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Innovation Practices: Co-creation in Tech Sectors in North American Cities

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Abstract

The process of technology design and innovation directly shapes society and who benefits or is burdened by said technology. This project is a descriptive and explanatory research undertaking aiming to understand innovation practices in specific tech sectors–space sector, robotics, and urban energy–in two North American metropolitan areas: Greater Boston and the Detroit Metro. This study analyzes co-creation facilities and living labs in these technical and geographic domains and aims to understand what innovation practices these organizations are using, why they are using these practices, what their standards of success are, and why. The role of cultural embeddedness, geographical embeddedness, and technological embeddedness is examined in this project as well as that of inclusive innovation as a concept and practice. In order to address these research aims, a mixed methods approach is used for data collection–including stakeholder interviews, site visits, and technical analysis. Data is analyzed using a systems architecture and enterprise architecture framework. This paper focuses on the space sector in Greater Boston, both in comparison to other previously analyzed sectors in the region—robotics, urban energy, and biotechnology, and in reference to other important space innovation hubs in the United States. In particular, we focus on a comparison of innovation objectives and stakeholders, and how this informs the types of innovation practices used in these regions.

1. Introduction

This paper provides an update and new results on our existing project, Innovation Practices. This project involves using mixed methods in the social sciences, systems architecture, and a framework on antiracist technology design in order to describe, understand, and evaluate the innovation cultures within two north American cities: the Greater Boston metropolitan area (subsequently, Greater Boston), and the Detroit metropolitan area (subsequently, Detroit Metro). Within these two cities, we are examining innovation practices and cultures within three technology sectors: robotics, urban energy, and the aerospace sector.

The purpose of this project is to understand the role of geographical embeddedness, cultural embeddedness, and sectoral embeddedness in creating innovation cultures in these specific sectors and regions. Further, we hope to understand if and how the organizations we study within this project conceive of and implement practices of inclusive innovation. Specifically, we are particularly interested in the role that identity-based frameworks around access and inclusion to innovation—such as antiracism—may or may not play in these organizations' practices of innovation.

The organizations we are studying in this endeavour are tech startups, co-creation facilities (CCF), or living labs (LL). CCFs are open spaces for the collective advancement of innovation efforts. They typically provide physical and/or virtual infrastructures, and host individuals and organizations who are working on specific innovation projects in a particular sector—e.g. robotics. CCFs often provide important resources to members: such as funding, office space, equipment-sharing, lab-space, expertise, and support staff. They may also have existing relationships with funders, local policy entities, academic institutions, and other organizations in the particular tech sector—and the CCF organization may serve as a bridge between innovators and these entities. CCFs can play an important role in gathering together many stakeholders who are interested in a particular kind of innovation such as robotics—and providing a hub of resources, shared ideas, and infrastructure to advance the field or sector as a whole through demonstrations, technical development, and networking, among other things. Many of the organizations in our study that are co-creation facilities are under the sector of robotics; one example of why this makes a particularly good match is due to the high cost of robotics equipment and infrastructure—co-creation facilities allow emerging innovators shared access to this equipment, which is sometimes hundreds of thousands of dollars or more.

Living Labs, in contrast to CCFs, are sites where potential future technologies can be designed, developed, demonstrated, and piloted under real-world like conditions. Living Labs often feature collective

innovation, and the infrastructure may be contained to a building or two, or expansive to include an entire municipality or campus. Living Labs may have a feature of idealism in their conception—with ideas of "sustainability" or "green technology" being an often an important part of their culture. The variables of scale and autonomy are also important parts of Living Labs; by providing a controlled or semi-controlled environment to test new technologies, LLs can achieve a "closed system" context. Autonomy comes into play with the governance of Living Labs, which often have their own organizational structures and rules that interact with data collection and experimentation. For example, many of the Living Labs we have written about in our previous works have been on the sites of university campuses in Greater Boston, and have focused on sustainability and green energy technologies. The university as a "container" for these LLs provides a site for controlled experimentation, interdisciplinary and cross-sector innovations. Additionally, the physical and virtual infrastructure of the university setting, as well as the self-governance of universities, makes them ideal examples of LLs to test out innovations relating to infrastructure, sustainability, and green technology.

1.1 Previous Work

Our previous work has detailed several case studies of CCFs and LLs in Greater Boston, in the technology sectors of robotics and urban energy. These case studies have aimed to address two research questions of our project:

I. (Describe) How are organizations using the innovation practices of hosting co-creation facilities and living laboratories to seek to spur innovation in the fields of urban energy and robotics?

II. (Explain) Why are organizations that seek to foster innovation choosing the methods that they are choosing and what is the role of regional cultural embeddedness to explain these choices?

We have found that in Greater Boston, there are several examples of CCFs and LLs that fit within comparative definitions of these facilities by other authors, notably, similar types of facilities in Europe. Key features of innovation we have found in our case studies include innovation around ideation and sourcing, resource allocation, and closed system innovation for LLs, and innovation around networking, workspaces, team creation, policy + resource investment, and reputation management for CCFs.

Living Labs in Greater Boston generally sought to leverage the college and university model to foster closed system innovation, leverage existing university resources for sustainability, foster structures in which people from different professional roles in the university could interact and play important roles in innovation, and incentivize global and outward-facing work on sustainability to brought into Boston. Importantly, Greater Boston's reputation for excellence in science and engineering was an important driver for this, as was the network of many colleges and universities that exist in Greater Boston—several of them research institutions that attempt to bring in research funds.

Co-creation facilities in Greater Boston sought to rely on economic and policy factors at the state and local levels to situate the region as a powerhouse in particular technology sectors—such as robotics. The role of CCFs in robotics in Greater Boston was multifaceted and multi-scalar: aiming to stimulate and concentrate innovation locally, while regionally aiming to influence broader narratives about Greater Boston as a hub for robotics research, and garner support for funding, policy, and partners that support these endeavours.

1.1.1 Literature review

A detailed literature review on co-creation practices, the histories of Greater Boston and the Detroit Metro, and the role of regional and cultural embeddedness in innovation can be found in our previous paper. Overall, this work emphasizes questions of place, history, and culture—and the role these features have on defining and shaping regional innovation cultures and sector-specific innovation cultures within.

Previous work has discussed the role of the aforementioned features in innovation cultures—notably in Greater Boston. Particularly, works about the role of colleges and universities, the private sector, and policy in Greater Boston have suggested that the intersection of these features contributes to the uniqueness of the region as a place for cutting-edge innovation. Additionally, work underscoring the limits of "transferability" in innovation—that is, the ability to create innovation hubs and cultures such as the Silicon Valley Model or the MIT Model—elsewhere—suggests that features of history, place, and culture are extremely important to understanding innovation cultures in general.

Our work aims to understand how these features interconnect in Greater Boston, and how these features contribute to innovation cultures. Further, we aim to understand the role that these cultures play in defining and shaping what "inclusive innovation" means in Greater Boston. Inclusive innovation has been modelled theoretically—e.g. the inclusive innovation ladder, as being stepwise and linear. But recent scholars have discussed the role that features of history, place, and culture shape what is seen as acceptable inclusive innovation, and what the limits of inclusivity are in the innovation sectors. For example, our previous work showed how inclusion in Boston was primarily driven with a global lens and a perspective around class. The

idea that Boston is an innovation center not just for itself, but for the world at large—features heavily in how organizations think about and implement inclusion. Additionally, in the innovation workforce of Greater Boston, inclusion was marked by thinking about the class hierarchy traditionally represented in Greater Boston of academics and "white collar" workers contrasting with blue-collar workers. Important practices of inclusive innovation in Greater Boston had to do with bringing together these employment classes to work together on problems and define them—e.g. in the case of Living Labs at colleges and universities. Additionally, by considering the impacts that existing practices of manufacturing and other employment sectors had on innovation definitions and priorities in fields such as robotics—inclusiveness was marked by centering the concerns of the blue collar class of workers—e.g. policemen, lobster boat workers—in the objectives of robotics projects at CCFs.

1.2 Current focus

The focus of work in this paper is additionally on Greater Boston, but here we turn to considering innovation organizations and cultures in the aerospace engineering and technology sector of Greater Boston.

2. Methods

The methods of this research project emerge in part from its four-part theoretical framework (Fig. 1) described in detail in our previous paper.

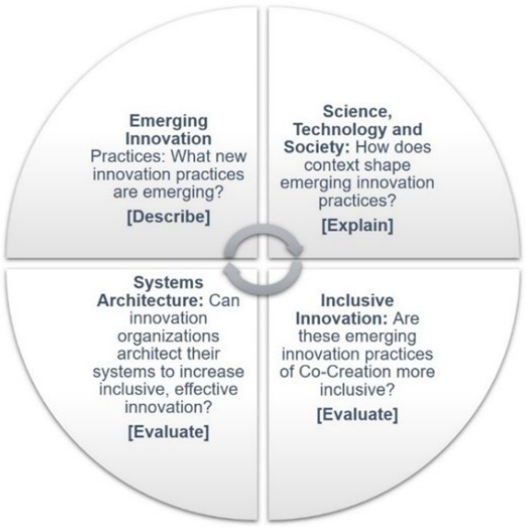

Fig. 1. The project is based on a theoretical framework that combines the study of Innovation Practices; Science, Technology and Society; Inclusive Innovation; and Systems Architecture

The framework works to bring together work on Innovation Studies, Science Technology and Society (STS) Studies, Systems Engineering, and Inclusive Innovation. The framework works to guide the type of questions we ask as research questions and in interview methodology—as well as the organizations, sectors, and geographies we have chosen for the project.

Notably, this framework brings together disciplines and schools of thought which do not always traditionally work together—STS and systems engineering. The framework of system architecture we use to describe and understand innovation cultures (Fig. 2) is a descriptive tool to understand systems such as a particular innovation organization or a particular innovation ecosystem—however, scholars of STS and innovation studies rarely rely on these types of systems-engineering frameworks. In part this is because of historical practice, but in part it is also due to epistemology. Here we use systems engineering frameworks such as systems architecture as descriptive tools to understand how innovation ecosystems work, and aim to understand the role of society and cultural embeddedness in our systems engineering considerations.

We use a case study approach of innovation organizations in the project, which allows us to draw detail-rich and contextual descriptions of the innovation practices and cultures of various organizations. The systems engineering approach allows us to organize these descriptions and analyse them for dynamics and relationships. Each case study is seen as a unique experiment, rather than one of a statistical sample.

Methodologically, we draw from analysis of literature, press, and primary sources from the innovation organizations we've studied (e.g. websites and publications), as well as qualitative interviewing and site visits. Interviews are conducted with various stakeholders in innovation organizations—managers, corporate leaders, engineers, communications specialists, and technical specialists. Interviews pertain to topics of organizational structure, day-to-day operations, and network interactions; each interview is approximately 60 minutes. Interviews are typically conducted via Zoom, and the conversations are coded and analysed theoretically in order to develop a grounded theory. Site visits, when available and appropriate, are conducted to support interviews as well: with particular attention paid to location, infrastructure, organization, and technology.

3. Results and Discussion

3.1 Space Sector Organizations in Greater Boston

We are focusing on five innovation organizations within Greater Boston in the space sector. They are summarized in Table 1.

Table 1. Innovation organizations in the Greater Boston space sector

Organization Name	***Purpose***
Aurelia Institute	designing future of space infrastructure
Redwire Space	creating flight hardware for space systems
Lunar Station Corporation	data servicing for lunar project decision support
Space Exploration Initiative	demoing imaginative + creative futures for space use
Axiom Systems	designing new propulsion systems

These five organizations currently serve as case studies for the space sector in Greater Boston. These organizations do not fit neatly within existing academic definitions of CCFs and LLs. Rather, these organizations have characteristics of traditional startup organizations. One feature of these organizations is that they largely grew out of academia—with Aurelia Institute, Lunar Station Corporation, the Space Exploration Initiative, and Axiom Systems resulting from spinoffs within the academic research sector at MIT. Redwire Space does not fit this pathway; rather, it resulted from the combining of two existing companies to define a different purpose.

An observation from these existing companies and their beginnings is related to the presence of the space technology sector in Greater Boston, particularly as it relates to other sectors such as robotics, urban energy, and biotechnology. While Greater Boston is known as a hub for these three technology sectors, it is not widely considered a hub for space-sector innovation. As a hub does not exist in the same way in Greater Boston—we do not see the same types of easily defined innovation organizations such as living labs an co-creation facilities. Many of the co-creation facilities in Greater Boston, in particular, rely on an existing hub of research and entrepreneurial infrastructure in order to collaborate and form CCFs. As the space sector in Greater Boston is not as widespread, we do not observe the same phenomenon as seen in the case of robotics, for example.

Some features of Living Labs can be seen in the example of the Space Exploration Initiative, in particular. The Living Labs we've observed in Greater Boston largely grow from the university space, and employ practices and policies to foster innovation across job sectors, expanding and redefining the scope of possibility in a particular technology sector, and providing sites for demonstration of ideas. The Space Exploration Initiative (SEI), while not exactly defined as a Living Lab in name, shares many of these features. In particular, SEI is hosted at a university, MIT, and aims to provide opportunities for demonstration and community around the use of space for research, art, and life. SEI offers opportunities for creative ideas to be demonstrated in space-like environments, such as microgravity flights.

3.2 The Space Sector in Greater Boston

The space sector in Greater Boston serves as an interesting case study—both in reference to other technology sectors in the region, as well as to other cities with a space sector presence.

In the United States, Greater Boston is not known a particularly strong hub for space sector innovation. Regions particularly strong in space-sector innovation in the US typically have a focus around NASA research centers—for example, the San Francisco Bay Area and its proximity to NASA Ames, Los Angeles and its proximity to Jet Propulsion Laboratory, or the Space Coast of Florida and its proximity to NASA launch sites. Other space-sector innovation hubs in the US may have another focus point in industry or in the military—for example Colorado and its proximity to the US Air Force Academy, or Seattle and its proximity to Amazon and Boeing.

In Greater Boston, there is no major industry, military, or government nucleus from which the space sector forms. Rather, in Greater Boston, the space sector grows from and is largely influenced by existing academic research on space in the region—which takes place mostly at MIT. Existing space research at MIT is, for the most part—not highly collaborative. Rather, the typical academic university structure of professor-led research laboratories working on dedicated specific topics—from bioastronautics to in-space propulsion systems—is common. Under this academic model, highly specialized research in a given area may sometimes turn into an entrepreneurial spinoff-sometimes with the collaboration and buy-in of the academic principal investigator who trains the researchers. This academia-to-startup model is common in other sectors of technology in Greater Boston, and is particularly common at MIT—this distinctive feature of the Greater Boston innovation ecosystem is present in the space sector.

MIT has a strong culture of research on space and a presence in space. MIT has a highly-ranked aerospace engineering department, and has many alumni who were able to work at astronauts at NASA. The lore surrounding space at MIT is something evident even in the smallest social markers—for example, the Muddy Charles Pub, the MIT campus pub, has framed artwork of the NASA headshot photographs from MIT alumni who have gone on to become astronauts. MIT additionally has space-related research outside of the aerospace engineering department. The Media Lab, in

particular, is the home to several research groups who are either in-part or entirely devoted to the study of various questions in space.

Other universities and colleges in Greater Boston also have a key space presence in academia—from Harvard University's space week which aims to host scientists, policymakers, and artists for a week of space-related programming and community, to undergraduate aerospace programs at colleges like Boston University and Olin College.

3.3. Research Question 1: How are co-creation facilities and living labs in Greater Boston in the space sector seeking to spur innovation?

Space sector organizations in Greater Boston are seeking to spur innovation in a few key ways: 1) leveraging existing partnerships in academia and industry, 2) expanding on the idea of space as a future venue for manufacturing, technology, science, and art, and 3) providing opportunities for individuals and groups not in the space sector to take part in space sector ideas and demonstrations.

The space sector organizations in Greater Boston all exist in part due to a previous connection in academia, industry, or both. In the case of academic connections—organizations like Aurelia Institute and Lunar Station Corporation can be thought of in some ways as spinoff organizations from an academic hub of research at MIT. In these cases, existing research and partnerships were leveraged in order to build a company. The proximity of the research geographically to the company is important both as a means of collaboration, continuity of work, access to potential employees and collaborators, and access to shared resource opportunities—e.g. funding, publications, demonstrations, conferences.

Some space sector organizations in Greater Boston do not explicitly benefit from an academic connection, rather one in industry. Redwire Space is an example of this kind of organization. Redwire results from existing industry corporations combining and changing focus. The previous organizations used to make innovative hardware that was not in use in space systems, but at Redwire, a similar type of hardware is being created and innovated upon for the space sector.

The space sector organizations in Greater Boston all are seeking to expand upon the use cases of space. Important to the missions of each of the companies is the idea that in a present or near-future, space can and should be a place for manufacturing, art, science, experimentation, and technology. The idea that space should be a venue for exploration, creativity, and curiosity underpins organizations such as the Space Exploration Initiative. The idea that space should be a place where manufacturing and engineering takes place is an important part of Redwire Space. The feature that space should be not just a place that humanity goes to and visits, but a place that itself is a terrain for novel ideas, demonstrations, innovation, and possibility—is evident in each of the space sector organizations in Greater Boston.

Importantly, innovation organizations in Greater Boston's space sector provide opportunities for individuals and groups outside of the space sector to take part in it. This is also a feature of Living Labs and Co-Creation Facilities that we have studied in the region in the sectors of robotics and urban energy. Two important cases of this in the space sector are in the examples of the Space Exploration Initiative and Redwire Space. Within the Space Exploration Initiative, opportunities for researchers, artists, and designers to leverage the Initiative's access to space and space-like environments is and important feature of the organization. The Space Exploration Initiative has events regularly such as microgravity research flights. Many of the research ideas tested on these flights are highly creative and not necessarily immediately needed in the way that space is being used now—but are testing and pushing the limits of what space as a frontier and terrain could do. For example, research projects on these flights have included research on the effect of microgravity on a bee colony, and on the way that different textiles behave both aesthetically and performatively in a microgravity environment. Some demonstrations on these flights are and important proof of concept that might not even extend to a practical use in space. However, the Space Exploration Initiative makes all of these types of experiments and demonstrations possible and achievable, and norms the fact that space can and should be a venue for this type of work.

Redwire Space, through its previous partnerships and connections with more terrestrial-based hardware applications, is providing opportunities for individuals and groups to take part in the space sector, as well. Though space research and manufacturing can often be a specialized and niche area of innovation, Redwire leverages the existing manufacturing and hardware community in its work on space.

3.4. Research Question 2: Why are organizations in Greater Boston that seek to foster innovation choosing these practices; and what is the role of regional cultural embeddedness to explain these choices?

When considering the space sector ecosystem in Greater Boston, a key insight emerges when thinking about the purpose of the sector there—both in comparison to other technology sectors in Greater Boston, and also in comparison to the space sector elsewhere.

Both the robotics and the urban energy sector in Greater Boston are concerned with both Boston's position in the world as a place of excellence in research in these areas, and are interested in leveraging Boston's unique features—e.g. the constellation of universities, and the geographic proximity of outdated manufacturing processes—to provide a canvas for innovation and demonstration. The space sector in Greater Boston, though, is less concerned with the role of Boston in current and future innovations. Boston is not necessarily a hub of space innovation—and this is perhaps a feature to space sector organizations there.

In Greater Boston, the role of the space sector is to push the boundaries of what is already accepted and operational in space: whether this is about hardware, or about the purpose of space itself. Whereas space regions like the Bay Area are discuss the role of space in enacting justice or sustainability on earth—the space sector in Boston is concerned with "space for space's sake." Innovation organizations in Greater Boston are often exploring the intrinsic value of space without having to set or define deeper values beyond that. This is likely in large part impacted by the MIT research presence in the space sector, as well as the fact that the space sector in Boston is not as crowded, competitive, or watched as places like the Bay Area, Los Angeles, or Colorado.

A driving factor behind many of the space organizations in Greater Boston is the idea that doing more in space—whether that be art, manufacturing, experimentation, etc—is inherently good. That if the world had more space work, that would inherently be a positive thing that would lead to good outcomes, even if one can't say yet what those outcomes might be. The audience of the space sector in Greater Boston is therefore less about a particular company, partnership, or unifying ideology of utilitarianism or justice. Rather, the audience is both the existing space sectors elsewhere, and the naïve person who thinks that their work might have absolutely nothing to do with space. The space sector organizations in Greater Boston seek to epistemically expand the role that space plays in our collective present and future.

6. Conclusions

Here, we have explored the beginnings of case studies on innovation organizations in the space sector in Greater Boston. Through comparison of these organizations to other technology sectors in Greater Boston—robotics, urban energy, and biotechnology—we begin to form a picture of the innovation cultures of Greater Boston in general. Through examining the space sector in Greater Boston, we are able to see an example of how innovation in the region looks in a tech sector which it is not inherently known as superior or dominating. Examining the space sector in Greater Boston therefore provides valuable insights not just on the sector itself, but also as it relates to the Greater Boston ecosystem, and to the cultures and norms of the space sector worldwide.

Future work on these case studies and the others within the Innovation Practice project includes the examination of the concepts of "inclusive innovation" as it relates to these case studies. Understanding how inclusion may or may not be present, and in what ways—drives our continued work and line of inquiry.

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