Escher: A New Technology Transitioning Model

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The Escher model relies on a mix of government and industry funding to identify cross-industry needs and select technologies for maturation and transitioning.

Embedded systems and software provide the basic engine of innovation for a broad range of industrial sectors. This technology transforms products, creates new markets, and disrupts the status quo. Rapidly progressing embedded-design technologies have a tremendous potential impact on industrial competitiveness, creating significant pressure to make technology transitioning more effective.

The US research community has a reputation for aggressive commercialization of innovative developments. Despite this reputation, an innovation's *technology-transition path* from lab bench to marketplace remains the most risky and unpredictable part of the process. The technology's backers must determine and monetize commercial potential in a complex calculus that includes opportunity cost for pursuing one investment and not another.

The demanding timelines required to produce adequate return on investment replace the permissive milestones set in the research environment. At the end of the day, this process excludes many worthy developments that don't fit the investment, development, and commercialization model.

The situation isn't any better in transitioning new technology back to the research enterprise. Certainly, researchers are intimately familiar with the "not invented here" syndrome, and it's not hard to find reinvented "results" with superficial or overblown differences with prior art. However, there's a huge difference between producing software for demonstrating a concept's feasibility and making it available for others as infrastructure for new research.

Researchers are rarely motivated to make software or tool prototypes exceed their own programs' minimal requirements. This attitude has led to the current situation, where the term "research quality" often means poorly engineered and incomplete.

Using unstable, unsupported software introduces risks in research programs that few groups can accept and manage. This risk results in decreased productivity, since researchers waste significant resources reproducing or fixing existing but low-quality components. Another undesirable side effect is the lack of a research culture that appreciates and rewards the creation of usable results and demands accountability in the promised dissemination of research products.

TECHNOLOGY TRANSITIONING MODELS

Figure 1 shows three models for technology transitioning.

Traditional model

The *traditional model* is based on a societal agreement that universities and nonprofits receive public funding as knowledge seekers, and in return place their findings in the public domain via publications and education. In this model, technology transitioning is the responsibility of the internal research arms of corporations, whose primary mission is to "internalize" published results. Corporations can hire students with knowledge acquired in funded research programs to help in these efforts.

The traditional model worked effectively until competitive pressures, globalization, and technology's increasing complexity made it unaffordable for all but the largest corporations.

Consortium model

The *consortium model*'s appearance in the late 1980s and early 1990s prompted fundamental changes. First, industry partners formed consortiums to share the cost of precompetitive research. Second, the consortiums partnered with university teams, offering them new funding opportunities. Consortiums forced companies to give up some competitive advantage and made universities run better-coordinated research programs with a mission-oriented interface toward industry.

The consortium model has worked well and produced notable success in areas such as semiconductor technology. The model provides opportunities for establishing long-term technology investment strategies and facilitates better interface between technology users and producers via increased interaction.

The consortium model's primary problem is its complexity: Setting up joint consortiums is hard, requires historic drivers that motivate the players, tends to remain closed, and is hard to sustain.

It's also clear that neither of these two models creates the infrastructure that the research community needs. Adoption of a more diverse set of paths that let innovations transition back to a research infrastructure or to the marketplace would lead to better payoff from research investment and result in subsequent benefit to society. Innovations such as open source licensing and community software-development projects are examples of alternative models that have already yielded many benefits.

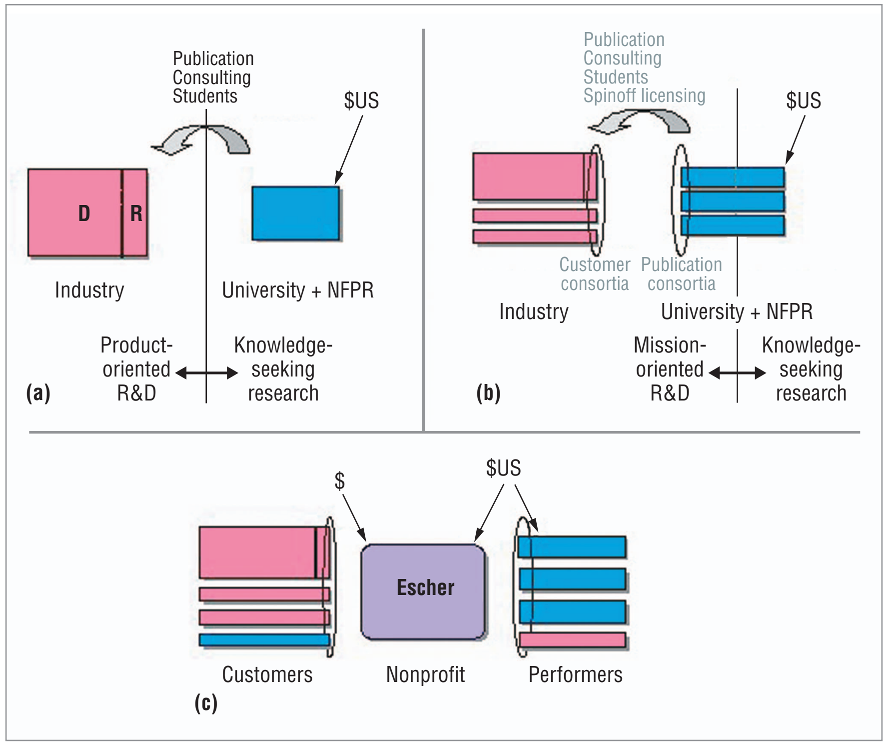

Figure 1. Technology transitioning models. (a) Traditional model; (b) consortium model; (c) Escher model. The Escher model provides an alternative to traditional and consortium models for technology maturation and commercialization.

Escher model

The Embedded System Consortium for Hybrid and Embedded Research (Escher) model offers an alternative technology maturation and commercialization path for innovations in the area of *networked embedded systems and software* (NESS). Government investment, primarily from DARPA and the US National Science Foundation (NSF), stimulated the establishment of the Escher Research Institute in 2003. The objective was to preserve, maintain, and mature the fruits of government research investment via a business model that serves the interest of government, industry, and research organizations.

The Escher model relies on a mix of government and industry funding to gain leverage that sponsors acting alone couldn't otherwise achieve. As opposed to the closed consortium model, the Escher model is open, providing benefits not only for industry sponsors but also for unaffiliated research groups and corporations.

The model uses a selection process to identify key cross-industry developments that will significantly advance critical NESS technologies for which the market isn't yet large enough to support an independent venture.

Escher uses funds from government and industrial sponsors to mature leading research groups' key contributions. Guidance from an Industrial Advisory Board is essential in keeping the academic groups focused on the highest-value advances. To promote advancement in the field, the institute releases results of completed maturation programs to the public.

Escher has funded projects with the University of Michigan; the University of California, Berkeley; and Vanderbilt University to adapt research results for the realization of embedded systems *tool chains* that address embedded-system design challenges that are common across many industries.

A key element of Escher's approach to enable the transition of government-sponsored research results is the operation of a quality-controlled software repository. Escher has developed a set of objective quality criteria to ensure that the repository contents provide dynamic and useful tools for developers and function as more than monuments to past projects.

The repository provides a single focal point for software development, allowing easy access for users. It monitors the integratability of components via adopted standards and requires the adoption of bug reports and bug-tracking mechanisms to improve the software. The repository aids in the transition of government-research results by making them widely available through a central portal, thereby creating a wider audience for the technology and increasing the chance that an industrial concern will adopt it.

In an *honest-broker* role, which doesn't compete against universities or other research labs, Escher helps integrate ongoing government-research projects that are looking toward eventual transition of their research products. This activity includes the development of industry roadmaps, the maintenance of architecture and configuration management that are critical in bridging funding in specific research areas. Neither industry nor the government has the resources or infrastructure to maintain active repositories for the products of individual research projects. Escher, however, can consolidate and maintain collections of such artifacts so that technological "retooling" transients are smoothed, and the infrastructure and legacy government-off-the-shelf components need not be rediscovered and rebuilt for each new development program.

RESEARCH STAKEHOLDERS

Systems industries—defense, automotive, automation, telecommunication, and others—that increasingly use software as a "universal" integrator are the primary NESS research stakeholders. DARPA and the NSF have paid for fundamental research that could significantly impact industrial programs. The systems industries are interested in results that government programs produce because the market for software technology in these areas is still too small and the work too premature to support a stand-alone industry.

Escher—whose founding sponsors are Boeing, General Motors, and Raytheon—is identifying a crucial but unfilled niche in embedded-system development specifically and in technology transition in general. We don't envision the Escher organization growing to become a massive funded center with major manpower needs. Rather, we expect that software creators will store and evaluate products at their own sites.

The Escher organization serves as a thin layer of management to join end users and the research community in setting standards, directing users to available sites, using uniform community-established criteria to monitor software's effectiveness, and taking advantage of user feedback to identify bugs and other software problems. Additionally, we foresee that Escher will increasingly provide a common meeting place where stakeholders can develop a roadmap for the future and discuss common concerns and needs in NESS evolution.

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