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CORPORATE-UNIVERSITY ALLIANCES AND ENGINEERING SYSTEMS RESEARCH

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Learning from the Ford-MIT Alliance

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1. INTRODUCTION – Why this paper?

This symposium is focused on the possibilities for deeper, more fundamental understanding of engineering systems. Many of the papers address characteristics of engineering systems. As noted by others, engineering systems can not be studied in the laboratory. Researchers must venture into these systems for extended periods of time and develop the academic field of study. It is essential for the MIT Engineering Systems Division to find ways for active observational and experimental work to take place in these systems. To sustain their engagement in those systems, and gain validity for their claims, researchers will need to go beyond study to affect practice.

Although obvious, it has not generally been established that engineering systems are most often designed, developed and run by large corporations. The need for practitioners within corporations to better understand engineering systems is equal to that of academics. As consumers, investors and citizens we expect corporations to reliably and effectively operate these systems. Government plays only a role in enforcing regulations and restrictions to safeguard citizens. Market mechanisms determine which corporations are successful in gaining the resources to become more influential over time. Better theory and education can help to improve corporations' design and operation of engineering systems.

What makes the study of engineering systems challenging is that something essential to their nature is lost when they are decomposed, studied or improved in terms of their individual elements. How we engage a system determines what we see. What we see is largely determined by our language, tools and approaches (Maturana and Varela, 1992). A scientist's field of study, or a manager's responsibility, creates a lens that determines the system elements he experiences. Each sees what he pays attention to and from that comes to particular assessments. These assessments are accurate given the relevant details, but even when taken together they are incomplete and deficient in providing an understanding of the system as a whole.

As people design and operate engineering systems, challenges will continually arise from their limited view of the system. When faced with challenges, people's natural reaction is to take in less information, simplify their analysis, and decompose problems into smaller, more "manageable" chunks. This reaction takes place at a time when the real need is the opposite – to take in more information, particularly information that disconfirms what would otherwise be misleading actions. Human nature is to cling to the certainty that familiar tools provide rather than reconsider the basis of our understanding for what is happening. Using Weick's allegory, when faced with new challenges, there is a need for researchers to "drop your tools or you will die" (Weick, 1996).

Managers, engineers and researcher need to work together in order to develop new approaches that look across organizational and discipline boundaries. To engage and sustain an interaction among university researchers and corporate practitioners study needs to be combined with practice. We propose, along the lines of the phrase by Kurt Lewin, that "the only way to understand a system is to change it." We are to validate our claims for understanding a system with evidence of our abilities to produce desired results within it.

MIT's alliances with corporations, many of whom design and operate engineering systems, are uniquely situated to support this type of engagement. This paper examines what would make for idealized alliance conditions, what has been learned from working closely with one corporate partner, and how that learning might be applied to engineering systems.

2. AN IDEALIZED ALLIANCE

The foundations that sustain a corporate-university alliance are similar to those in business alliances. In either form, partners enter into the alliance to create value, address new opportunities, save expenses and work with one another because they can not develop or maintain the needed complex, specialized and costly resources themselves (Hagedoorn, Link, & Vonortas, 2000; Link & Bauer, 1989; Doz & Hamel, 1998). For universities and corporations, the unique capabilities of each provide opportunities for the other. Alliances are attractive when there are net benefits or risk reductions compared to go-it-alone alternatives (Contractor & Lorange, 1998). The complexities of managing a relationship with a dissimilar partner makes it harder to work through an alliance than on your own, requiring particular capabilities to make this effort effective. Two key features of an idealized alliance are abilities to resolve conflicts and the abilities to continually learn and restructure in addressing new opportunities.

In forming corporate alliances MIT has diversified its funding sources, decreased its reliance on the federal government, gained greater access to real world research, enhanced its educational opportunities, and learned what is needed to sustain these efforts. Corporate alliances provide another mechanism for accomplishing MIT's primary purpose – supporting ground-breaking research and innovations in education. These alliances are important to MIT's future opportunities and essential to establishing ways for the faculty to study engineering systems.

Corporations benefit from these alliances through their access to the specialized knowledge of the faculty. It is too costly for a corporation to hire or develop the depth of expertise that top research university people have. Through an alliance they can "share" in cost of those faculty members and support research in areas of specific interest to them. Research conducted in corporate settings provides fresh perspectives, demonstrates the application of new ideas and gives valuable feedback.

While there are natural synergies in corporate-university alliances, there are also areas of likely conflict. Society has developed different roles and expectations for corporations and universities. Universities have non-profit, tax-free status and receive public funding with the expectation that they will create and disseminate knowledge for the broad benefit of society. Making knowledge freely and widely available through education and publication are basic expectations of universities. These ways of operating are often thought of as immutable, rather than choices that were made based on public funding. Society's expectations for corporations are very different. Corporations survive in contested marketplaces where they compete for customers and investors. They need advantages over their competitors in order to provide the growth and profits for their owners and employees. The need for competitive advantage extends to the corporation's requirements for returns from university research investments. If the research is not related to the core of a corporation's current or future capabilities, managers and engineers will not spend much time on it. The university's desire to freely disseminate the research through publication and education can be in opposition to the corporation's need to protect and maintain competitive advantages.

An idealized corporate-university alliance will have mechanisms that recognize these problems and minimize potential conflicts. It will find opportunities that are created from synergies that are derived from the unique capabilities of universities and corporations. The general research on alliances finds commonalities – matches between partners' requirements, objectives, capabilities and assets – as important factors in their success and longevity (Chiesa & Manzini, 1998; Buckley & Casson, 1988). The differences between corporations and universities require careful attention to finding and developing areas where there are good matches. At the center of this match is the need to develop and maintain a close working relationship that creates value for both partners. It is necessary to dedicate people, time and attention to actively address differences and balance the value for each partner. These people can together test new ways of thinking and working together through experimental projects that would capture synergies and avoid conflicts.

The Ford-MIT Alliance provides an example of one of these experiments to address the contradictory desires of freely disseminating and carefully protecting knowledge. Ford sponsored students in the SDM program do their MIT thesis work linked to the Ford-MIT Alliance or other sponsored research (examples have been the Design Structure Matrix, Voice of the Customer, and Assembly Methods research). The student's thesis involves implementing research ideas at Ford and reporting the results. This approach provides Ford immediate value through the application of the research while students learn important skills, bring new capabilities into Ford and progress their careers. MIT gains research feedback through its implementation and Ford learns as the research is being done, and well in advance of its publication. Ford has gained immediate access to knowledge, ahead of others, but much more significant than any temporal benefit is that Ford people gain greater depth of knowledge and a better contextual understanding from which to build a lasting competitive advantage.

As this example illustrates, efforts to work together to create and apply knowledge requires more than financial support from a corporation. While top managers in a corporation provide the needed financial commitment to establish the alliance, considerations such as specific projects and personnel are at too detailed a level for their involvement. In an ideal alliance, senior managers would stay involved, rather than leaving these decisions to other managers, in making personnel and strategic decisions. Together they would get engineers and managers get involved in projects, who then provide access, support for implementation and spend time working with researchers. It is, however, not always easy given the day-to-day pressures and differences in corporate priorities for engineers and managers to stay active as research participants.

Corporate people need to be engaged completely as partners, recognizing that their ability to maintain their involvement is often difficult. First, the research needs to be truly leading edge, the path to its application clear, and its benefit relevant to the company's competitive advantage. Secondly, there needs to be good individual matches between university researchers and corporate counterparts. These interpersonal linkages are the mechanisms to influence research at the university and transfer and apply the resulting knowledge in the corporation. Learning takes place and knowledge is transferred through people and their interactions. People do not say all that they know, so the working together is important in this process. University researchers need to spend time in these corporate setting to understand and learn from what goes on there. Nonaka and Konno (1998) showed that the *ba* (Japanese word for "place") is a foundation for the creation of knowledge in organizations. Informal interactions allow people to share experiences, practices and learn new ways of thinking and working. An idealized alliance would create formal organizational structures and activities that support the development of informal settings and interactions for creating and transferring knowledge. Ongoing attention is needed in creating and renewing these personnel matches as people are promoted, transferred, retire or for some other reason change their positions.

The abilities to regularly discuss and adjust the direction of alliances are critical over time. The pace of change in industry is such that top corporate executives have not remained in place for the terms of the alliances. Gaining the support of new management requires adjustments in the alliance to changing corporate priorities. The ability to make these transitions depends upon mutual influence and thus the depth and breadth of the relationships created between the university and corporation.

Our ideal conditions for a corporate-university alliance have their limitations. They should only be taken as guidance in considering changes in existing alliances or as suggestions for initiating new ones. The ability to sustain a corporate-university alliance depends not only upon where you start, but also on your abilities to learn together. Longer-term success comes when partners re-evaluate and restructure (Doz, 1996). The initial conditions created by senior management in establishing an alliance provide the basis for people at many levels to work with one another. It is the experience from working together that provides insight into each other's capabilities and it is restructuring that will allow for the newly identified opportunities to create even greater value than what was originally envisioned. For this value to be realized, an alliance must be created and operated with the capabilities for ongoing change.

3. MIT'S CORPORATE ALLIANCES

MIT has large scale, multi-year, multi-program alliances with eight corporations (Amgen, Merck, Ford, NTT, Merrill Lynch, DuPont, Microsoft and HP; see http://web.mit.edu/newsoffice/nr/2000/alliance.html). While MIT has made greater strides than other universities in developing these both broad and deep relationships with companies, it is not alone in these types of efforts. Other alliances include Novartis with UC Berkeley, Caterpillar with Purdue, University of Illinois at Urbana-Champaign, Milwaukee School of Engineering and Carnegie Mellon, General Electric with the University of Connecticut, and Mitsubishi Chemical with UC Santa Barbara.

What all of MIT's alliances have in common is the commitment of the corporation to work on important research areas for both institutions. Each of these corporations' products and services involves engineering system problems. The dollar figures that are shown are the financial commitment that companies have made to MIT and do not include the company's internal time, effort and expense. A timeframe and commitment of at least five years ensures sufficient stability to support work in longer-term research. Details are worked out in ongoing discussions among company managers and scientists and MIT faculty and administration once the alliance has started.

TABLE 1. MIT'S CORPORATE-UNIVERSITY ALLIANCES

Year started	Company	Size	Departments/fields
1994	Amgen	30M in 10 years	Biology
1997	Merck	15M in 5 years	Biology
1997	Ford	20M in 5 years	All MIT – Engineering Product Development and Environmental Policy & Science
1998	NTT	18M in 5 years	Artificial Intelligence & Computer Science Laboratory
1999	Merrill Lynch	20M in 5 years	Sloan & Engineering – Financial Engineering
1999	DuPont	35M in 5 years	Chemistry, Biology, Biomedical & Materials engineering
1999	Microsoft	25M in 5 years	All MIT – Educational innovations
2000	Hewlett Packard	25M in 5 years	All MIT – digital libraries, software

As discussed in the previous section, an idealized alliance has people actively managing corporate-university differences. Alliance success depends upon the partners' experience in cooperation (Tyler & Steensma, 1998), the ability to create an ongoing learning process (Doz & Hamel, 1998), the development of trust between partners (Hutt et al, 2000), and good communication across partners (Doz, 1996). With its multiple corporate alliances, MIT has opportunities for learning about these issues. It is in a position where it could develop and test practices with one corporate partner and diffuse what is successful to its other partners. The learning across partnerships is a major opportunity that MIT has only done informally to date.

4. THE FORD-MIT ALLIANCE

A review of the history of the Ford-MIT alliance, with lessons learned from the efforts to date, provides a context for the guidelines we propose for engineering systems alliances. The Ford-MIT Alliance involves a number of formal initiatives (see Table 2). It is a multi-faceted program based on a sponsored research projects as well as involvement in consortia, educational programs and recruiting. Involvement in these programs also creates opportunities for many other informal interactions that are not easily captured by statistics or well represented in tables. The sum of these activities, points of contact, projects and interactions are what make the alliance robust, attractive and valuable to both Ford and MIT.

In reflecting on the evolution of the Ford-MIT Alliance, we have to consider the importance of our own and other's personalities (see endnote with author's biographies). At project and individual levels, considerable effort has gone into establishing and developing working relationships. As Executive Directors, we developed a relationship that allows us to debate and consider what is needed and then together present these ideas to our own organizations to gain the needed support to achieve desired results. At times

Ford's voice may be more clearly heard than internal suggestions in catalyzing change at MIT. Similarly, MIT's feedback can help create needed changes at Ford. We work with each other's senior people in articulating messages that provide the impetus for needed changes.

TABLE 2. FORD SPONSORED PROGRAMS AT MIT

(as of January 2002)

Program	Scale of Participation*
Research Program Areas	**$ 3,000,000 annually**
Environmental Consortium (MIT/AGS)	$ 750,000 annually
Environmental Research	200,000 annually
Product Development Process Technology (PDPT)	750,000 annually
Virtual Education	200,000 annually
Active Safety	600,000 annually
Program Development & Alliance Management	500,000 annually
Consortia Membership	**$ 1,000,000 annually**
Innovation and Product Development	$ 300,000 annually
Media Lab CC++ Digital Cars of the Future	300,000 annually
Joint Program on Global Climate Change	175,000 annually
42 Volt Vehicles	100,000 annually
Engine Research	75,000 annually
International Motor Vehicles	75,000 annually
Others (MIT/Japan, etc.)	
Educational Programs	**$ 750,000 annually**
Leaders for Manufacturing	2 to 3 students per year
Systems Design and Management	8 to 12 students per year
Sloan Fellows	1 student every 2 to 3 years
Recruiting	**$ 750,000 annually**
Diversity fellowships & exchange	$ 300,000 annually
Faculty fellowships	100,000 annually
Course Development	100,000 annually
Student clubs and research support	100,000 annually
Design competitions	75,000 annually
Graduate fellowships	40,000 annually
Lecture Series	20,000 annually

** The approximate scale of Ford's participation is provided in terms of approximate annual funding amounts provided to MIT. They do not include the funding of associated time and expenses on Ford's part. Not all programs are currently funded at these levels; however, the numbers provide an approximate scale of the funding which is somewhat commensurate with the annual effort and involvement.*

The importance of alliance managers is readily apparent in considering the dynamic nature of the relationship between Ford and MIT. Research projects require a long-term view and stability in the underlying relationships. The reality of an ever changing business environment for Ford is evident in the frequency of managerial changes. Relationships have to be continually developed as new people, both from Ford and MIT, come into positions of responsibility for the alliance. These relationships need to be built prospectively to broaden and deepen connections between the two organizations. The only certainty seems to be that there will be continual changes.

The recognition that there is a dynamic relationship at the heart of a corporate-industry alliance is consistent with management research on business alliances (Doz and Hamel, 1998). Whatever the conditions at the start of an alliance, the experience gained from initial collaborative efforts enables each partner to better understand the other. Having the flexibility to evaluate and restructure the alliance creates possibilities for even greater value than what was originally envisioned. In business alliances these changes are hard because they often require foregoing current product and service efforts so as to create new ones. In corporate-university alliances ongoing change is part of a project portfolio, one which can incrementally change if there are numerous projects. Some projects end or are wound down in order for time, attention and resources to go to new, higher value opportunities.

One of the more difficult challenges in the Ford-MIT Alliance has been integrating across a variety of activities to gain synergies from them. A research university and its faculty are accustomed to working independently and entrepreneurially. This behavior is consistent with the task of obtaining outside funding and creating research breakthroughs. Cooperation and team work is not a necessity as professors' careers, promotions, and fame are established based on their individual reputations. Corporate managers and engineers have many responsibilities and are typically overcommitted in their responsibilities. The long-term timeframe of a research effort often makes it difficult for them to sustain their involvement with short-term deadlines looming.

Establishment of the Ford-MIT Alliance

The Ford-MIT Alliance officially started with the funding of several new projects in September of 1997. MIT and Ford had over two decades of experience with one another through research sponsorship, membership in educational and research consortia, hiring graduates and faculty consulting. Discussions started between MIT President Charles Vest and Ford CEO Alex Trotman, both members of IBM's board of directors. Trotman's 1995 speech at MIT provided an opportunity for him to meet with faculty members and led to discussions based on his suggestion that the two institutions "should do more together." It did take two years of MIT faculty meeting with Ford managers to define what "do more together" might mean.

Finding basic common areas of interest – the role of information technology in engineering and education, the globalization of products and the work force, and bringing better science into environmental decisions and policy-making – led to the development of program areas for research. Discussions about possible projects within these program areas led to widely varying estimates, ranging from \$2 to \$18 M in annual funding, for the size and scope of alliance activities. The funding for the alliance was set in July of 1997 when Ford Technical Affairs VP John McTague proposed an initial five-year timeframe with \$3 M annually in new corporate funding allocated to six program areas – development of an environmental research and policy consortium, environmental chemical and physical research, virtual engineering (developing and testing new information technology supported approaches for design and development of products), virtual education (information technology enabled methods for the education of an engineering workforce spread across the globe), and program management and development of needed infrastructure.

The formal arrangements put in place for the alliance were minimal. It was agreed that specifying detailed procedures was less important than getting the right people involved and letting them decide how to best work together. Standard MIT research conditions ensured that there would be no barriers to faculty participation. Ford committed to maintain its current support of MIT programs and research centers. The alliance was to be directed toward initiating new collaborative research and not as alternative funding for existing programs. Forming and carrying out new research projects required a deeper and more intensive working relationship between Ford and MIT people at many levels.

Management of the Ford-MIT Alliance

MIT and Ford put in place a three-level collaborative management process (see Table 3). At the first level are MIT PIs and counterparts at Ford responsible for projects. At the second level projects are parts of program areas and each program area has an MIT faculty member and a Ford manager appointed as Program Area Managers (PAM). These program areas relate to important strategic areas for Ford, and through a collection of projects can have cumulative impact and greater value than individual projects. Both PAMs provide strategy, direction and oversight of the program areas. The MIT PAM is generally substantively involved in the research and leads at least one of the projects while also representing other faculty and projects in strategic considerations. The Ford PAM's organizational responsibilities relate to the program area. He or she makes decisions regarding the selection of projects and works with Ford project counterparts to see that research results are implemented.

The third level is the overall alliance strategy. Direction is set by Alliance Directors from Ford and MIT. For Ford this originally was Technical Affairs VP John McTague, then Research VP Bill Powers and now Global Core Engineering VP Will Boddie. For MIT the Director was Provost Joel Moses, later Chancellor Larry Bacow and now Chancellor Phil Clay. Other people active in developing strategy included Associate Directors (Manager of Technical Planning Gary Heffernan from Ford and Associate Dean of Engineering Systems Dan Roos from MIT), and Executive Directors (for Ford it was originally Phil Abramowitz and then Chris Magee, and for MIT it is George Roth). Executive Directors work at all three levels, guiding day-to-day activities associated with establishing, funding and carrying out research projects, working with PAMs on program areas and developing the alliance by engaging new people, and supporting Directors in the development of strategies and new program areas. Recruiting is also an important focus for Ford, and has its own set of focused activities. Weekly Operating Committee meetings, chaired by the Executive Directors, provide a regular venue for discussion of ongoing projects, planning upcoming events, gaining synergy across efforts and collaboratively addressing opportunities and resolving conflicts.

The purpose of the Ford-MIT Alliance is to create new knowledge and unique value from working together. This purpose is achieved through a number of activities, the predominant of which is research projects. Interactions among people provide the basis for proposals written by MIT PIs that involve and are supported by Ford counterparts. Proposals are reviewed by PAMs and Executive Directors, who, with their recommendations, pass them on for approval from the Alliance Directors.

TABLE 3. FORD-MIT ALLIANCE MANAGEMENT
(as of January 2002)

	Ford	**MIT**
Executive Committee (meets quarterly)	Will Boddie, Director Marty Zimmerman Al Ver	Phil Clay, Director Dan Roos, Associate Director
Program Area Managers (PAMs)	Ellen Stechel, MIT/AGS and Environmental Research Simon Pitts, PDPT Tom Foot, Virtual Education, Priya Prasad, Active Safety	David Marks, MIT/AGS and Environmental Research Dan Whitney, PDPT Jan Klein, Virtual Education, Eric Feron, Active Safety
Executive Directors	Chris Magee	George Roth
Recruiting (Ford Fund/Corporate Relations Sponsor Program)	Marty Zimmerman, Sponsor Kristin Schondorf, Recruiting team leader	Phil Clay, Sponsor Jason Walls, Career Services Elaine Savage, Corporate Relations
Operating Committee (meets weekly)	Chris Magee, Executive Director Ed Krause, Program Coordinator	George Roth, Executive Director Dan Roos, Associate Director Elaine Savage, Corporate Relations

The benefit of this management structure is that there are many and varied communications that take place on an ongoing basis between Ford and MIT. This communication is so diffuse that no one person can know all of what is happening. The "unmanageability" of this communication is essential to the success of the alliance as it is what is needed to organize, align and deliver the projects, activities and exchanges of people and ideas that create value in the corporation from the research of the university.

Evolution of the Research Projects

At the end of its first year, in December of 1998, 18 projects had been started and 16 were continuing (one project had finished and another had been terminated). Challenges in initiating projects included MIT faculty who were available and whose research was relevant to the strategic program areas as well as developing contacts with Ford technical and management counterparts. The initial research projects varied greatly in size and scope. Several seed projects were funded at $50,000, supporting only one graduate student and travel expenses. Large projects, with groups of students, post-doc and faculty summer support were funded at $250,000 to $500,000 per year. The duration of most projects was two to three years, although several were active for only a semester (for example, using technology and developing remote collaboration techniques to design a classroom at the Henry Ford High School).

The total number of projects has risen slightly over time and there has been a considerable turnover (see Table 4). This turnover reflects a better understanding of what has value and how to select and connect projects to Ford. The size of the projects continues to vary, with there being some seed projects at $50,000 to $75,000 annually, and larger team-based projects at $200,000 to $300,000 annually.

TABLE 4. NUMBERS OF PROJECTS BY PROGRAM AREA
(see Appendix A for detailed list of projects by year by program area)

Program Area **Year end**	**1998**	**1999**	**2000**	**2001**	**Current** (as of 2/02)
Environmental Consortium (later renamed MIT/AGS – part of Alliance for Global Sustainability)	*Consortium started and multiple projects initiated*	*Consortium continues with multiple projects*	*Consortium continues with multiple projects*	*Consortium continues with multiple projects*	*Consortium continues with multiple projects*
Environmental Research	- **2** projects started	**2** projects ongoing	- 1 completed - 4 started **5** projects ongoing	- 1 project completed **4** projects ongoing	**4** ongoing projects, none of original
Product Development Process Technology (initially called Virtual Engineering)	- **8** projects started	- 2 projects added **10** projects ongoing	- 2 projects completed, 1 started **9** projects ongoing	- 1 stopped, 2 completed 1 reassigned **7** projects ongoing	**7** projects ongoing, 4 of original
Virtual Education	- 5 projects started - 1 project stopped, 1 completed **3** projects ongoing	- 1 project added - 2 projects completed **2** projects ongoing	- 1 project completed **1** ongoing project	- 1 project completed, 1 started **1** ongoing project	**1** project ongoing, none of original
Active Safety				- **4** projects started	**4** projects ongoing
Other	- **3** project started	- 1 project completed **2** projects ongoing	- 1 project completed, 2 started **3** projects ongoing	- 1 started, 1 reassigned **3** projects ongoing	**3** projects ongoing, 1 of original
TOTAL number of ongoing projects (with additions and subtractions in that year noted)	**18-2=16**	**16-3+3=16**	**16-5+7=18**	**18-6+7=19**	**19** (of 35 started)

Personnel Exchange

One of the ongoing discussion topics for creating value through the alliance has been around personnel exchanges. The desire to have people spend periods of time in residence at each others' facilities is to provide both hands-on and strategic help. At the end of 1999 a senior Ford person was appointed to the Executive Director and resident at MIT. By being on campus he could work more closely with MIT faculty to enhance Ford's value from existing and new projects. It was his efforts that help to create a closer integration among research, educational and recruiting efforts at both Ford and MIT. His presence also increased connections to Ford management. Several top Ford managers visited MIT (see Table 5). Their visits included speeches, reviews of projects and meetings with faculty and students. In the initial two years there had been only one visit by a Ford senior manager (Neil Ressler) for other than for an alliance meeting. The quarterly alliance meetings were upgraded to include three Ford VPs. It is not typical for

Ford's top managers to spend time at a university; the fact that they did so indicates their interest to come to MIT with a willingness to contribute and learn from it. There was also similar increase in senior and middle Ford managers visiting and support alliance activities. People at Ford's officer-level visiting MIT made it easier for the levels below them to visit and be active in the alliance.

TABLE 5. FORD SENIOR MANAGEMENT VISITS TO MIT

Date	Senior Manager	Focus and Speech Topic
June 7, 1999	Neil Ressler, Chief Technical Officer	Keynote address at conference on Traffic Congestion, discussions on environmental and engineering research, visit to Media Lab
October 5, 2000	Richard Parry-Jones, Group VP Product Development	Speech on Statistical Engineering, discussion in engineering research, dinner with faculty group, visit to Media Lab
March 21, 2001	Will Boddie, VP Global Core Engineering	Discussion on product development and engineering research projects, visit to Media Lab
May 16, 2001	Wolfgang Reitzle, Group VP Premium Automotive Group	Keynote address at MIT conference on future of automobile, discussions on engineering and computer systems research, lunch with students, visit to engineering, AI and Media labs
July 19, 2001	J Mays, VP Design	Speech on design, discussion on engineering research, visit to engineering and Media labs
August 1, 2001	Gerhard Schmidt, VP Research	Discussion on product development research, visit to manufacturing, AI and Media labs
February 4, 2002	Gerhard Schmidt, VP Research	Speech on future of automobiles and mobility, discussions on environment, engines and vehicle electronics research, visit to Media Lab.

The transition to a new Ford Executive Director involved a review of the alliance projects. Project progress and how well they were linked with Ford people that could implement results was carefully considered. These reviews and the visits of Ford managers to MIT improved the alignment of projects to Ford and built stronger interpersonal connections. An inability to make this connection resulted in winding down some projects (Design Rationale Capture and Computer Aided Industrial Design) while good new connections led to the start of several new projects (Robustness, Robotic Coupling and Orthogonal Sets) and a new program area (Active Safety with four new projects).

Lessons from the Ford-MIT Alliance

Through actively discussing how to improve current projects and initiate new ones, we developed a set of principles that have guided our efforts (see Table 6). The first four principles apply to the selection of people and projects, and the latter three to orientations across projects. Taken together they provide guidance in selecting people and projects that supports a learning process that creates value for Ford and MIT. These principals are themselves an important part of the learning from the initial four years of the Ford-MIT

Alliance. The learning that had taken place and the evolution of the alliance to its current projects contributed to the decision to renew the Alliance for a second five-year term. This learning is also the basis for future collaborative research and practice in engineering systems. In the sections that follow we describe and illustrate each principle.

TABLE 6. PRINCIPLES APPLIED IN THE FORD-MIT ALIANCE

1. **Engage interesting and innovative people**
2. **Support personality matches**
3. **Link projects to company priorities**
4. **Align with existing organizational resources**
5. **Look beyond costs and orient to value**
6. **Gain both local and organizational benefits**
7. **Seek and capture multiple value streams**

Principle #1: Engage interesting and innovative people. The Robotic Kinematic Coupling project involved working with Alex Slocum, a mechanical engineering faculty member known for his energy and innovativeness. He enjoys being exposed to entrenched problems and inventing new engineering approaches to solve them. His research included applying a unique mechanical connection to improve the abilities of maintaining and upgrading assembly line robots. This project was selected not only for its good fit and for the interest of the Ford counterpart, but also to provide opportunities for Alex to get more exposure to other Ford people. Other research and valuable connections have resulted from this project and his connection with Ford.

Principle #2: Support personality matches. The Orthogonal Sets project is in an area important to Ford – using computer and telecommunications-based methodologies to analyze large amount of data and more effectively operate its business. Ford created a new group within its research labs specifically to study and apply these approaches. Members of this group visited MIT several times to have discussions in this area. The MIT faculty member, Dan Ariely, was interpersonally compatible with the Ford scientist, Tom Montgomery. There was a clear interest and connection between MIT and Ford counterparts so that each would *want* to spend time with the other, possibly even a period of time in residence. Knowledge is held by and travels with people. When they willingly and regularly spend time together they themselves facilitate the transfer and application of knowledge.

Principle #3: Link projects to company priorities. The Robustness and Axiomatic Design project is linked to an initiative by Group Vice President Richard Parry-Jones. One area that the current university education does not address well is in bringing statistical techniques into engineering design. These techniques help engineering designs accommodate variability in materials, manufacturing and operating conditions, improving performance over a wider range of conditions. Incorporating statistical approaches has helped improve Ford quality and reliability. Parry-Jones wants the education of engineers at universities to include these statistical approaches. This foundation is not provided in the current university education, and Ford needs to provide additional training to the engineering graduates it hires. Parry-Jones came to MIT and made a well-received technical speech on this topic. A new research project led by Dan Frey and Nam Suh at MIT explores approaches to greater design robustness. Their Ford counterpart, Tim Davis, works for Parry-Jones and is an expert in this area. The research project outcomes will improve these techniques and influence the engineering curriculum at MIT. Ford hopes that changes in MIT's curriculum will also influence other universities' engineering programs in the United States.

Principle #4: Align with existing organizational resources. Ford recently reorganized its research and advanced engineering groups. Key technologies are targeted in programs known as the "big bang" process. This process organizes research and engineering activities into a few specific projects that create discernable customer benefits. One of these areas is in safety. Ford and Volvo have considerable expertise in this area, and new safety developments are important to brand attributes for Ford. Safety research includes testing technologies to sense threats from surrounding environments, alert drivers, take actions to avoid collisions, and when unavoidable, protect vehicle occupants. Ford engineers and scientists met with MIT people doing related research. Many of these safety-related technologies have been developed through research done by MIT faculty for aviation, aerospace and military applications. These discussions led to a set of new projects that were formed into the "active safety" program area. These projects take a longer term view of research issues while learning from and contributing to the Ford groups testing and deploying these technologies in current experimental vehicles.

These four principles are complementary. The new Active Suspension project provides a good example. One – the MIT professor's (Steve Hall) style is very engaging. Two – he has good personality matches with his Ford counterparts. Three – the project studies the use of piezoelectric materials in suspension components to provide adjustable ride characteristics. These are capabilities that are important to Ford and its customers. Four – Ford has dedicated a person to this research and it is linked to internal resources as part of the big bang process.

The next three principles go beyond individual people and project matches to include approaches that enhance the overall partnership and provide guidance for all activities.

Principle #5: Look beyond costs and orient to value. Corporate-university alliances are different from traditional sponsored research in the amount, breadth and timeframe of their commitments. A corporate partner must achieve commercial impact and create value in order to sustain its involvement. The rate of change in industry is such that many of the executives, managers, scientists and engineers involved in establishing an alliance will have changed jobs over its term. Creating demonstrable corporate value helps the alliance transcend these personnel transitions. When these corporate realities are recognized, considering how a project contributes to shareholder value becomes an orientation in selecting new projects. This value orientation differs from a typical university-based research orientation that views the creation of knowledge as an end in itself. The typical university orientation is to focus on costs and finding needed funding. Historical support from government, foundations and consortia has limited universities in needing to consider the commercial value of research. Researchers are more attuned to costs and intrinsic research merits than to the value that sponsors gain from providing funding, access and involvement.

The Ford-MIT Alliance was established by the CEO and top Ford managers negotiating with MIT senior administration and a few faculty members. The CEO and senior company managers committed significant financial resources toward working with MIT. Discussions at that level did not specify the details of the alliance. Strategic interests were discussed from which programs were created. It is *after* funding commitments were made that other managers and faculty worked out specific details. The project portfolio was developed by making the alliance, funding availability and interests known, finding faculty with relevant research interests, establishing linkages with Ford counterparts, and then generating proposals. The proposals were accepted based on the availability of funds and expected contributions to Ford.

A study of thirteen initial Ford-MIT Alliance projects (Gao and Roth, 2001) found a strong qualitative linkage between how a project was initiated and then carried out to whether or not it was successful. For this study, success was equated with achieving both Ford's and MIT's expectations. Projects based on interactions prior to writing a proposal, a historical working relationship or direction from senior management were more successful than those based on initiation that involved a request for proposals or extensions of ongoing research. Greater depth and frequency of interaction in carrying out projects was also linked with greater success.

Equating success with whether or not projects met or exceeded expectations is incomplete. These expectations came from statements made by the Ford and MIT people involved in proposing and carrying out the research. Expectations change with time and experience in working together. This change is good, as revised expectations provide for better alignment from the research (see earlier reference in discussion of idealized alliance about the important of re-evaluation for success). The review of the research projects added criteria of value, improving core competencies and competitive success as expectations from research. None of the initial projects included explicit statements of how Ford would create value from research outcomes. Bringing a value creation focus to alliance projects has made these expectations explicit topics in the discussion for new projects.

Principle #6: Gain both local and organizational benefits. It is hard for a corporation, particularly in the short term, to gain sufficient value from a research project to exceed the current funding costs. The nature of research is that its benefits may seem diffuse in the short term. Value is only realized for a corporation when research is applied and combined with other necessary actions. If just the research outcomes are considered, then costs are usually high relative to value. However, when the research outcomes are considered with associated interactions and exchanges of knowledge, particularly knowledge that is linked to competitive advantage, costs could be considerably less than the value that the corporation could gain. Considering value and benefits at multiple levels, beyond just project outcomes, and actively managing these multiple components, can create a value proposition that makes the corporation's return on university research more attractive.

Ford is interested in value created from research, particularly value that enhances its core competencies and provides competitive advantages. This organizational value is not the same as the individual value that Ford counterparts gain from their involvement. When the research is closely related to the counterpart's job, it is easy for him or her to convert ideas, learning and knowledge into immediate application and personal gratification. A virtuous cycle is created when there are mutually reinforcing benefits at organizational and individual levels. The creation of "local" value from MIT research reinforces the involvement of the Ford counterpart. Local value leads to more frequent and deeper interactions, greater sharing of knowledge, and better research feedback and guidance for MIT. This feedback improves the relevance of the research, leading to further engagement by Ford people, and providing a broader basis for the application of knowledge beyond the project in which it was created. That application of knowledge goes beyond the project to create greater organizational value. Good alignment of the research to core competencies provides Ford with competitive advantages while helping to advance the careers of those Ford people. The creation and capture of this value sustains the alliance and builds individual relationships between Ford and MIT participants.

We identified, articulated and supported the creation of value at multiple levels, from broader societal levels to individual levels (see Table 7). The benefits derived at these multiple levels are important criteria for judging the overall benefits of the alliance for both Ford and MIT.

TABLE 7. FORD-MIT ALLIANCE BENEFITS

<table>
<tr><td>Level of benefit:
<u>Societal</u>:
industry, academia and government levels</td><td colspan="2">➢ set industry standards
➢ model for global environmental stewardship
➢ educate future leaders
➢ transfer knowledge
➢ influence policy</td></tr>
<tr><td rowspan="2"><u>Organizational</u>:
alliance, strategic, company and university levels</td><td colspan="2">➢ share strategies
➢ shape each other's futures
➢ co-location
➢ understanding of complex system design principles
➢ greater credibility</td></tr>
<tr><td><u>FORD</u> <u>SPECIFIC</u>
➢ hiring
➢ new knowledge
➢ innovative technology
➢ novel business models
➢ market opportunities
➢ competitive advantage
➢ improved marketplace reputation
➢ inventive spirit
➢ contribute to Ford's workforce</td><td><u>MIT</u> <u>SPECIFIC</u>
➢ job opportunities
➢ new research
➢ industry relationships
➢ teachable knowledge
➢ funding, access and support
➢ understanding of real world problems</td></tr>
<tr><td><u>Local/individual</u>:
executive, manager, faculty, staff & student levels</td><td>➢ source of project support
➢ insight and learning
➢ advice
➢ consulting</td><td>➢ funding
➢ access and data
➢ feedback
➢ impact
➢ consulting</td></tr>
</table>

Principle #7: Seek and capture multiple value streams. In addition to local and organizational value created through research, there are multiple value streams that can be captured from the range of Ford-MIT Alliance programs and activities (see Table 2). For example, linking recruiting activities to Ford research counterparts working with students can provide benefits in hiring MIT graduates. Individuals, departments and programs in a university operate relatively autonomously, so integrating activities are needed to identify and capture this value.

TABLE 8. VALUE STREAMS FOR FORD AND MIT

Increasing positive value

Ford

- **Competitive advantage** and higher profitability
- **Shareholder value** and new revenue
- **Impact** on current product or process
- **Recruiting** advantages in hiring MIT students
- **Education**, **knowledge** and **technology transfer** (**stimulating environment** for technical people)
- **Convening power** of university as an honest broker on important social, economic and policy issues
- Ability to give an idea **publicity**
- Priority in **commercializing** technical developments
- **Information** transfer
- Inexpensive **research**
- **Association** with prestigious institution, profession and individuals
- Sense of good **stewardship** & citizenship
- **Philanthropy** and donation of time and money

MIT

- **Breakthrough research**, theory and publications
- Academic **journal article**/peer reviewed publication
- Academic conference **presentation**
- **Book** or book chapter
- Industry or trade **publications**
- **Faculty development**
- **Education**/opportunities for faculty & funding
- Education opportunities for **students**, funding, and employment (hands-on work with top executives)
- Educational **materials** (real case studies)
- **Information** on research, business and engineering issues and problems
- **Access -** time spent with sponsor, meeting industry managers and technical people and understanding industry issues
- **Money** and funding, prestige of link with successful industrial companies

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Ford

- Produce good research that is **not implemented**
- **Raise expectations** of Ford employees and students so that they leave Ford
- Educate and **inform competitors** of Ford's know-how
- **Implement ideas at competitors**

MIT

- Funding and **time spent** that doesn't lead to publications or education
- High % or time spent **reacting** to sponsors information and meeting requests
- Good research that is not implemented because **Ford constrains** it

Increasing negative value

Table 8 shows a list of the multiple value streams and their relative hierarchy for the Ford-MIT Alliance. This list was created to help Ford and MIT people recognize that while their involvement in the alliance is generally based on particular goals of the project they were involved in, they could also help to create additional value by supporting natural byproducts of their primary efforts. It is also important for people to know that inappropriate byproducts can destroy value and harm the relationship. The autonomous and entrepreneurial nature of university research requires efforts at the alliance level to not only capture positive value but also to avoid negative value.

One of the sources for transferring and applying knowledge has been to involve Ford employees enrolled in the Systems Design and Management (SDM) program. Ford sponsors a cohort of employees in this program (see Table 9). Having Ford students do their thesis work applying research concepts creates individual, local and organizational value. For example, Agus Sudjianto, Craig Moccio and Anthony Zambito of Ford have all used the Design Structure Matrix in their thesis work and continue to use it in their current responsibilities. Ford hired Gennadiy Goldenshteyn and Qi Dong, MIT masters and PhD students who worked with Dan Whitney on Ford research.

TABLE 9. FORD EMPLOYEES IN ENROLLED IN MIT SYSTEMS DESIGN AND MANAGEMENT (SDM) PROGRAM

Class starting in January 1998	Class starting in January 1999	Class starting in January 2000	Class starting in January 2001	Class starting in January 2002
17 employees as students	**12 employees as students**	**13 employees as students**	**10 employees as students**	**9 employees as students**
Canice Boran Matthew Cadieux Mark Cummins Steve Daleiden Edward Esker Howard Gerwin James Goran Nancy Jankowiak Jerrold Lavine Chris Mann Michael Pepin Mark Schmidt Michael Shashlo Manu Vedapudi Joseph Wickenheiser Joanne Woestman Anthony Zambito	Jared Clark Sandra Corbett Kram Viesturs Lenss Ronald Mastronardi Sean Newell Milind Oak Michael Paskus Christopher Renaud Dawn Robison Agus Sudjianto Laurie Hart Hai Truong	William Biberstein Shui-Fang Chou David Thomson Kurt Ewing Adnan Khan Erika Kristin Low Thomas K. Mathai Donald Mecsey Craig Moccio Ben Saltsman Hans Schumacher Venu Siddapureddy Nathan Soderborg	Scott Ahlman Kathleen Blackmore Lisa Cratty Dan Douglas Nathan Everett Jyoti Mukherjee Dawn Pauszny William Phillips Matthew Sahutske Kelly Zechel	Candy Chatawanich John Fallu Ramasunder Krishnaswami Harris Lieber John Penney John Pommer Daniel Rinkevich Timothy Rush Frederick Samson

Capturing multiple value streams depends upon the awareness of these opportunities by the various Ford and MIT people. Ad hoc personal interactions with Executive Directors, annual project reviews, including people in quarterly meetings, visits and speeches of Ford executives, monthly newsletters and semiannual program reports (as background packages to quarterly meetings) are all part of the communication that helps to keep them informed and aligned.

5. CONCLUDING REMARKS

The basis for developing and sustaining an alliance is that the value gained exceeds the cost incurred for both partners. Value is achieved and sustained by a continuous learning and restructuring process that better supports ongoing efforts and addresses new opportunities. The innate differences between a university and corporation and the reality of continuous change requires an ability to quickly address opportunities and conflicts as they arise. These differences and the ongoing change are at the heart of what allows an alliance to create value through the combined efforts of two very different organizations. Our efforts have sought to create relationships between people that gain benefits by using those differences to achieve results that would not be attainable for either partner on their own. The learning and relationships that are in place provide the foundation for further developments. Change and evolution is necessary in any alliance as both partners are continuously changing individually. Without being able to accommodate change it is difficult to sustain an alliance. The principles we have developed in the Ford-MIT Alliance to proactively manage this relationship apply to other corporate-university efforts, including Ford’s relationships with other universities and MIT’s alliances with other corporations. What we are learning is particularly significant to the Engineering Systems Division because of the importance of possible MIT alliances to this field.

One direction for the evolution of corporate-university alliances is toward approaches for engineering systems studies. While academics excel at the details involved in research, the size and scope of engineering systems studies requires considerable coordination and project management capabilities. By the very nature of engineering systems studying just its components is insufficient. Broad access and stable settings with multiple tests, different methods, and the longevity to observe changes are needed. Through alliances, faculty and students can be in residence at corporations for extended periods of time to conduct studies, work with engineers and managers, and coordinate activities across multiple studies. If MIT is to fully engage its corporate partners and make alliances have lasting value, it will need to create rewards and incentives for its faculty to spend extended periods of time at partner corporations. As MIT faculty members are regularly able to spend time in residence, we expect even better research and greater value to come from these alliances.

The importance of corporate and university people working closely with one another can not be overemphasized. The specialized knowledge required for research on engineering systems is probably not a capability that corporations could develop and retain on their own. A university alliance allows a corporation to work with world-renowned research faculty while only paying for a portion of their costs. Faculty members bring experience and insight from different industries, along with a depth of knowledge in specific research fields. A university can also help a corporation to integrate across departments and professions. Differing priorities and contributions often makes it challenging for corporations to work cross-departmentally. The prestige accorded to university faculty in their research and educational activities can help to bring corporate factions together. Research and educational interactions bring longer-term perspectives and alternative, fresh views of important issues that are often beyond the horizon of what executives have time to consider.

A corporation can help a university integrate across its departments and schools. Engineering systems requires researchers from multiple fields to work together. The size, scope and relationships established in an alliance are a way to bring university people from different departments and fields together. As issues are encountered, the attention of university senior administration to the alliance helps in providing experiences that can be used as levers for positive change within the university.

When addressing new and unique challenges, the differences in priorities, cultures and capabilities of corporations and universities can become strengths. Engineers, managers and executives will see different aspects of engineering systems, just as research from different fields examines alternative system elements. Sustaining engineering systems studies for a sufficient time to develop, synthesize and test ideas from multiple perspectives requires stable, ongoing relationships. Corporate-university alliances, working toward idealized states, can provide the benefits needed to sustain these efforts. Progress in developing new theories and practices would be less rapid without the creation of these alliance-like settings for engineering systems studies.

Endnotes

Author's biographies – We have included our biographies to provide relevant details on the personal experiences and backgrounds of us as co-authors. We, as well as the people and their matches and engagement at project levels, recognize that these characteristics matter in seeing and bridging the differences between Ford and MIT.

George Roth:
George is MIT's Executive Director for the Ford-MIT Alliance and Research Associate in MIT's Sloan School of Management. His background includes ten year's industry experience at Digital Equipment. In addition to being involved in starting several new ventures with suppliers he managed a joint venture with Eastman Kodak for digital imaging systems. George has an engineering and MBA degree from the University of New Hampshire, and a PhD from MIT Sloan.

Chris Magee:
Chris recently retired from Ford Motor Company. He is currently Professor of the Practice, responsible for MIT's Engineering and Sloan Management School Center for Innovation and Product Development. For the prior two years he had been Ford's Executive Director for the Ford-MIT Alliance. His accomplishments include credentials important to MIT – research publications, industry honors and appointment to the National Academy of Engineering – as well as experience important to Ford – a member of senior management, leadership in introducing new technologies and contributions to vehicle design, product development, systems engineering, computer-aided engineering and design, and work with manufacturing. Chris has a bachelors, masters and PhD degrees from Carnegie Mellon University and an MBA from Michigan State University.

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