for preventing nuclear reactor new builds has been to endlessly raise concerns about nuclear waste repository safety concepts to drive up their costs and create delays. Not allowing the nuclear waste to achieve containment in a repository, the thinking supposedly went, could make the total nuclear reactor package appear less economical overall. Activist informants meanwhile noted how if Fortum and TVO could convince publics and politicians that Posiva's repository had fully contained Finland's nuclear waste problem, then appealing to these closures could promote the acceptance of more reactors among them. These activists extended the containment concept to warn of how one issue's closure can open another: with Finland's waste contained, more reactors could be built. But those new builds would elicit more containment. More containment could elicit more nuclear, which would elicit more containment, which could elicit more nuclear, *ad nauseum.* To extend Chapter 3's devices to this line of thought: nuclear energy's waste outputs generated needs for containment as an input, which, when achieved, generated calls for more nuclear as an output, and so on.[259]

Iterations and reiterations of distinctions between contained/non-contained have helped make complex nuclear contexts thinkable for social scientists, activists, and nuclear sector insiders alike. Attuning to this extensibility gives glimpses into such familiar devices' power. For anthropologists, the container term is no more or less useful for thinking through nuclear futures

[259] Of course, this is an oversimplification, but it does show the inertia that delicate dances between nuclear and containment-thinking can enact. It shows how container-concepts can propagate to generate nuclear worlds.

as it is for thinking through centuries-old Mayan pottery. For Finland's nuclear professionals, it was no more or less useful for thinking through waste disposal concepts as it was for thinking about pots in their kitchens. In international shipping worlds, "containerization" describes the post-WWII push toward the global standardization of containers used in cargo planes, trucks, rail, and boats. When nuclear materials are shipped off for reprocessing or disposal, they are subsumed to those container logics too. Container, a thin form that can hold all sorts of content, has extended across spheres of life. Yet for one's understanding of container to be widely intelligible and hence efficacious, it first must loosely sync with other transforms of the container notion immanent in others' understandings. When this was achieved, container became extensible across years, kilometers, economic sectors, academic fields, and cultural difference. If not achieved, iterations of it would only propagate cacophony.

The nuclear concept and container concept have, iteration by iteration, proliferated widely and evoked interpretive horizons of significant stability. An ethnographer can attend to how they have been iterated amidst the flux of rapidly changing politics, policies, or innovations. To analyze them is to posit a more stable, less contested, often black-boxed object of inquiry that is less prone to definitional flux than would be, say, that of a social study of an innovative knowledge management platform's effects on an organizational culture or of the changing relations between lay locals and nuclear organizations near a power station. But these devices' relatively stable interiors, like those of predecessor or input/output or recruit/retiree, enable their outward propagation across difference. Attuning to these shared platforms of intelligibility – and the many changes and contingencies unfolding on, around, or in the wake of them – can draw expert intellects toward the countless devices that first had to achieve innumerable extensions across time, space, and terrain as a prerequisite for specialized expert knowledge to materialize. This is part of expertise's deep humanity.

Just as Safety Case deep time reckoning appeared as just one extension of part/whole and input/output thinking, "containing the nuclear" can appear as just one extension of container thinking, broadly construed.[260] Nuclear's and container's histories did not begin with the Atomic Age.[261] Their continuities long predated it. Given their sturdiness over time, they can be powerful jumping-off points for future-gazing speculation among today's nuclear experts. Will future societies still iterate nuclear and container so commonly? Which ones will and how? Can the idea of a thing being contained in a container even become thinkable without first mastering the broader thought pattern of, to use Chapter 3's example, "inputting" the former into the latter? And would the "output" of this be "containment"? Will the broader pattern of "containing" outlive the more specialized pattern of "containing nuclear technologies" if nuclear technologies are, in far futures, forgotten?

Such simple devices can inspire profoundly challenging inquiries. As nuclear experts move into uncertain futures, wrestling with these fundamental questions can help them refine their intellects and think big-picture about tomorrows. They could reflect on the following. Will far future

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[260] Some contexts have the term "nuclear" intentionally removed from them. An MRI at a hospital could easily be called NMRI – nuclear magnetic resonance imaging – but the N is often removed to assuage patient fears given the stigmas associated with nuclear technologies. As another example: Hecht (2011) has shown how, after apartheid ended, the mining industry lobbied for exemption from nuclear regulation, insisting that South African mines were not nuclear places. The South African Chamber of Mines ruled that mines don't fall under jurisdiction off nuclear regulators. Similarly, a 1968 IAEA safeguards document specifically excluded uranium mines and mills from being categorized as a "principal nuclear facility." Designations of "nuclear" or their withholding can have consequences for how a (nuclear) thing is or is not regulated and overseen.

[261] While etymological analysis of nuclear's derivation from the "nucleus" term – which, in the eighteenth century, was iterated to describe a nut's kernel – would be outside this study's scope, I gesture to how reflecting thoughtfully on container-thinking's concepts' extensibilities across time can pique rich questions among the experts who iterate them.

societies ground their thinking on distinctions resembling, to use Chapter 3's example, input/output or part/whole too? Will they organize themselves by iterating with relational formations resembling Chapter 2's intergenerational role templates? Will some do so while others do not? Can their extensibilities across time serve as grounds for analyzing nuclear energy technology in time horizons deeper than those of, for example, Hecht's analysis of post-WWII France's techno-political regimes (1988)? At what point does it become too naïvely universalizing to assume that familiar devices like Chapter 4's predecessor will be less likely to become obsolete in the future than, say, current computer modeling programs? Is it safe to assume that the part/whole distinction will endure for millennia even if today's cutting-edge nuclear technologies are totally forgotten? Or will near-future human extinction make this all moot?

My fieldwork offered me zero definitive answers to these questions. But it did present many impetuses to encourage experts to exercise thinking in time horizons that sync more neatly with those of nuclear waste's deep time, of nuclear reactors' eighty-year project lives, of Posiva's 120-year institutional horizons, and of meltdowns like Fukushima or Chernobyl that have caused crises that, years and decades later, are still ongoing. Ethnography of how familiar devices like part/whole, container, predecessor, recruit/retiree, or mankala extended across time and space can help an expert leap momentarily from his or her specialized niche to think at a wider level of breadth. From that vantage, nuclear expertise becomes, in part, a tremendous, but fragile, artifact of the ubiquities of countless familiar devices of thought and action—evoking wide spatial and temporal horizons that extend beyond those typical of, say, contemporary ethnography's contextualizing, historicizing, and situating. This can help experts look a (far) future (near) certainty in the eye: when long-term futures do elapse, and if humans are alive to elapse in and with them, they will be navigated only in and through available repertoires of well-established, widely-shared patterns of thought. To emphasize this is to gesture to the timebound, presentist limits of experts' conceptual repertoires for reckoning deep time.

Closure

This ethnography showed how incessant repetitions of familiarities are not just for the mad.[262] Some can find wonder in their infinitions.[263] All can reflect thoughtfully on them. This Conclusion's takeaway points about continuity, thinkability, and extensibility sought to provide a compass for cutting through the difference-making effectuated by experts' reflexive engagements with messy realities. This trajectory was not primarily about envisioning future disasters (e.g. Eden 2004), developing scenarios for coming events (e.g. Benford 2000: 31-86), or explicitly arguing for or against nuclear energy's adoption. It was about performing a sensitivity to how, even when political-epistemic uncertainties mount – and even when radical difference appears insurmountable – grounding devices of familiarity will be still iterated and reiterated to help navigate them. That is why this ethnography calls experts to – when the next big nuclear event, innovation, or crisis comes about – scour the familiar devices being iterated to give it shape. Getting better acquainted with one's own technical knowledge's continuities, thinkabilities, and extensibilities can help experts of many kinds accomplish this.

[262]Ceaseless repetition has been linked to insanity. As sociologist Emile Durkheim explained: "appearance very frequent in madmen; that they remain whole days and nights, sometimes whole years, in the constant repetition of some remark, some complaint, or song; which having struck so powerfully on their disordered imagination, in the beginning of their phrensy, every repetition reinforces it with new strength and the hurry of their spirits, unrestrained by the curb of reason, continues it to the end of their lives" ([1897] 1975: IV, 12/14).
[263]As Edmund Burke put it, succession may impress "frequent impulses on the sense to impress their imagination with an idea of their progress beyond their actual limits… to stamp on bounded objects the character of infinity" ([1757] 1958: 74).

This ethnography's mission to ethnographically track, recursively replicate, and then narratively perform the futurological work that iterations of the familiar can do was classically anthropological in spirit. At times it emphasized how, when one reiterates a familiar device, there are no guarantees it will have the same effect it had during previous iterations. Doing so showed how an iteration act can contain a subtle hope that the device will remain efficacious in a new context despite knowing full well the act might later be obviated as having been naïve. Other times this ethnography emphasized how an act of iterating familiarity can be a comforting defense against fears of one's settled orientations to the world breaking down. This showed how experts respond differently to diverse contexts thrilling, harrowing, or mundane. Still other times it stressed how nuclear professionals iterated familiar devices in trial-and-error spirits to inspire fresh uncertainty navigation techniques. This showed how – even though any iteration act is always in part a leap into the unknown from a platform of the seemingly known – it can still pave ways forward into futures.

Without iterations of the familiar, any sense of what comes next collapses. Motivations for building better tomorrows deflate and what-if rumination runs haywire. Action is paralyzed. Planning is foreclosed. The past, not repeatedly called forth, dissipates. The present loses forward momentum. But, with familiar devices iterating, intellectual feats as mind-bending as deep time-reckoning can take shape. This is so even in uncertain milieus in which a few months hence can seem as unknowable as distant futures. Yet each chapter of this ethnography reinforced how, even amidst intense uncertainty, familiar devices of some kind must be iterated lest knowability, or the practical illusion of it, implodes. Walking through how and why experts writ large should become more attentive to this was a hortative move not found in philosophical treatises about form or iteration.

If we are to survive environmental collapse, our lives must be repositioned within the wider time horizons opened by climate change, biodiversity, sustainability, extinction, nuclear waste, and (Anthropocene) planetary degeneration. Some argue that lay publics must today prep their intellects for thinking the long now (Brand 1999). Others say the challenge is to routinely exercise long-termist thought patterns to help inspire fresh ways of dwelling on a damaged planet (Ialenti 2015).[264] For some, plotting the human story in these deeper timescales risks relegating our species to a more marginal position in a Big History narrative of the cosmos—making our very existence feel instantaneous and thus meaningless. Yet the real advances made in deep time-reckoning over the past few centuries – including those overseen by Posiva and SKB – can be reason for humankind, or at least segments of it, to feel elevated in its growing capacities to grapple with deep time and harness fragments of the long now. Opening oneself to patterns that attach to and emanate from familiar devices used to reckon these deep time horizons can cultivate the subtle consciousness necessary for blazing wiser paths forward into tomorrows. This is an absolute prerequisite for changing course to avert planetary devastation.

[264] This could elicit new alter-politics (Hage 2015) or fresh routes for thinking otherwise (Povinelli 2014b).

Inside the SKB's Äspö Hard Rock Laboratory in Summer 2013. This was another KBS-3 repository research site where insights about deep time-reckoning could be found.

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