Translating Ideas into Impact:

Supporting and Accelerating the Innovation Orchards at MIT and Beyond

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I. Defining the Opportunity

While the United States leads the world in innovation and entrepreneurship, there is concern that the country is not fully benefiting from its innovation capacity because of the challenges of bringing advanced, complex, emerging technologies to the market place. While the basic research stage has long received critical government support, once that research phase is surmounted, the challenges for emerging technologies multiply. These technologies are characterized by their complexity, in terms of the basic science involved, the longer proof of concept and proof of product processes, and often the advanced manufacturing capabilities required to scale them. Some established technology fields have routinized the development process, supported by established markets that can more readily absorb new advances in the particular field, such as in information technology.

Innovations in new technological frontiers, in many cases combining hardware and software, face a much more challenging entry process. This complexity can lead to longer development time horizons in order to demonstrate viability at scale (potentially over a decade) as well as significant capital costs due to the cost of unfamiliar development pathways and new manufacturing processes. This poses challenges for private-sector investment in the development cycle both from the typical venture capital investor, who is interested in exiting in an earlier timeframe, and for the strategic industry partner, who often needs to see a sufficient development of proof of product before investing. While the defense sector has long been a source for patient capital for development of defense-related technologies, many technologies fall outside areas of defense interest. This challenge has been identified in a range of technologies/industries including advanced materials, medical devices, biotech and energy.

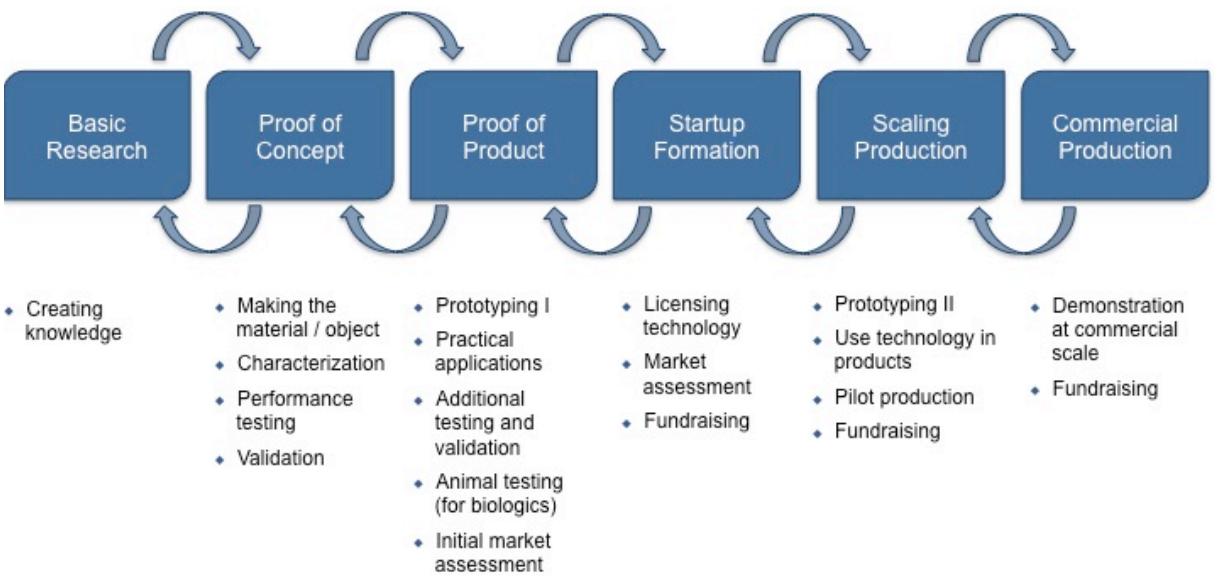
This paper explores how these types of complex technologies move from the lab to the marketplace at academic institutions and beyond in order to understand how this process might be supported, enhanced and accelerated. It builds upon a concept introduced by MIT President Rafael Reif[1] in an op-ed in the Washington Post termed "Innovation Orchards." Reif identified the problem of developing these important technologies and raised the possibility of building new collaborations that would support nurturing "the orchards". This

[1] Reif, Rafael. "Op-ed: A better way to deliver innovation to the world." *The Washington Post*. May 22, 2015.

paper provides an overview of what this might look like based on interviews with MIT faculty and researchers who are actively involved in bringing new technologies to the market place. It also raises larger questions, important to MIT and other institutions, such as the role of translational research in education and how to best provide students with the knowledge and experience that will help them solve the global challenges facing society today and in the future. Many of the examples or scenarios described come from MIT experiences, but they can be broadened to many other research-based organizations. A next step in this process will include additional discussions with industry, startups, government, non-profits and other academic institutions.

II. Framing the Challenges: From Idea to Impact

These idea-to-impact challenges are best understood in the context of the full innovation process. The process for moving innovations from an academic lab to the marketplace has several typical steps, though, as every technology and startup has a unique story based on the technology, the founder, and the market conditions. Nevertheless, we can identify several stages and steps that outline the process. While presented as linear, in fact there is a great deal of iterative and recursive knowledge sharing and learning that takes place throughout this process.



Researchers are engaged in **basic research** that may develop ideas for a new product or process, often focused on a technical or scientific problem to solve rather than one that is customer-oriented. This research typically takes place in faculty laboratories with funding primarily from federal sources, although industry is sometimes involved in this stage. From this point, they may move into a stage of determining technical feasibility.

Proof of concept, where a potential solution to a problem is being explored, involves making the material or object and characterizing its properties, performing tests to determine its feasibility and validating its performance under certain conditions. Financial support during this process can involve some of the same basic research funding but will often include more focused industry partnerships as well as programs which provides grants and services to support proof of technical feasibility such as the MIT Deshpande Center, NSF I-Corps, and SBIR/STTR[2].

Proof of product may involve making the first prototype and conducting additional testing and validation under a broader or widening set of conditions[3]. It may also mean developing more of a "data package" that proves the feasibility of making the product. Faculty and students typically have access to specialized equipment and facilities that make this possible.[4] It is often the creation of the first prototype ("**Prototyping I**") that is critical to the inventors' ability to attract interest and potential investment from outside. At this stage funding varies depending on a number of factors, including company status. Sources of funding for proof of product activities may more likely include industry as well as the proof of concept funding sources mentioned above. These partners and others can also help with the critically important process of determining where potential market demand exists for the new technology/product. Furthermore, during this period, as the development team begins to consider launching a startup, an exploration of additional funding sources often takes place, including traditional venture funding.

Once these initial stages are complete, the next stage involves building the technology at a greater scale. This may involve a **"pre-pilot" stage** with an additional prototype or something more substantial before moving into pilot-stage production. At this point, faculty often move the technology development outside the walls of the university since the institution typically does not have the adequate resources or expertise to develop new technologies to scale. A first step in this process for university researchers typically involves patenting and potentially licensing the technology through an entity such as the MIT Technology Licensing Office (TLO). In most cases, the technology is licensed to a **startup** in which faculty are involved, rather than to an established company (though this does occur). Space is a concern at this point as the startup, either on its own or in partnership with a

[2] More information on these programs can be found in a separate appendix document.
[3] While the term prototype does not accurately describe the process for many biomedical innovations, the general stage of testing and validation (often in animals) holds true.
[4] MIT is engaged in a process of assessing "maker space" capabilities to determine how best to increase access to such space for faculty and students.

strategic partner, will typically invest in new lab space (often in the Cambridge area for MIT ventures) to continue the early stage pre-pilot proof of product work and to build the infrastructure for the new company. If the type of technology and its potential development timetable fit established development pathways, venture capital, industry strategic partners and family and friends (“angel investors”) can be the key investors at this stage.

After a company is formed, the process of proof of product continues at various stages of scale up. These stages can be particularly challenging for these types of complex technologies. While risk capital may be available at what might be termed **Prototyping II** (production at a scale that is larger than lab-scale but smaller than pilot production), and even at the pilot production stage, as the timeline extends and the capital requirements increase, risk capital, particularly from venture, becomes more difficult to obtain. The capital required to **demonstrate viability at the commercial scale** is often much more significant and as MIT research has suggested,[5] startups are increasingly looking toward strategic partners, who often have different motivations regarding return on investment than venture capitalists, to help invest in order to cross this threshold. This is particularly challenging in the cases of biotech and energy. This later stage scale up process, from pilot to commercial scale, can cost tens of millions to hundreds of millions of dollars. Clear market demand must be established for investors to step in at this scale of investment.

III. Identifying the Barriers

To flesh out the above framework, a series of interviews were undertaken with MIT faculty who have worked to bring technology to markets. Several themes describing opportunities and challenges for complex technology innovation emerged from these interviews. The themes can be grouped into three categories: ***funding structures, talent transition and development,*** and ***physical product development space***. This section summarizes each of these areas.

Funding Structures A critical issue throughout the process is the question of funding and investment to drive complex technologies from the lab into the market place and to successful scale up. The process of developing the technology sufficiently to attract investors and then launching the new company from inside the

> *We need a larger pot of money [to] take basic science and apply it to a particular problem.*
>
> *…if I were designing a fund, I would rather put the money toward ideas than space.*

> *The critical funding issue is not post-startup, but rather providing for successful proof of concept and proof of product.*

[5] Reynolds, E. Samel, H. and Lawrence, J., “Learning by Building: Complementary Assets and the Migration of Capabilities in U.S. Innovative Firms,” in *Production in the Innovation Economy*, Ed. Richard Locke and Rachel Wellhausen, MIT Press, 2014.

university to outside in new commercial space for additional proof of product activities is at the heart of the challenge. Obtaining funding for the proof of concept and proof of product phases are often challenging. In some cases, this process is complicated by the fact that the technology is so frontier in nature that the idea of launching a company and finding the people and resources outside the university is unlikely and undesirable to the university researchers. There was unanimity that proof of concept/product centers such as MIT's Deshpande Center and funds such as those often provided by DARPA and SBIR play an important role. A new pool of funds to support early stage development and provide more time for new technologies to develop was suggested, as many of the interviewees felt MIT is missing out on building more fluid and creative relationships with funders that would lead to greater impact while also making a university such as MIT more competitive in attracting prospective faculty and students.

At the later scale-up stage, when pilot and commercial-scale production is required ("Scaling Production phase"), links to a university have usually decreased due to conflict of interest requirements as well as the nature of the work as it moves into more applied, scalable activities. Questions were raised regarding the kinds of funding that could assist at this stage of development and the university's role during this phase. Many suggested that traditional funding vehicles should be the emphasis at this point. For early stage scale-up, (pre-pilot and pilot), some thought there may be government, industry and non-profit funding opportunities to address specific barriers such as the potential need for shared facilities. Other possible partnership models will need to be explored.

For a company, it's going to take 10 to 100 times what you're spending at a university in order to get your first product.

Talent Transition and Development

Many of the interviewees suggested that engaging the right talent beyond the research stage was the critical issue for building a successful transition from lab work to startup. Success often depends on the people interested and available to make that transition ("entrepreneurial agents"). Barriers include conflict of interest policies and career advancement incentives. Furthermore, preparing and equipping this talent to run successful startups and be entrepreneurs has been identified as an important opportunity.

Talent is the major issue for complex technology startups to thrive and a key part of the issue are incentivizing the innovators to continue developing their technology outside MIT.

Addressing conflict of interest restrictions in particular was identified as a challenge that needs further exploration. This is a complex issue as these policies are critical to maintaining the intellectual integrity of the Institute. Conflict

Rather than avoid conflict of interest, can we manage it?

of interest rules restrict students from working on startups with faculty financial interests, and MIT's, in particular, are respected for being some of the most strict in the country. However, they create real barriers to translational research and disincentives around transparency. In addition, it is exactly the kind of applied research students engage in with faculty that they are often most excited about and from which they, in many circumstances, can learn the most. There are no simple solutions to this issue, but careful management is required.

Furthermore, some point to the lack of incentives and the need to create a smoother pathway for graduate students, post-docs and junior faculty to move between the academic institution and the starting of a new firm to help facilitate this transition. An opportunity exists to develop programs for these innovators to spend time on startups in a more formal way at MIT. They underscore the important value of this translational experience as part of the students' education. Many believe that it is in this area – in the transition from lab to the market – that real education occurs for MIT students and faculty. MIT, for example, has prided itself that this is a key factor that differentiates it from other institutions.

I found working with MIT difficult in trying to transition the technology. I was even discouraged from starting a company. Instead I was told to focus on my lab and getting tenure.

Finally, the importance of understanding the market for the technology is a crucial component of the success of the startup. Furthermore, support for other business activities including product development, finance, law and human resources was identified as a need. Mentoring and fostering industry connections for this purpose were identified as opportunities, building on programs at MIT such as the Venture Mentoring Service, Martin Trust Entrepreneurship Center, Gordon Engineering Leadership Program, Deshpande Center, iTeams and Start6[6]. A critical part of the process is finding the "business entrepreneur" who can partner with the academic founders and commit themselves to building the company. Identifying this person is often facilitated by investors such as venture capitalists as well as experienced faculty-entrepreneurs.

The difference between the failure of one of my companies and success of a follow-up company with similar technologies was the ability to understand the market opportunity

Physical Product Development Space

While MIT has significant space for innovative activities, especially in the form of laboratories, several of those interviewed indicated that additional prototyping/incubator space would be valuable to allow for proof of product processes to develop and

I think it's absolutely the most important thing we could do, to have facilities that help people try out ideas.

It is interesting to watch so many other schools that have [an incubator], where you can move something out of the lab and develop it and still be connected to the lab.

[6] More information on these programs can be found in a separate appendix document.

technologies to "ripen." However, there was also some skepticism that more space is really the issue (rather than funding) and indications that the laboratory is often the location of choice for development of specialized technologies. In general, there was agreement that greater utilization of existing space at MIT and at other universities and increased "maker spaces" would be beneficial to the community as a whole.

Many suggested that a space for entrepreneurial teams that provided opportunities for more mentoring and collaboration would significantly help advance these emerging startups. Such a space could support interaction and exploration within the MIT community as well as be used to convene industry partners, investors from the tech community, venture capital and philanthropy interested in exploring partnerships and supporting impactful research. Finally, several faculty spoke of the value of creating a way for the problems of industry or society at large to be brought to MIT to be discussed and possibly addressed.

We know what it means to make a new technology…but what does it mean to make a new product?

The hardest part is the initial startup phase out of MIT. It's very difficult to put together all the infrastructure, a lab with all the equipment – it's very expensive.

Once a company has been formed, physical space becomes a critical issue, particularly since there is significant value to the startup of being in proximity of the university. Finding the right physical space to take steps toward commercializing a technology can be a time consuming and expensive process, primarily because of the specialized equipment these types of startups need to continue their proof of product work. For MIT, creating a product development space near the Institute could do much of what is listed above and provide a landing pad for newly formed companies for 6-12 months to help during the transition to creating new company headquarters. This question of physical space between university-based technology development and startup-based technology development was what some referred to as the "boundary problem." Partnerships between academia, industry, government and non-profits can potentially help address this problem.

IV. Next Steps: Exploring Opportunities to Develop an Innovation Orchard

The next step in developing the concept of an "innovation orchard" is to explore further the ideas outlined in this document within the Institute, as well as with additional stakeholders such as industry, the investment community, government, non-profits, and other academic institutions to determine feasibility and priorities. While there was no "silver bullet" that stood out as a clear strategy for supporting the process of moving ideas to impact, several ideas emerged that would facilitate and accelerate this process.

While the proposals below are written specifically to be relevant to MIT, they also have broader applicability. In effect, if the various suggestions below are adapted at MIT in some form, they could help pilot them to a broader audience where we believe many will prove relevant.

Many MIT faculty interviewees underscored that MIT has very good resources for entrepreneurs and there is a need to build and expand upon existing assets. It is also important to note that many of the opportunities outlined have been captured and described in the MIT Innovation Initiative Report released in December 2014.[7]

Based on discussions to date, the following are potential areas to explore for developing an innovation orchard in and around MIT. The previous structure of funding, talent, and physical space are used to frame the components of an innovation orchard.

Funding Structures:

- Explore new funding and collaboration models with industry, venture capitalists, tech-entrepreneurs and philanthropists through a "virtual translational lab"; focus in particular on developing new models of industry partnerships given the keen interest to improve the innovation process within industry.
- Explore possible partnerships and models with industry, venture capitalists, tech-entrepreneurs and philanthropists to support funding startup activity as it transitions out of the university. At MIT, one model is the Media Lab's E14 Fund.
- Strengthen and expand the Deshpande Center whose focus is to empower researchers to develop innovative technologies in the lab and bring them to the marketplace in the form of breakthrough products and new companies. This would enable more ideas to be advanced and lengthen the support during the critical proof of concept/product phase.

Talent transition and development:

- Review and modernize university-industry conflict of interest rules ("contractual infrastructure") to better enable interested students to participate in start-up activity if they so choose. This will need to be done in a thoughtful and careful manner.
- Create opportunities for post-grads to stay engaged with MIT while also working on entrepreneurial efforts outside MIT. Build upon existing fellows programs (i.e., the RLE Translational Fellows Program) or other possible ideas (an "Innovation Year" for students to focus on a startup) that provide resources and services to pursue commercialization of university research-derived technologies.

[7] https://innovation.mit.edu/sites/default/files/images/MIT_Innovation_Initiative_PreliminaryReport_12-03-14.pdf

- Leverage and enhance existing mentoring (particularly industry mentors) and support programs (at MIT, these include the Martin Trust Entrepreneurship Center, Venture Mentoring Service, Start6, Gordon Engineering Leadership, and Deshpande Center).
- Reform student and faculty leave policies to allow for more translational work. Consider programs for PhD students supporting translational/startup work even after graduation during their post-doc years.
- Review tenure policies to allow faculty more flexibility for pursuing startup opportunities.

Physical Product Development Space:

- Better utilize existing prototyping/maker space on campus (per the recently launched MIT maker initiative) as well as planning for development of new innovation space in east and west campus and especially the construction of MIT.nano.
- Open up existing MIT Lincoln and Draper Laboratories for more entrepreneurial and technology prototyping piloting activity for non-classified work.
- Consider "incubator/prototyping" or "technology transition" space on campus with access to MIT equipment for faculty/students engaged with developing new technologies, pre-startup, which would facilitate interactions within the MIT community as well as with potential strategic partners and investors.
- Consider opportunities to develop "incubator/prototyping II" space in Kendall Square for MIT entrepreneurial teams to "land" as they launch their startup for a fixed period of time and connect with investors/partners while staying connected to MIT.
- Explore corporate/regional interest in a shared proof of product/pilot manufacturing facility in the region that could involve industry, government and non-profit partnerships. Also explore collaborations with industry and labs with relevant technologies and equipment for advanced product design and development.

The next phase of this exercise will further explore partnership models with industry, government, investment community, non-profits, academia, etc. Also, it may be instructive to begin with a pilot initiative focused on a technology area and involving not only campus but other potential partners to test some of these ideas and opportunities. Finally, while the MIT programs described have been recognized as leading edge, other institutions also address elements of this innovation challenge, and understanding these approaches can be helpful as the innovation orchard is developed. Examples include Berkeley Labs Cyclotron Road, Fraunhofer TechBridge, federal Proof of Concept Centers, the Army Research Laboratory Open Campus, and other specific academic centers/programs.[8]

[8] More information on these programs is in a separate appendix document.