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(NOTE: paper draws from a forthcoming book; footnotes not yet included and conclusions outlined in this draft, but will be completed before the meeting.)

Institutional Persistence, Change, and Agency: The Case of Air Traffic Control

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In this paper, I explore the relationship between institutional persistence, change, and agency based on an historical ethnography of air traffic control that encompasses the life course of the system. The research focuses on system effects: the relation between historic events, conditions, social actors, and actions in the institutional environment, as they impacted the air traffic control system, changing it, and how those changes in turn affect the workplace, the work, and the interpretation, meaning and actions of air traffic controllers. To clarify, history is not a social actor in its own right, but has a causal effect on the present only through the actions of assemblages of heterogeneous social actors – ideas, people, organizations, inventions, devices, material objects, rules and procedures – originating in different places and times that intersect with a developing system and throughout its life course in unanticipated ways, both positive and negative. Far from a top-down model, the analysis demonstrates the agency of air traffic controllers as they respond to external events, actors, and actions and system effects on their work, complying, contesting, improvising, and contributing to both institutional persistence and change across time and social space.

We know a lot about institutional emergence, evolution and patterns of change across time and social space. We have extensively explored persistence, much of which exposes larger institutional structures, conformity to normative expectations for legitimacy, and mechanistic processes that stabilize organizations. And we have a mature literature on institutional change. However, we know less agency: its role in institutional change and persistence, and how the past – historical trajectories of actions and conditions - materialize in organizations in the present, and the agency in response to system changes.

My research is based on field work in four air traffic control facilities in the New England Region of the National Airspace System, chosen because they represent the four kinds of work that air traffic controllers do. Because they exchange airplanes with each other (as well as other facilities inside and outside the Region) the four represent a microcosm of the structure and dynamics of larger system. The air traffic control system is admittedly an exotic case: highly standardized, rule-bound, many people doing the same job, everyone in the system at all levels of hierarchy (except those political appointments at the top) having trained and worked as controllers. Yet, its exotic qualities allow us to see aspects of institutional persistence, change, and agency not readily visible otherwise.

Next, I discuss the methods and theoretical framing of the project, then I present two examples that demonstrate the role of controllers' agency as history materializes in the present. The first shows how across time and social space, controllers supply the resilience that provides the dynamic flexibility of the larger system, even in periods of decline or unprecedented situations when system risk increases. The second example shows how they became changemakers, improvising and initiating repair in periods of decline. In both cases, just doing their job, participating in change, and even in active resistance to change, controllers unintentionally contribute to system persistence.

Theoretical Framing and Analytic Strategy

Originally, the research was located firmly in the present: having written three books about how things go wrong in organizations, my questions were, what makes this system so safe, or is it? - and, what do controllers do that technology can't replace? My central focus was on system effects and dead reckoning, which is an early marine navigational term referring to the prediction of the position of objects in space without benefit of direct observation or direct evidence. Dead reckoning is the essence of what ATCs do.

The four facilities were Boston Logan Air Traffic Control Tower, Bedford Tower, a small busy tower in Bedford Massachusetts, and two radar facilities: Boston Air Traffic Control Center, in Nashua NH, handling high altitude traffic for the region, and Boston Logan TRACON (Terminal Radar Approach Control) working intermediate altitude traffic. However, my research changed while I engaged in field work in the four facilities 2000-2001 becauseI saw how the past materialized in the workplace, affecting their work. Moreoer, after leaving the field in June 2001, on September 11, the two airplanes terrorists flew out of Boston Logan Airport into the Twin

Towers were handled by three of my four facilities so I returned, witnessed the impact of history on the system as post-9/11 controllers enacted change to meet this new threat. At both the system level and the individual level, I knew their capabilities to handle the unprecedented feat of bringing all the planes out of the sky that day and changing the system after had developed incrementally over time as the system evolved to meet new challenges, showing how the past impacted the present. Then because the system had automated, I returned in 2017 to discover a system under stress, as again history manifested in the present, with controllers engaged in repair.

The analytic problem was how to organize the temporal dimensions of 3 interventions into a book-length explanation, showing a) similarities and differences across time and space, b) system effects, and c)) how the past manifests in the present. Based on the developing data, I used two main strategies in the theoretical framing. Following Simmel's formal sociology, I had developed *analogical theorizing*, which relies on cross-case (rather than same-case) comparisons, looking for analogies and differences in order to elaborate theoretical explanations. Comparing different units of analysis to examine similar structures, processes, or outcomes can produce data at different levels of analysis, filling gaps, contradicting or changing existing interpretations. Second, I used a *situated action* approach, locating the action in its larger social context to capture system effects: the relationship between historical actions and conditions in the institutional environment, as they affected the air traffic control system, which in turn, affected controllers' tasks, material practices, interpretive work, and the meanings the work has for them. Doing so opened a window on agency and situated change. Consequently, this research became an historic ethnography that was comparative three ways:

1. Four facilities at the same time (2000-2001 period of field work)
2. Four facilities sequentially, across three periods of field work (2000-2001, post-9/11, and two facilities, Fall 2017.
3. I located the action (i.e., the field work chapters) not only within this layered system context, but in its history, showing system emergence, development, and patterns of change across time, allowing multiple points of comparison across time, thus providing an opportunity to see how the past materialized in the workplace, affecting action in the present.

Consequently, the organization of the manuscript begins with the history of the system life course in Ch. 2, "History as Cause: System Emergence, System Effects," framed as Hirschman and Reed's "Formation Story," which is an analytical sociological narrative that traces how a novel social form comes into being and how it incrementally develops the characteristics it has in the present. Following the data, I divided the analysis into four eras that revealed the pattern of development and change across the life course prior to the 2000-2001 field work, then picked up post-9/11 history through 2017 to frame the last field visit. (Show era titles and subtitles here)

Tracing events over the life course as they unfolded, I found no central pattern leading to some predictable outcome. Instead, the life course of the system was messy, typified by historical contingency, unanticipated consequences, and unexpected convergence of multiple causal links. The four eras were "event-full," following Sewell and specifically, Abbott's identification of the life course of organizations – as sequences of many events that were not equally weighted but were of greater or lesser import or impact on the system. The history of the air traffic control system was marked by many turning points, some the culmination of a series of events – a trajectory in itself, not a single event. One of the patterns across time was that the system has never been static, but always vulnerable, always changing in response to changing external conditions. The system had survived two crises, President Reagan's firing of over 14,000 striking controllers in 1981 and September 11, and periods of decline when risk increased. But surprisingly, even the two most extreme shocks were absorbed by the existing structure rather than eliminating or destroying parts of it, changing its basic direction.

So we must ask the question of persistence: what enabled this system to avoid collisions on a day-to-day basis, maintain safety, and survive as a public agency, maintaining its organizational form, rather than failing to the point that it was replaced by privatization or single corporate ownership? The answer is in the role of controllers in both institutional persistence and change.

Resilience and Persistence:

Interpretive Work, Ethnocognition, and Boundary Work

Historically, as planes were able to fly higher, the sky became airspace, consisting of artificial lines that represented airways, with routes and intersections. Incrementally, the airspace was bounded by lines that divided it into sections by altitudes and geography to keep planes from colliding. The National Airspace System became a system of many parts. Over the

life course, the glue that has held the NAS together as a dynamic system lay in the resilience that had been built into the system structures in the preceding eras. *Resilience* refers to the ability of social actors - individuals, organizations, technologies - to respond to external and internal disruptions and shocks without losing the ability to cope and recover from them. However, system resilience is possible only because controllers are interacting with each other and their technologies to enact it. Once controllers were invented and technology enabled them to bridge system boundaries, the boundaries could be expanded or consolidated, fixed or flexible, permeable or shut. The parts could be either loosely or tightly coupled as situations demanded. The system could be decentralized on a daily basis, with the capability to quickly become centralized either in a facility, a region, or nationwide.

The National Airspace System today is divided into 9 regional sections and within each region, 21 sections of the regional airspace belong to towers, centers, and tracons on the ground. Ownership is a central safety principle of the system. As an aircraft moves through the sky, it cannot cross the boundary between one chunk of airspace and another without the owner's permission. Ownership rests with the controller holding responsibility for each stage of an airplane's movement.

The airspace a facility owns determines the architecture, the tasks and the culture of a place. Controllers work elbow to elbow in small intimate spaces, trained to work all positions and rotate with 3-8 people, coordinating thought material practices and action. They know each other well, strengths and weaknesses, so are known for their silent coordination. Dead reckoning is about foresight: predicting the position of objects in space without benefit of direct observation or direct evidence. They can predict each other's behavior, coordinating to fill in the gaps and compensate or others' workloads

Interpretive work is what controllers do that technology can't replace. Interpretive work is controller's fine tuned ability to give meaning to what they see, hear, and experience. The craft of dead reckoning consists of two distinct but interacting threads of interpretive work: boundary work and ethnocognition. They are acquired in controllers' intensive training and in experiential learning on the job and empowered by technologies. Air traffic controllers do two kinds of boundary work: controllers move airplanes across the boundaries of the sky and in doing so they must also cross the boundaries on the ground, exchanging their airplanes with other controllers in the same facility as well as with controllers in other facilities in the region and in other regions.

This is not easy, because traffic patterns in each airspace are different, making boundary work a site of struggle and conflict between facilities because one controller cannot pass an airplane into another's airspace without the owner's permission. A busy controller may say "unable," causing the first controller to "put the airplane on spin," thus jamming up their own airspace and backing up adjacent others

Ethnocognition is essential to boundary work. Controllers are *in* and *of* both workplace and system. Geertz describes local knowledge as a cultural system of knowledge peculiar to a specific time and place. Controllers training transforms them, giving them a cultural system of local knowledge, common way of thinking, acting and being, enabling them to coordinate activity with controllers in the room and in other facilities. At the same time, controllers ethnocognitition is shaped by the culture mandates of the system: Safe, Orderly and Expeditious Delivery of Air Traffic (expeditious = speed and efficiency). DiMaggio's work on culture and cognition and Hutchins on distributed cognition - the idea that cognition is not just in the head but distributed across people and material objects in a confined physical space - take on new meaning: ethnocognition is not only distributed beyond the room, it is *layered*. We can see it in what people say and do. (brief examples)

It is systems, within systems, within systems: controllers in their small areas being the smallest system, moving traffic in the facility as a system, coordinating throughout the regional, and beyond to other parts of the system. On September 11, controllers embodied common cultural system of knowledge, interpretive work, ethnocognition and boundary work empowered system resilience. Normally decentralized, the system became centralized with a common goal. The normal conflicts of boundary work disappeared as they engaged in a cooperative endeavor to bring down all the planes in the sky – internationally, nationally, and locally. The US airspace closed. Controllers in other countries took over the traffic. Those not yet halfway across the oceans went back, others went to Canada or Central and South America. In the United States, the Command Center in DC coordinated with all facilities and controllers - not to cross boundaries, but to land all planes, no matter what the destination, in their own airspace wherever they could.

Locally, in the New England Region, the dynamics resilience of the system was displayed when at 11 a.m., with only 375 airplanes remaining in the Boston Center airspace, the Center was warned that an unidentified aircraft flying low down the Merrimac River toward it. The Center went to "ATC Zero": controllers brought all their airplanes down to 18,000 ft, put

them on visual flight control so could land themselves, closed their airspace and evacuated. Centers in adjacent regions took over high altitude traffic and towers and TRACONS in NE region took over the traffic and brought the planes down where ever possible without incident.

Repair and Resilience:

Changing Space, Changing Place, Changing Culture

In the years following 2001, historical actions, begun in the 1990s, created two trajectories of independent events that intersected, increasing system risk and threatening safety. The first was an FAA modernization effort, NEXTGEN, which included both automation and organizational innovations: relocating and consolidating regional TRACONS in one Large TRACON, and streamlining and standardizing the FAA operations of the air traffic control system for greater efficiency. The second trajectory, also begun in the 1990s, was a staffing crisis due to years of congressional budget cuts that resulting in hiring freezes and fueled by controller retirements. Then to recover from the staffing crisis, the FAA made system wide adjustments to hiring and training that had negative unanticipated consequences on all facilities and controllers' dead reckoning.

Yet a third historical trajectory led to controller interventions to salvage the situation. Historically, changes made by the leaders of the Air Traffic Control System to improve safety resulted in one-size-fits all standardized rules, procedures, technologies, or changes in work arrangements. However, because airspace differs, standardized changes do not work for all facilities. So controllers became skilled at improvising to correct for standardization: "How can we make this work here?" Then after several public FAA failures, controllers were called into fix things. Finally, in the 90s, the Clinton administration legally empowered controllers to have input into the design, development, and implementation of all technological and organization innovations. Controllers could become Subject Matter Experts (SMEs). Becoming and SME was unpaid labor in addition to work responsibilities. Controllers were overjoyed that they could officially and formally participate in repair, adapted innovations to fit the local situation.

Next Gen became operational in the New England Region in 2004. When I revisited Boston Tower and Boston TRACON in 2017 to see the system effects of NEXTGen, controllers were still deeply engaged in repair. Boston TRACON will be the example, because it demonstrates both automation and consolidation of individual TRACONS into a single regional Large TRACON.

. Before the New England Region, NEXTGEN had several large TRACONS already successfully consolidated and in good working order. However, the Boston Consolidated TRACON was an experiment. The operational Large TRACONS had joined TRACONS that had airspace of the same size, traffic volume, and complexity, so controllers for each facility worked their own airspace. However, BCT was combining Boston TRACON with two smaller TRACONS with less airspace size and complexity with the understanding that the airspaces would be integrated - meaning that the smaller TRACON controllers would learn to work the more complex airspace of the original Boston TRACON. Boston was the test case. Retaining the name of the largest facility, the orginal Boston TRACON and Manchester NH TRACON both moved in January 2004, with Cape TRACON scheduled for 2018.

Although all controllers had been trained on the new automated equipment before moving in, everyone was overwhelmed by the liabilities of technological and organizational innovation. Moreover, inequalities were built into the project from the beginning. Although both Boston and Manchester controllers collectively participated in integrating the facility– "how can we make this work here" - the original Boston TRACON, having the highest skilled controllers and the most challenging airspace, bore most of the responsibility. The staffing shortage impaired ability to acquire and train new controllers and at the same time train the Manchester controllers on the Boston airspace. The responses of the Boston TRACON were new forms of boundary work: how do you combine separate facilities with unique local cultures and ways of doing and being into a larger facility in which coordination is essential to the work and the system. Ultimately, repair involved reshaping social, physical, symbolic, and cultural boundaries. Thirteen years after moving in, the past was still visible in the workplace. In 2017, 13 years after the new facility became operational, controllers efforts to repair the system were still in progress. Boston controllers were engaged in erasing the structural, cultural boundaries and inequalities of the facility: they worked to unify the separate facilities to overcome the liabilities of technological and organizational innovation and restore what had been the unified cooperative, coordinated culture that had been lost in transition. (Section incomplete, examples to be inserted here)

Discussion and Conclusion (TBA)

I will return to the literature on institutional persistence, change and agency and extract from the case ways it elaborates existing research in historical sociology, historical institutionalism, and sociological institutionalism. What is the utility of analogical comparison, and shifting units of analysis ? (e.g, Haydu on time sequences and problem solving applies at each of three levels of analysis: macro, meso, and micro). In addition, I will make some general observations and suggestions about the utility of looking at existing organizational systems, other than nation states as the units of analysis, using system effects as a perspective that along with ethnography and interviews, allows use of micro analysis in order to learn more about the role of agency in system persistence and change.