

New Model for University Research and Technology Transfer

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ABSTRACT

As non-profit organizations, universities serve the public good through their primary missions of teaching and conducting fundamental research. In the past, American universities obtained the bulk of their funding in the form of basic research grants from U.S. government agencies such as NSF, NIH, USDA, DOE and the DoD. These grants funded graduate students and their faculty advisors who published their research results to benefit society through the free dissemination of knowledge.

Though the academic research model still adequately describes most university research programs, a new model has emerged that can accommodate new requirements imposed by government agencies and can provide R&D services for commercial companies. The model serves sponsors who want to see university technology applied in settings directly relevant to their mission or business operations. This allows the sponsors to see “what’s possible” with the technology without making a large investment to build or acquire an internal development capability. Those applications that show operational viability get transferred to the sponsor by imparting know how to sponsor employees, licensing, and providing well-documented technical data packages.

One example of this model is the National Robotics Engineering Center (NREC), part of Carnegie Mellon University's Robotics Institute. NREC has enjoyed tenfold growth since its founding in 1996 providing applied robotics research and technology transfer to government and commercial clients. This paper describes the unique operating and business practices, personnel make-up and client mix that underpin its success and illustrates a new and valuable approach to university research. The paper concludes by comparing the nascent service robotics market with the early

automotive industry and projects how an NREC-like organization could have contributed to automotive innovation at that time.

INTRODUCTION

This paper introduces a new model for conducting academic research that places greater emphasis on developing technology in the form of integrated, robust systems then on the publishing-driven, basic research model that dominates academia. The paper contrasts the traditional academic research model with the approach taken by the National Robotics Engineering Center (NREC), part of Carnegie Mellon University's Robotics Institute. It provides the rationale for this approach based upon the needs of research sponsors that naturally derive from the state of the robotics market and the unique characteristics related to developing robot applications. The paper concludes by presenting NREC's technology transfer process and provides examples of NREC-developed systems successfully commercialized by industry.

TRADITIONAL ACADEMIC RESEARCH MODEL

Universities exist to discover and disseminate knowledge, create and evaluate new ideas and technologies, and foster an environment that encourages exploration, sharing and questioning. They execute this mission through teaching and research. In the former, they equip students with the knowledge and the methods to apply knowledge to solve problems or execute tasks important to future employers. In the latter, university faculty direct research teams composed of graduate students and sometimes technical staff. To perform their mission, universities receive student tuition to meet teaching expenses and capture funding to cover research expenses. The ability of a faculty person to win research grants and publish the results in peer reviewed journals

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Table 1. Estimated Distribution of R&D Funds in the U.S. in 2010 (Millions of U.S. Dollars)

<i>SOURCE</i>	<i>PERFORMER</i>					
	Federal Gov't	Industry	Academia	FFRDC*	Non-Profit	TOTAL
Federal	\$28,308	\$27,114	\$26,284	\$16,032	\$6,393	\$114,131
Government	100%	95.6%	62.2%	100%	39.3%	
Industry		\$255,892	\$2,888		\$1,521	\$260,302
		4.4%	4.9%		9.3%	
Academia			\$11,635			\$11,635
			31.2%			
Other			\$3,277			\$3,277
Government			5.7%			
Non-Profit			\$4,212		\$8,362	\$12,574
			7.2%		51.4%	
TOTAL	\$28,308	\$283,007	\$58,296	\$16,032	\$16,276	\$401,919

*Federally Funded R&D Center SOURCE: Battelle, R&D Magazine

Table 2. Federally Funded R&D Expenditures at Universities and Colleges: FY2008 (Millions of U.S. Dollars)

<i>Field</i>	<i>Total</i>	<i>DoD</i>	<i>DoE</i>	<i>HHS</i>	<i>NASA</i>	<i>NSF</i>	<i>USDA</i>	<i>Other</i>
All fields	31,231	3,077	1,134	17,508	1,061	3,768	893	2,868
Computer sciences	1,031	302	34	55	21	437	3	115
Environ. sciences	1,826	166	90	60	243	628	77	532
Life sciences	18,664	523	140	15,530	93	579	722	968
Math sciences	445	48	13	114	5	210	4	25
Physical sciences	2,739	344	415	483	389	806	7	183
Psychology	637	31	3	475	9	52	1	59
Social sciences	810	64	20	294	9	130	37	250
Sciences misc	373	97	16	59	13	86	3	79
Engineering	4,705	1,502	402	437	278	835	39	652

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of R&D Expenditures at Universities and Colleges: FY: 2008

heavily influences the university's decision to promote or grant tenure to that person.

For the university research model to work funding organizations must exist that value the long term societal benefits that result from university research and publishing. Not surprisingly, government agencies are the primary funding source for university research. Table 1 presents the estimated distribution of R&D funds in the U.S. in 2010 classified by funding source and research performer. Federal and other government agencies devote their largest share of research funds to academia (\$36B out of \$114B total) which funds more than two-thirds of academia's research output. With the exception of industry's small share (4.9%), all of academia's funding sources are government agencies, non-profits or the university itself (presumably from endowment proceeds).

As Table 2 shows, the Department of Health and Human Services (HHS) and to a lesser extent, the Department of Defense (DoD) and the National Science Foundation (NSF) dominate university funding. The table's field descriptions hint that the U.S. Federal Government largely funds basic research. The DoD funds the largest amount of engineering research but still directs most of its academic funds to basic research. The DoD [1] devotes to universities 50% of basic research (6.1), 15% of applied research (6.2), and 10% of advanced technology development (6.3) funds.

Universities, like all successful organizations, structure themselves and their processes to serve their large customers. So they hire bright faculty with ideas, skills and credentials that enhance the school's research reputation and leaves them largely free to pursue research as they see fit. Universities maintain some degree of control by weighing heavily the faculty person's number of grant wins and published papers in promotion and tenure decisions.

ROBOTICS RESEARCH AT CARNEGIE MELLON UNIVERSITY

Carnegie Mellon University (CMU) in Pittsburgh PA is often referred to as a “research” university because its greater than \$300M yearly research budget approaches that of schools with two to three times Carnegie Mellon's student enrollment. As Table 3 shows, Carnegie Mellon's research funding profile resembles the classic university profile described previously with the exceptions of a higher percentage in defense and slightly higher in industrial funding (7.3%). It should be pointed out that Carnegie Mellon's faculty/principal investigators must capture nearly all research funds externally as the school's relatively small endowment does not support internally funded research. Within Carnegie Mellon's research community exists an organization, the National Robotics Engineering Center (NREC) that performs the university mission of creating and disseminating knowledge quite differently than the traditional approach.

Table 3. Sponsored Research Breakdown: 2009
(Thousands)

	2009	Percentage
Federal		
Defense	\$65,890	20.6%
NSF	\$62,972	19.6%
HHS	\$26,080	8.1%
Energy	\$12,203	3.8%
Other federal	\$17,362	5.4%
TOTAL	\$184,507	57.5%
Non-Federal		
Industrial	\$23,536	7.3%
Other non-federal	\$24,949	7.8%
TOTAL	\$48,485	15.1%
Software Engineering Institute (SEI)*	\$87,525	27.3%
GRAND TOTAL	\$320,517	

*An FFRDC that also receives some industrial funding.

SOURCE: CMU 2009-2010 Factbook. CMU web page.

NREC is a center within the Robotics Institute (RI) which is an academic department within Carnegie Mellon's School of Computer Science (SCS). Carnegie Mellon created the Robotics Institute in 1979 to conduct basic and applied research in robotics technologies relevant to industrial and societal tasks. The Robotics Institute began a Ph.D program in 1988 and a Masters program in 1998. The Robotics Institute created NREC in 1994 with a five year contract from NASA, who wanted to apply space-related robotics technologies for the benefit of American businesses. Figure 1 shows NREC's facility, located about 10 minutes drive from

Carnegie Mellon's campus and some NREC systems developed for government and commercial customers. Applying the DoD's vocabulary, NREC performs applied research (6.2) and advanced technology development (6.3). In a typical NREC project, the team develops and matures robotics technologies that typically have not been applied outside of a laboratory environment and then integrates these technologies into a “robust” prototype. Robustness is important because the paying sponsor wants to see the prototype perform in an environment that resembles as closely as possible the everyday environment of a production system. For example, NREC tests DoD systems at army and marine posts across the U.S. to expose them to the same range of terrain and environmental conditions faced by soldiers and marines deployed across the world. For commercial customers, NREC test systems in orange groves, coal mines, surface mines, shipyards and underground pipelines. Through extensive field testing and evaluation in realistic settings, sponsors can better assess whether the technology has the right combination of performance, price, and operational benefits to justify additional investment for full commercialization by either the sponsor or a third party.



Figure 1. Clockwise: NREC facility, LAGR robot, Pipe Explorer, Crusher

Figure 2 presents NREC's revenue growth, the breakdown between Federal and Industry funding and the three stages that describe the organization's maturity over time. The 5-year NASA contract required an industry cost match equal to the NASA funds, so NREC recruited industrial sponsors in many domains to build proof-of-concept demonstrations. At the time the NASA contract ended, the Defense Advanced Projects Research Agency (DARPA) and the Office of Naval Research (ONR) created new programs to develop new large size, unmanned ground vehicles (UGV's) and equip these