PROOF-OF-CONCEPT CENTERS (POCC) REQUEST FOR INFORMATION

SUMMARY OVERVIEW OF ERC RESPONSES

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Overview of ERC Responses

Executive Summary

Twenty current and "graduated" National Science Foundation (NSF) Engineering Research Centers (ERCs) responded to a Request for Information (RFI) on ways to foster the commercialization of university research through Proof-of-Concept Centers (POCCs). Their responses varied greatly in detail and format, but ERCs were uniformly enthusiastic about a new effort to move research results into tangible concepts worthy of industry funding.

POCCs are seen as closely related to the work being done at ERCs. The ERCs are viewed as one of the nation's most effective programs to date at commercializing research and see themselves as good partners, perhaps even hosts, for POCCs.

As part of their academic mission, ERCs organize multidisciplinary research programs involving faculty and students across departments and campuses, while industrial partners comprise a central element of their structure. Every ERC has undertaken POCC-like activities, such as the careful pairing of researchers with entrepreneurs that enables academics to participate in commercially developing their work while remaining with the university. POCC-like programs at ERCs often succeed at least in part because of added funding from NSF or other sources.

As ERCs envision them, POCCs would go beyond the ERC construct and provide the marketing, legal, and investment disciplines that are not typically part of an academic setting. Building on the ERC model, each POCC should focus on a specific cluster of related technologies and be located at a major research institution but would be open to researchers from other universities and encourage a diversity of ideas. A POCC would have its own laboratory and office space and would be managed by experienced entrepreneurs as the director and program manager(s). It could be built conceptually or geographically alongside an ERC, perhaps drawing its board of directors in part from the scientific and industry boards that already advise the ERC.

Most ERCs see their centers as a feeder to the POCC, which would be overseen jointly by academics and executives, thus offering deeper relationships with industry. The POCC board, like the board of a venture-backed startup, could review plans and drive for results. The POCC’s staff would give small teams of faculty, entrepreneurs, and students the support needed to attract outside funding and transform projects into viable startups and products. A formal "stage-gated" process would allow fixed periods for proving technical and market feasibility, and then for developing prototypes or otherwise proving market viability. As a project progresses, the POCC would require that the project attract matching funds from the private market.

POCCs could also build on the uneven success of incubator programs run by universities and local governments, as well as business-driven efforts that have suffered from a lack of technology insight. Through POCCs, the federal government can step in and underwrite a new wave of innovation activity designed to bridge the "Valley of Death" that too often looms between promising academic research and commercial viability.

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SUMMARY OVERVIEW OF ERC RESPONSES

Following is a summary overview of the responses submitted by 20 current and "graduated" Engineering Research Centers (ERCs) to a Request for Information (RFI) on ways to foster the commercialization of university research and stimulate the commercialization of early-stage technologies through Proof-of-Concept Centers (POCCs).* The ERC RFI responses varied greatly in length, detail, and format. Consequently, rather than being a center-by-center summary, this overview is presented in an integrated fashion that seeks to describe relevant experiences of the ERC program, how a POCC might be organized and function based on the experience and vision of the ERCs, and related views on promoting the commercialization of university research.

The challenge of turning university research into commercial products and processes reflects vast differences in the cultures and mindsets of university and industry, which work to different reward systems and risk tolerances, and have different approaches to measuring the success of research projects. Most university-generated inventions arise from the exploration of scientific questions; then the inventors try to transform the findings into a commercially viable product—but this process is risky and often unsuccessful. Only recently has an "unmet need" approach begun to take hold whereby the market and its unsatisfied needs, especially medium- and longer-term needs, drive research projects from the beginning. For 25 years, the ERCs have pioneered this approach to meeting real-world needs with strategically targeted research.

The Need for POCCs

Given that background, the ERCs responded enthusiastically to the idea of a new program for moving ideas into tangible concepts worthy of industry funding. POCCs are seen as closely related to the work at ERCs, which are focused on the early stages of the process of commercialization, from research leading to concept generation and discovery through concept evaluation in the form of testbeds. Clearly, the testbed process represents the early stages of proof-of-concept. At this stage, ERCs will often hand off further development to start-up entities or companies willing to invest in such early-stage research and development. But product advancement can terminate at this stage—the phase often termed "the Valley of Death"—if sufficient support does not exist in the commercial sector. A POCC could maintain a project's focus for a longer time, bridging that gap and conceivably turning more transformational ideas into market reality.

Build on ERC Accomplishments

The ERC program itself is viewed as one of the nation's most effective efforts to date in helping faculty see their research make an impact on society and go beyond traditional

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outputs of scholarly endeavors. The centers see themselves potentially as good partners, perhaps even hosts, for POCCs.

As part of their academic mission, ERCs organize multidisciplinary collaborative programs involving faculty and students across departments and even campuses. This broad input and diversity fosters a diffusion of ideas that helps the best ideas to emerge from traditional academic disciplinary silos that often limit the exposure given to emerging technologies. An example is the recently-funded project to develop a reliable, safe, and cost-effective highway assessment and maintenance system. This $18 million, 5-year translational research project was made possible by the ERC for Subsurface Sensing and Imaging Systems, based at Northeastern University, and its interdisciplinary collaborations in civil engineering, acoustic sensing, and radar development. The outcome will be a prototype sensor suite that will provide a continuous stream of accurate, up-to-date information about the state of roadways and bridge decks gathered by sensors mounted on vehicles already traveling highways, while also eliminating the hazardous, congestion-prone work zones that are often set up to gather this critical data.

Even more germane to the proposed POCCs, the ERCs also include strong industrial and technology transfer components, with industrial partners comprising a central element of their structure. The centers typically offer company memberships at different levels of investment and engagement. Large companies that want broad access to research and licenses pay higher fees on a scale that includes much lower fees for small companies more interested in early access to particular projects, results, and students. Industrial partners also serve on advisory boards and participate actively in research, contributing industry know-how and providing other valuable tangible and intangible contributions.

In that sense, the ERCs foster the formation of university-industry consortia that often persist even after the ERCs “graduate” from NSF funding. The consortia cultivate university-industry communication and avenues for spinning technology from academic labs to companies. Member companies also host student interns, hire students after graduation, and actively participate in mentoring, research, and strategic planning of the centers’ research programs.

The industry relationships at the core of the ERC mission have also fostered ground-breaking mechanisms for better sharing and accessing the intellectual property associated with new technologies. A good example is the Intellectual Property Protection Fund (IPPF) developed at the Center for Power Electronics Systems (CPES), a graduated ERC based at Virginia Tech, to remedy an IP-related bottleneck. A conventional process of individual non-disclosure agreements and patenting decisions for each invention proved too cumbersome for the 15-20 invention disclosures a year. The IPPF, developed in 2002, allowed Principal (top)-level members to join IPPF for an additional annual fee. The fund sponsored quarterly teleconferences to discuss invention disclosures with CPES researchers and jointly decide which technologies to protect, with patenting costs covered by IPPF and fund members gaining a license to use the technology. With the implementation of IPPF, IP protection and access for CPES Principal-level members improved greatly.

In recent years, the ERC program has funded a number of “translational” research awards that support direct collaboration between an ERC and a small business to carry out research aimed at handing off commercially promising ERC discoveries and technologies to industry. In addition, all ERCs awarded from FY 2008 on (known as "Generation-3" [Gen-3] ERCs) are required to support start-up firms in carrying out translational research through the ERC's research program.

POCC-like Initiatives at ERCs

While ERCs are unusual in their central goal of promoting the commercialization of academic research, they, like the broader universities in which they exist, still struggle to bridge the "valley of death" that exists between concept and early stage development (see Figure 1). Projects are too often left to die on the vine because the university research typically ends before the production of commercial prototypes and even pre-prototypes begins. Discoveries too often are insufficiently developed to even present to potential investors. This hurdle can be overcome by continuing to develop nascent technologies while they are in the university. Effective bridging of the valley of death with translational research funding by the government (as is done through core funding for Gen-3 ERCs and special supplements to both Gen-2 and Gen-3 ERCs, or by Small Business Innovation Research [SBIR] awards, for example) or by venture capitalists allows us to characterize this region in the figure more optimistically as the valley of the "shadow" of death.

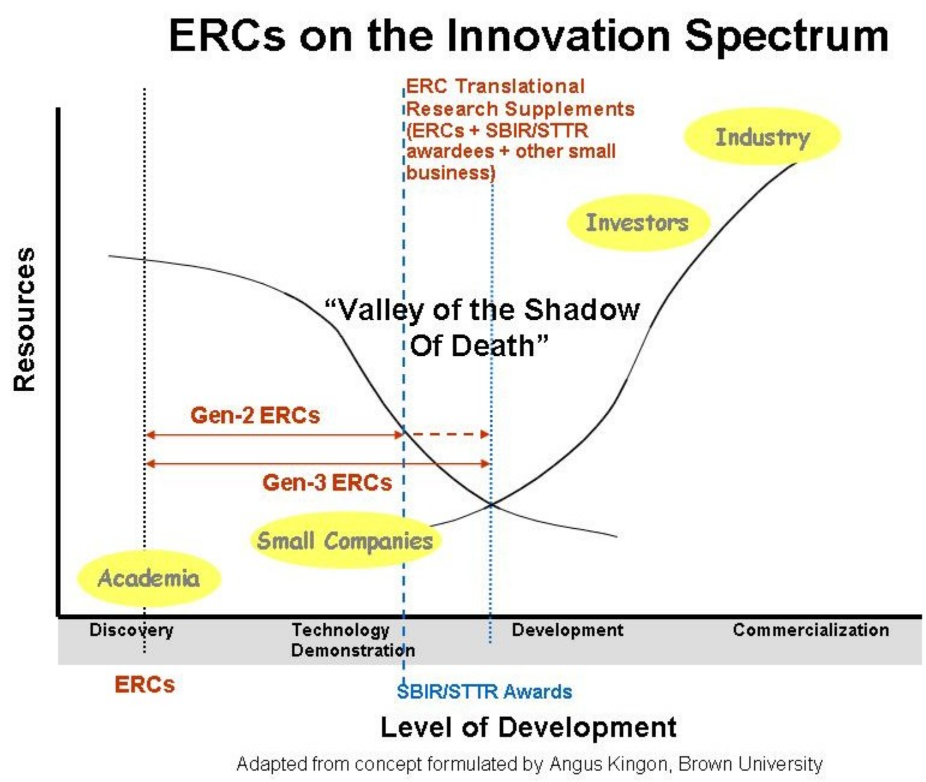

Figure 1. *The gap between discovery and concept demonstration at universities and early-stage development in industry is a "Valley of Death" that often stymies the commercialization of potentially useful new technologies—unless translational funding that bridges this gap removes the "shadow" of death. (Adapted from Angus Kingon, Brown University)*

Most academic engineering researchers intend to spend their entire career in universities. Thus, when their work leads to a result with commercial potential, they are faced with a dilemma: leave the university to pursue that potential in a spin-off company or keep their "day job." A happy medium is enabling faculty members to contribute to advancing the technology—the work that they enjoy most—while the company itself is launched by partners with business skills. While such partnerships are occasionally formed on their own, ERCs report that deliberate, careful matchmaking is usually required.

Most ERCs have developed specialized staff, organizations, and initiatives to spur those partnerships. Experience suggests that the matchmakers should be university employees embedded in the research environment to gain the respect and trust of researchers, but also be well-connected in the business community and ideally with firsthand experience in startup ventures. Every ERC has an Industrial Liaison Officer (or the equivalent) who functions in this way, often in collaboration with the university-wide tech transfer office. The initiatives include collaborating directly with industry associations, entrepreneurs, venture capitalists, angels, and others in their communities to establish gap funding and other workable ways to advance POCC-type endeavors. That puts the ERCs at the forefront of a highly visible change starting to take hold nationally—the paradigm shift of university tech transfer offices moving away from a licensing-driven focus and toward a long-term business development mission.

Important lessons for new POCCs can be drawn from an innovative trial program at the Quality of Life Technology (QoLT) ERC, based at Carnegie Mellon University. An ERC Innovation Grant from the NSF helped to fund what's called the QoLT Foundry, which started in 2008 to test and validate mechanisms to accelerate the commercialization of research. A veteran medical device entrepreneur leads the effort, bringing experience in technology management, business operations and investment, regional connectivity, and markets. His personal relationships with local economic development agencies, as well as industry, entrepreneurs, and investors, has helped to rapidly advance the ERC's innovative technologies via funded startup companies.

The Foundry seeks promising technology, not only within QoLT's primary charter to create advanced technologies for the benefit of people with reduced functional capabilities due to aging or disability, but also in the broader market potential of QoLT products. For example, the Foundry has helped launch a company that is developing a vibrating vest that helps any wearer *feel* music rather than just hear it. The vest, originally conceived for people with hearing problems, transforms sound from music players into vibro-tactile sensations. Another startup is pursuing broad market acceptance of computer technology that was originally developed for the vision-impaired. The combination of software with Web cams enables users to change magnification levels of images on a computer or cell-phone screen simply by moving closer to or farther from the screen.

Similarly, a Capture Center at the Center for Subsurface Sensing and Imaging Systems (CenSSIS) ERC at Northeastern University used initial seed money from a Massachusetts state funding source to develop an initiative, led by a technology programs manager, that has successfully acquired and managed additional, externally funded programs in various technology transfer activities. The Capture Center helps build relationships with the grant or contract program managers, creates a coalition of researchers and industrial partners, produces financial estimates and contract proposals, as well as negotiating successful contracts and managing the development tasks and deliverables. Thus, CenSSIS has created the seeds of an engine that can drive sustained economic development using the academic and industrial base inherent in an ERC. The Capture Center has been a notable success and is now self-sustaining.

The Capture Center's impact is illustrated in the Arrayed Spectrometric High Efficiency Radiation Detectors (ASHERD) program, which developed a monitor to screen for hazardous nuclear materials at ports of entry into the United States. A prototype was developed under the Capture Center and a subsequent production contract, worth $400 million, was won by Raytheon, a Massachusetts company and CenSSIS industrial partner. The Capture Center also built a collaboration model behind the BomDetec Program, an ongoing development contract to detect suicide bombers. This led to a major Department of Homeland Security Center of Excellence award, ALERT (Awareness and Localization of Explosives-Related Threats).

Even without formal initiatives, ERCs find themselves pushing beyond their initial mandate to promote the commercialization of their research, focusing extra efforts on particularly promising technologies. Such an endeavor, for example, has led to an industry initiative to build a fully integrated platform for continuous manufacturing of pharmaceutical products—a major research thrust at the ERC on Structured Organic Particulate Systems (C-SOPS), established in 2006 with its base at Rutgers University.

The C-SOPS invested a substantial amount of research resources to build an integrated technology testbed and assembled a multi-university, multi-disciplinary team that included participants from member companies. Functioning in practice as an ad hoc POCC, the team quickly demonstrated the feasibility of the concept and received a supplemental grant from the NSF ERC program to support commercialization of this transformative technology. Multiple companies have since expressed interest in licensing the technology or buying fully assembled platforms, including an ERC member company that has solicited bids for an integrated system that could cost $20 million.

The POCC-like programs at ERCs have succeeded at least in part because of an added boost in funding and resources from NSF or other sources, illustrating the potential and shortfalls inherent in university-based research programs. In short, the mission of ERCs to foster industry participation in discovery-oriented research has left the centers with constraints on the resources needed to push new discovery-based technologies into the commercial market, leaving them dependent on the availability of new programs or limited and competitive supplemental funding for this purpose.

What POCCs Can Provide

The campus setting, with its emphasis on discovery, is a crucial factor in the nation's research efforts—particularly with the demise of major corporate research laboratories. At the same time, the typical academic scenario often neglects areas, such as marketing and financial analysis, that are necessary to develop the holistic business plans required to consistently commercialize discoveries. It is those marketing, legal, and investment disciplines that POCCs can bring to the commercialization process.

The ERC program and its pillars of research, education, and industrial collaboration represent a proven system for innovation and technology transfer. The centers have successfully carried out their missions with an impressive record of scientific achievement, educational outcomes, and commercial spinoffs. But ERCs, as they are currently configured, do not necessarily apply rigorous marketplace analysis in their project management systems.

Studies of the product innovation process have consistently demonstrated that a major source of failure is insufficient attention to marketing and manufacturing issues during research. Current academic and federal policy have discouraged the emergence of true entrepreneurs in faculty ranks, and it is hard for campus researchers even to find regular access to mentors with real-world entrepreneurial experience. Thus, it appears that a natural relationship exists between POCCs, with their business-assessment function, and ERCs, with their significant resources for marshalling key industrial and academic players in a large but focused setting.

The current infrastructure of incubator programs, innovation centers, and extension services that many universities offer provides a support system that helps fledgling companies bridge the gap between discovery and the more challenging phase of technology commercialization and deployment. What is most often missing is the dedicated space, time, and facilities that campus enterprises need for focused technology validation and demonstration.

Thus, Proof of Concept Centers should go beyond the ERC construct. The POCCs would be organized and structured as an intensive place of technology development and demonstration, aimed at validating technical concepts and verifying their feasibility, functionality, and market readiness. Each POCC would be organized around a closely related set of technical competencies such as composite materials processing, ionic chemical synthesis, or power electronics development. Most respondents believe that activities in the POCCs should be centered on the later phases of technology development, from the prototyping in relevant environments through the actual application of technology in its final form and under mission conditions. This is well beyond the fundamental research phase that universities typically excel at, but stops short of the development process that businesses routinely carry out for new products.

The primary function of a POCC would be to provide university researchers with the tools and information they need to perform an assessment of the best market opportunities and business strategies for university-generated technologies. It is critical that this assessment go beyond simple census calculations of market sizes and apply a discipline that seeks to pose detailed questions that will provide the POCC researchers with a complete picture of the business opportunity afforded by their technology.

Organizing a POCC

It is important <u>not</u> to assume that a "one-size-fits-all" approach will work in designing POCCs for different technologies—which can vary widely in the time, resources, and money that must be invested to achieve commercial success. But generalizations can be made. Each POCC would be located at a major research institution, but would be open to researchers from other universities as well. Each center would be dedicated to a specific cluster of related technologies, although it would encourage a diversity of ideas and approaches. A potential model is to focus on a regionally concentrated industry and assemble a small-scale “innovation ecosystem,” where technology needs are identified by technology end users and where university researchers work together with technology integrators and market experts. Technology providers could maintain face-to-face dialogue with commercialization partners, together developing and validating technology solutions.

That approach has proven successful for ERCs, which already focus on areas of critical national interest including biotechnology and healthcare, energy sustainability and infrastructure, microelectronics sensing, information technology, and networking. In aligning closely with ERCs, POCCs could operate at various levels of autonomy: as separate but associated organizations, as distinct offices attached to the broader ERC operation, or as an added program within existing ERC organizations.

A POCC would have its own laboratory and office space and would be managed operationally by at least one full-time staff member whose responsibility would be to support the entrepreneurial work being undertaken. It is important that a POCC be led by a committed and experienced entrepreneur as its Director, whether this person is primarily employed as an academic or industry executive. Equally critical is an experienced program manager. Also crucial is participation by people from industry in direct involvement with faculty and students and on advisory boards. It makes sense to create a POCC in concert with a leadership team from an ERC who have experience in building a portfolio of commercial opportunities, protected intellectual property, and starting companies. A board could be drawn from the existing ranks of the scientific and industry advisory boards that already work closely with ERCs.

Operating a POCC

In the POCCs, small teams of innovators and entrepreneurs would receive the support they need to refine, perfect, and mature their technical innovations. In parallel, they would receive guidance in appropriately structuring and organizing themselves for attracting the outside funding needed to move beyond the project level and become a going concern. This will be a place of concentrated engineering development and concept validation.

The work will be carried out by the teams themselves, comprised of entrepreneurs, students, and faculty, supported by the POCC's full-time technical staff along with support from businesses. The POCC's board could be similar in function to a board of directors in a venture-backed startup that reviews plans, tracks progress to milestones, and drives for results. A formal "stage-gated" process would move each project through a well-designed set of development steps, and projects would need to demonstrate measurable progress at regular intervals. The stage-gated process is a well defined roadmap for moving new-product projects from idea to launch. A fixed amount of time would be allowed for each stage, after which projects would be expected to "graduate" from the POCC or otherwise exit the program.

The POCC's staff and board would review proposer-initiated projects falling under the center's topic areas. The review would identify projects for initial funding of technical feasibility and market studies, with the studies having a fixed cost limit (e.g., $150,000) and time period of perhaps a year. The studies would be the first gate in allowing the project through to the next phase.

The next phase—aimed at advanced research, technology development, testing, and prototyping—would involve more substantial funding of as much as $500,000 a year over four years, with each year's funding dependent on demonstrated progress. The POCC would require that the project include a university partner, and the company would need to raise matching funds from the private market.

In one scenario envisioned by a number of ERCs, the POCC would operate either within or closely aligned with an ERC to manage the latter stages of commercializing discoveries. The ERC would act as a feeder for the POCC, providing a steady stream of promising intellectual property and young spinoffs within the ERC's well-defined sphere of technology. The combination of a mature, well-managed ERC in a dynamic field of inquiry and a focused POCC in the same field of development will be a powerful accelerant for innovation, translation, and successful business creation.

This approach could be structured as a “Phase II” of the ERC itself, extending the ERC for perhaps another five years under a different structure. Instead of being led exclusively by academic faculty, the Phase II ERC would be co-directed by university and industry executives, with balanced funding from the government, university, and industry. Each project would give rise to a four-person team comprised of an academic faculty member, graduate student, industry mentor, and research faculty or staff. The Phase II ERC model would resemble in many respects the highly successful German Fraunhofer Institute.

Another scenario sees more value for the POCC as, conversely, a feeder to the ERC. The proposer would clear the initial market and technology feasibility studies at the POCC and, now formed as a small business, would submit a plan to bring the project into the ERC as an industry-led effort. ERC funding would be increased to cover the cost of development of the new technology to the alpha or beta stage. POCCs could thus help ensure that university research projects with market potential, often a driving force behind ERC undertakings, bring that potential into focus in their early stages.

In any scenario, involvement with the ERC can accelerate the development and commercialization of new technology that has reached the proof-of-concept stage by enabling access to equipment, including the extensive testbed infrastructure that is typical of ERCs. The ERC would also provide access to multidisciplinary faculty research and technical expertise, as well as an established system context for performing evaluations. The cutting-edge research conducted by ERC investigators could help shape a project's context and environment, and the research centers also offer access to large pools of top-flight student talent.

Figure 2 depicts the generic POCC construct, with the university-industry partnership that feeds it technologies ripe for further development and commercialization.

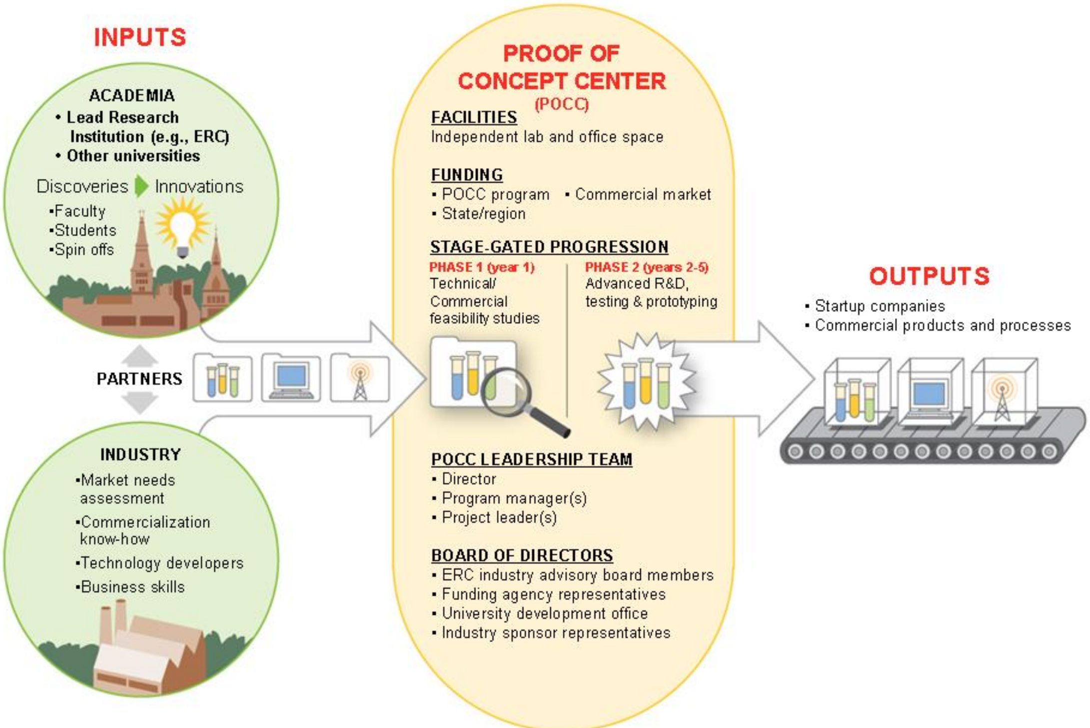

Figure 2. *Each POCC could form the nucleus of a regional "innovation ecosystem," where universities and industry collaborate in converting academic research to successful commercial ventures and products. ERCs are well positioned to serve as the lead university and a natural feeder of innovative technologies into a POCC. The success of ERCs in technology translation would be greatly enhanced by an associated POCC that provides added time and resources for technical, marketing, legal, and investment development.*

Measuring the Success of a POCC

President Obama's national innovation strategy, which provides context for our discussion of POCCs, seeks to stimulate sustainable growth, create quality jobs, and improve U.S. competitiveness in the global economy. To measure how well POCCs respond to those goals, traditional measures would include active licenses, patents filed, companies started, revenue earned, jobs created, net worth,, and products marketed.

Perhaps one of the most valuable measures for POCCs, with their emphasis on a stage-gated process leading to commercialization, is the number of startup firms. There should be specific measures of firms progressing toward commercial success and their number of employees, with listing of PhDs, MS, and BS degree holders. That responds to the question of quality jobs, where "skilled" is defined as high-tech content with the ability and knowledge to be successful in the new, information-rich economic environment. Along with actual startup entities funded by industry, an effective measure would also incorporate tangible commercial investment by existing companies in POCC-guided technologies.

In addition to the technology commercialized and the impact of that technology on the marketplace as well as jobs and profits, the creation of a new generation of skilled and knowledgeable innovators should be a prime goal.

Key questions are how the criteria of time-scale and societal value are applied in measuring the success of commercial technologies. Some require a long time to reach the market, such as medical devices and, even longer, pharmaceuticals. Similarly, measuring the impact of technology will require a sophisticated and flexible approach. For example, while both result in substantial economic benefit and improved quality of life, a partially effective treatment for Alzheimer’s disease is arguably more beneficial to society than the development of 3D movies. Wind and solar power may have economic benefit in the next 10 years, and could significantly improve the quality of life 100 years from now.

Education Initiatives to Encourage Technology Transfer

There needs to be more integration of students into actual tech-transfer activities. The best way to do this is to provide hands-on opportunities for students to work on the commercialization directly. Best practices today utilize Business Administration and Law students for business planning projects, but often missing are the technology-driven opportunities for science and engineering students. Junior business students often do not understand technology. It would be better to educate young engineers and scientists in how to develop realistic business plans. Encouraging students to actually start their own technology companies will spur much greater long-term impact.

At the University of Washington, for example, the Program in Technology Commercialization spans four academic quarters to generally introduce technology commercialization to a large student group, and then identify and nurture students who will pursue these ideas in detail and translate them to actual companies.

Also, formal educational components that draw in graduate and undergraduate students from across campus, and that reach into K-12 institutions, would increase the effectiveness of POCCs and would integrate them into the overall missions of a community's educational institutions. POCCs and the larger economy depend on a continuous supply of a well-educated, creative workforce at many levels. This can only be produced by an education system that is informed by the reality of research and development as practiced by POCCs, ERCs, and similar organizations. Contact with their research, development, and entrepreneurial activities are particularly powerful in enhancing students’ education in science, technology, engineering, and math.

Policy Changes to Encourage POCC Success

Expand and extend the ERC program. As already noted, there are advantages in funding university research at the scale and duration of an ERC. Most importantly, the research team can afford to take risks, experiment with proof-of-concept testbeds, include technical staff to build technology and non-engineering faculty, and address research problems over a longer time. That's especially important in domains such as healthcare because non-technological factors, such as understanding a complex market and government regulatory approvals, often do more to determine commercial success than do technical factors.

Once an ERC becomes relatively mature and is able to function effectively and support technology development and commercialization, an injection of funds to increase the scope and extend the ERC life cycle beyond the currently mandated 10 years would enable these centers to extend their success.

Foster more movement between industry and academia. A key challenge with industry-university collaboration is their different reward systems. University faculty tend to be recognized for outstanding individual contributions to research and the creation of a publication base. Industry leaders tend to be recognized for galvanizing teams that create high-impact products that dominate markets. Initiatives are needed that can improve mutual understanding of the different cultures and mindsets.

One approach is "industrial leave," in which university faculty may spend time working in industry as a way to increase their understanding of industrial needs and practices. Some ERCs already provide for this type of sabbatical, and it is seen as effective. The federal government could also encourage engineering colleges to hire faculty with 5-to-10 years of industry experience, perhaps through NSF awards that consider the industry experience of the principal investigator or by sponsoring special professorships that carry funding and prestige and are offered to candidates with industry experience.

In most universities, encouraging faculty entrepreneurship requires a change to the basic culture. Technology maturation is generally not rewarded or even acknowledged in the tenure-granting process. The internal tenure and promotions system instead promotes basic inquiry and the accumulation of publications and fundamental research grants. Indeed, there are strong voices in some cases *against* adding commercialization as a valued accomplishment for academic recognition. The ERCs and some other NSF centers programs have made considerable inroads toward changing this cultural mindset, but more is needed.

Adjust federal small-business spending. Most of the available funding for technology development and commercialization, such as that available through the federal government's Small Business Innovation Research (SBIR) program, is too short-term and small-scale. It is often inappropriate for the development of complex solutions required by challenging problems, as in developing integrated manufacturing platforms for personalized medicine.

SBIR and the related Small Business Technology Transfer (STTR) program should be expanded to include grants that are not necessarily directed to the mission of a specific government agency. The Department of Defense, for example, in many cases specifies the topics of an SBIR to satisfy its own needs. Also needed are projects that respond more directly to industry needs. Funding for translational research that links academic and industrial efforts in specific innovation efforts, such as the ERC/SBIR supplemental awards, are good examples of this type of work and should be expanded.

Also, to encourage spin-offs from universities the SBIR solicitation rules should be examined to encourage both students and professors to start new ventures. The current rule that a Principal Investigator (PI) needs to be employed by the company at a 51%

level imposes a barrier on those affiliated with universities. The PI rules make it difficult for faculty and postdoctoral researchers to seek SBIR proposals. The current rules also are a barrier for domestic graduates with foreign passports, as the visa issues become quite complex.

Spreading the Success of a POCC

The ERC model of requiring multi-university participation can help with assuring wider access to POCCs and related industry investment. Perhaps the POCC's lead university can be required to partner with a minority-serving university or predominantly degree-granting institution with fewer resources in an underserved region. That region might then produce opportunities that can be collated into the output of the lead university. This could very well seed a greater interest in forming a regional network for angel and VC investment.

Some local and state governments have had success in establishing investment in areas where there is less concentration of angel and venture capital investors. But a problem is that state and local governments are not generally tapped into the relationship of the federal government and the universities, and universities need to reach out more to the municipal economic efforts. A good effort in the 1980s with various incubator programs stalled because it became too focused on tax incentives rather than on coordination between the universities and the municipalities.

Having universities manage incubator programs has had some success, but they are limited by a lack of business experience. Conversely, the business-driven efforts have suffered from a lack of technology insight, particularly with highly innovative, early-stage opportunities. Perhaps the time has come when the federal government can again step in and underwrite a second wave of activity, targeting the "Valley of Death" for innovation. where the lessons from the past can help lead us into a more sustainable future.