TECHNOSCIENTIFIC IMAGINARIES

CONVERSATIONS, PROFILES, AND MEMOIRS

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The World of Industry-University-Government: Reimagining R&D as America

> Unfortunately, the overall quality of engineering design in the United States is poor. . . . Partnership and interaction among the three key players involved in this endeavor—industries, universities, and government—have diminished to the point that none serves the needs of the others. . . . This state of affairs virtually guarantees the continued decline of U.S. competitiveness.
>
> —National Research Council, 1991

> We're trying to do with the computer what we cannot do with our organizations.
>
> —David Grose

The ACSYNT Institute is rewriting a computer program for aircraft design that is twenty years old. In the process, institute members are also rewriting themselves. The ACSYNT Institute is experimenting with a new form of organization for technological research and development, a joint venture involving industry, university, and government as equal participants. Its technical objective is to get design engineers in industry to use a program, or code, called ACSYNT, originally written within government and recently improved within the university. Yet through its very organization and day-to-day activities, the ACSYNT Institute also offers a new vision of research and development, which I call here the world of industry-university-government, or IUG. I began following the activities of the institute in 1990, after an informal consortium among the participants had become a formal organization. My own feelings about the world of IUG are strongly ambivalent and, hence, somewhat confused.

ACSYNT is short for Aircraft Synthesis. The code synthesizes, or brings into interaction mathematically, technical constraints from different engineering areas in aircraft design, including the most prominent areas of aeronautics, propulsion, and structures. Aeronautical engineers from NASA originally wrote ACSYNT in the 1970s to help them evaluate and compare proposed designs for military aircraft. During the late 1980s, engineering

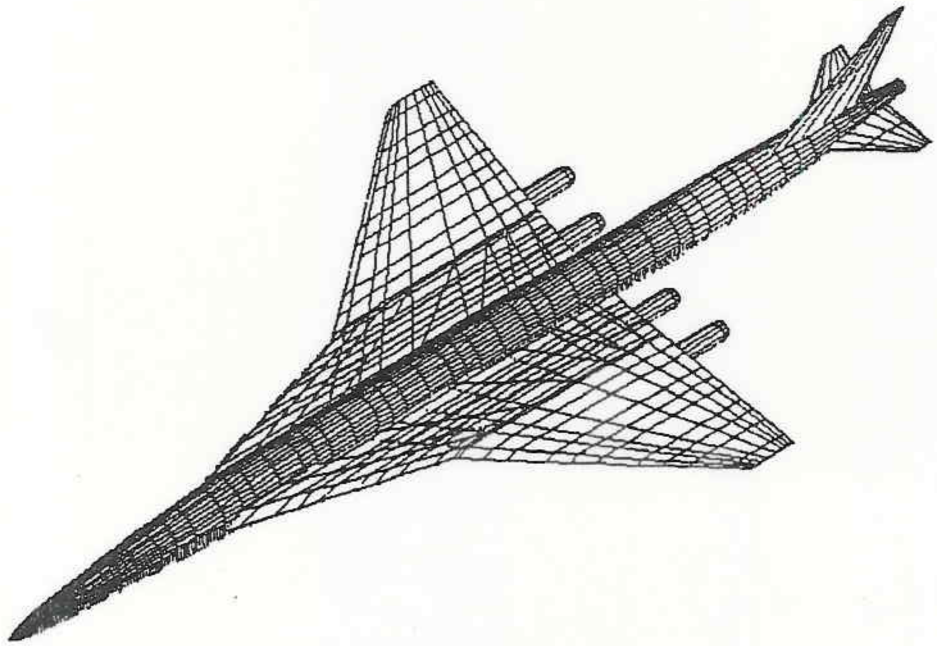

Fig. 1. Iconic representation of the ACSYNT Institute.

faculty and graduate students at the Virginia Polytechnic Institute and State University, working under a grant from NASA, merged graphical capabilities into the code, which means that they enabled it to display visual images of proposed aircraft in addition to presenting long lists of numbers. Design engineers in both government and industry find this new feature very appealing because it enables them to see an aircraft as they settle on its specifications. The institute represents itself iconically with one such image (fig. 1).

I find the ACSYNT Institute an interesting organization to study for two reasons. In the first place, I find its experiment attractive politically. The institute seeks to blur a bit the boundaries between industry, university, and government with the goal of benefiting the common good. A nonprofit organization, the ACSYNT Institute is motivated in part by a sense of citizenship. Its members try actively to move beyond a narrow focus on the maximization of self-interest and to work together. I watch people struggling to find ways of overcoming the boundaries that separate them. I see in the ACSYNT code an opportunity to introduce a wider range of design parameters, such as environmental considerations, into the mechanism of aircraft design, as well as to help an industry shift from military to commercial enterprise. I also like the people involved, and have become friends with some of them.

During the two years I followed the institute, its membership consisted of the NASA Ames Research Center, Virginia Tech, and eight aircraft companies, with four other NASA and U.S. Navy research organizations participating in minor roles. Each company committed $30,000 per year for a period of five years to support research and development activities on the code. NASA is actually the motivating organization behind the institute. A legal provision of the 1958 Space Act that founded NASA permitted it to enter into jointly sponsored research arrangements with nongovernmental organizations, something that few other federal organizations that do. In 1987 NASA provided staff to establish an independent, nonprofit organization, the American Technology Initiative, with a mandate to establish joint research and development projects, now known as dual-use technology development, that would transfer NASA technologies to private industry. The ACSYNT Institute is the second joint venture founded under the auspices of the American Technology Initiative, or AmTech, although the first to be funded under the broad authority of the Space Act (fig. 2).

The actual work of tailoring the ACSYNT code to fit industry practices is done by engineers at the NASA Ames Research Center and Virginia Tech. The government engineers are primarily responsible for improving its capabilities in mathematical analysis and synthesis, while the university engineers emphasize developing further its capabilities in visual and geometrical representation. Members meet for two days twice a year either at NASA Ames in California or at Virginia Tech in Blacksburg, to report on progress and negotiate future plans. I attended three of these meetings, conducted lengthy interviews with fourteen participants, and attended weekly meetings of the Virginia Tech research group.

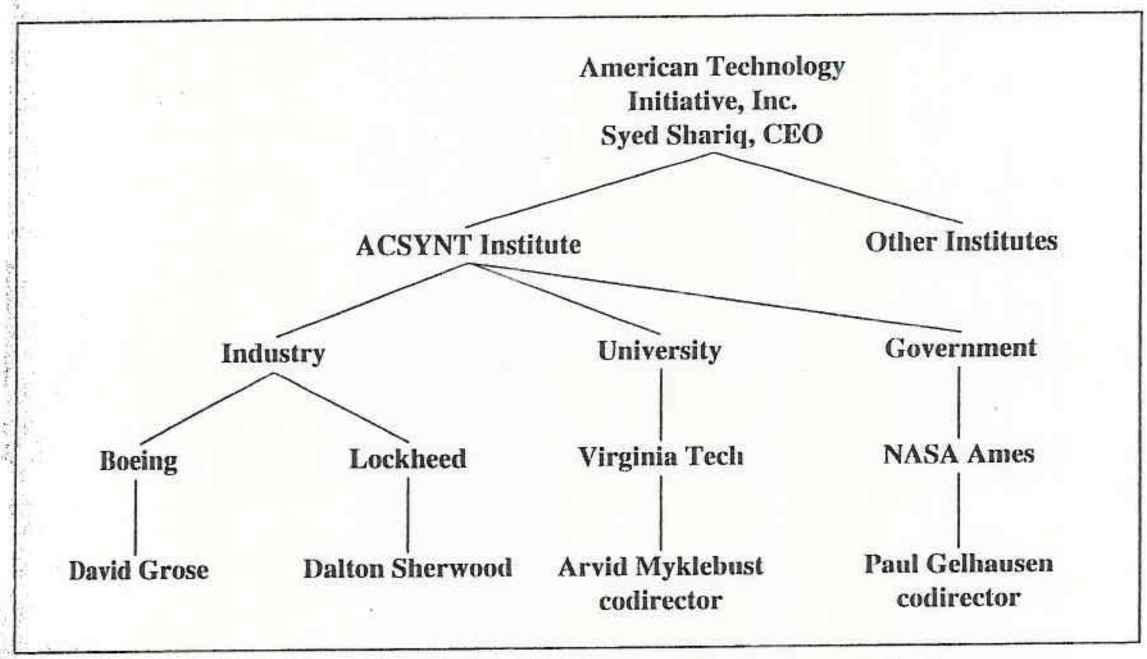

Fig. 2. Organizational chart and cast of characters, American Technology Initiative, Inc.

The second reason for my interest in the ACSYNT Institute is that its members are blurring the boundaries among their institutions by means of the code itself. David Grose makes this point in the epigraph: they are trying to do with the computer what they cannot achieve with their organizations. Showing connections between rewriting a computer code and redefining organizational relationships is a delicate task because it challenges common assumptions about the relationship between technology and society.

Throughout American history, a common strategy for producing social change without debating it explicitly has been to delegate the change to technology. This strategy often remains inexplicit because popular theorizing in America imagines technology not as a social phenomenon but as a force external to society that impacts on it and to which society must adapt. Separating technology from society in this way renders it legitimate to produce social change by means of technological change, for technological change is understood as inherently liberating and progressive. Since the technology itself becomes the cause for change, human participants in technological development may be absolved of responsibility for any social implications other than those that contribute to human liberation and foster social progress.

Academic research in the interdisciplinary field of technology studies has maintained that this theoretical attitude of technological determinism limits one's ability to understand increasingly complex relations between humans and technologies. A common academic strategy that I endorse is to reconceive technology as a part of society rather than apart from it. This conceptual move can make it easier to see how the technical process of developing a new technology also designs the social relations within the technology will work. Since institute members generally envision technology as lacking social content, they do not describe the transfer of ACSYNT from NASA to industry as a process of building new social relations into the code. Technical activities are different than social activities. Formal discussions tend to center on the technical features that the code should or should not have, or on whether the code itself is any good or not. At the same time, much informal discussion focuses on the participants' frustrations with what they often see as needless politics, that is, the nontechnical dimensions and issues that also always seem to be present. Grose's assertion linking the technology to organization is exceptional rather than typical.

If one starts, however, with the different theoretical premise that society includes technology, one gains a much different image of institute activities. For example, one can argue that the original ACSYNT code was limited because its developers had built into it the social relations of research but not of production. That is, the code fit nicely the research environment at NASA Ames, where it has always been appropriate to consider different design specifications simultaneously (for example, aeronautics, propulsion, and structures), but it did not fit the production environment in industry, which has institutionalized rigid separations among these areas. From this standpoint, by rewriting the code to incorporate the production environment, the ACSYNT Institute is now constructing innovative social relations that blur the boundaries among government, industry, and university.

The problem the ACSYNT Institute faced when I completed my participation in 1992 was not only to incorporate the production environment of industry into the code but also to define the three-way collaboration that constitutes the world of IUG. Whether the code was good or not had become a question of whether or not everyone could see themselves in the code. Producing code that everyone could accept and use would be an indicator that the institute was not simply an organizational artifice for an incomplete or impossible collaboration. These technical innovations and political innovations had to be realized together, through the same actions.

In the midst of my enthusiasm for this experiment, I also have strong worries about the world of IUG. I fear that such boundary-blurring, collaborative ventures have the potential of reproducing, or even magnifying, dangerous forms of national chauvinism. During the 1980s, official America retheorized international struggle from a political to an economic idiom. With its economic dominance of the world no longer assured, America theorized itself no longer as a site for competition among individual interests but as a single economic actor maximizing a collective interest. The national shift to economic struggle was sudden and dramatic, embodied and epitomized by the election and reelection of Ronald Reagan. Reimagining nationalism in economic terms and economies in nationalistic terms legitimized and opened possibilities for unprecedented levels of cooperation within industry, as well as the direct participation of university and government in economic development. More well-known examples of collaboration in R&D have included the Microelectronics Corporation, which brings together competing electronics companies, and Sematech, a joint venture between government and industry. During the 1960s and 1970s, such collaborative ventures would likely have met with significant protest that they fulfilled apocalyptic visions of the military-industrial establishment. In the 1980s, however, the power of patriotic commitment to this economic call to arms became concentrated in a single, one-word trope: competitiveness.

By successfully transferring the ACSYNT code from NASA Ames to the aircraft industry, the ACSYNT Institute explicitly hopes to improve the process of conceptual design, the earliest stage in aircraft design, in order to enhance U.S. competitiveness in aircraft manufacturing. During my participation, no one in the institute questioned the nationalist character of this objective. Although writing distinct visions of R&D from industry, university, and government into the ACSYNT code serves the common good, the common good is the welfare only of the United States in economic competition with other nations. The practices of research and development have become linked to the nation because national struggle has been reconceived as competition in a global market. Rewriting ACSYNT to achieve a world of industry-university-government is thus one instance of a national strategy to reimagine R&D as America.

Seeing two different possibilities in the institute at the same time, I find myself ambivalent. Is blurring internal boundaries the crucial first step toward developing a sense of global responsibility and citizenship? Or, by enhancing the ability of the United States to act commercially with a single voice, do collaborative ventures undermine the development of global responsibility and simply reproduce nationalistic struggle in a new idiom? My sympathies lie with the first, but the second appears more likely in the near term, for the end of the cold war has led to a sharp increase in the intensity of nationalism around the world. Despite the fact that the nationalist concern for competitiveness marks a shift away from production for military purposes, I worry that the cost may be to militarize American conceptions of commercial activities.

Strategies for reimagining R&D as America are likely to persist in the 1990s as the Clinton administration works to realize an activist government that not only participates in economic development but also actively directs it. As the country evaluates expensive proposals to reconstruct America through such technological changes as fiber-optic networks and electronic information highways, the popular theory of technological change is being put to use once again. In each case the stated objectives envision the technological delivery of social progress in the form of enhanced competitiveness, yet the implementation of these technologies will require other social adaptations as well. It is important for cultural studies of science and technology to examine critically the social engineering that is built into visions of R&D partnerships in order to make it clear that technological choices are also blueprints for social change. Discussions of new technologies should focus not only on which ones to choose but also on how to assess, evaluate, and acknowledge *a priori* the social changes written into them.

By splicing together bits of text from interviews and presentations at a semiannual meeting of the ACSYNT Institute, I introduce the reader both to the world of IUG and to the individual and collective stakes for those who inhabit it. For the people and organizations that participate in the ACSYNT Institute, moving from a world of old islands of knowledge into a world of newly blurred boundaries carries not only significant opportunities but also considerable risks. Participants can find themselves caught between the two worlds, subject to two different sets of responsibilities and expectations. The forms these tensions take vary significantly, depending on where one starts.

A Cast of Hybrid Characters

A significant feature of the ACSYNT Institute experiment is that its human participants are people whose careers have taken them across the borders that distinguish industry, university, and government. In a sense, participants are all hybrids. Not only do these people have some understanding and respect for the perspectives that colleagues from other arenas bring to the institute, but their individual biographies also contain some notable features or events that demonstrate a commitment to working for more than the maximization of self-interest. Note, for example, how the rise of Reaganomics redirected some careers away from work in environmental and energy arenas toward business and the military. The thread of continuity was the technical content of the work. Does the presence of hybrids in the ACSYNT Institute suggest a limited future for the world of IUG? Must one be a hybrid to want to participate in the first place?

Syed Shariq, 42, CEO of American Technology Initiative, Inc., Menlo Park, California, the parent organization of the ACSYNT Institute, works full-time at the institute while on leave from NASA Ames Research Center, Moffett Field, California.

DOWNEY: You were at Ames at the time this started?

SHARIQ: I had just joined Ames, having traveled a very long and circuitous path. I graduated from Virginia Tech back in 1974, where I got my Ph.D. in operations research in the industrial engineering department. I taught at Oklahoma State for a couple of years, and then got very interested in the decision sciences area. I went to Duke and was responsible for starting and heading up their program in societal risk assessment. How does society make the social decisions of risk, and how do you value human life? All those questions concerning the socioeconomic impact of technology were the focus. Also questions of ozone depletion and whether or not there's enough risk there to worry about, in terms of cancers and other ecological effects and so on. So I did that until about 1980–81, when I decided that I wanted to leave academia to pursue a career with more direct relevance and immediate impact on the world we live in—the real world.

DOWNEY: Did that business become boring around 1980–81 because of the Reagan election?

SHARIQ: President Reagan came into office, so I realized that the environmental agenda of the nation is going to be on ice for awhile. It was also a good time to really do something different. I joined the Stanford Research Institute [a prominent consulting firm, primarily on defense matters], and spent about four years working for companies as a consultant in strategic planning and diversification/acquisition of technologies. Just looking at how technology is developed and commercialized in large and small corporations. What does it take for these big companies to acquire little companies? How are they thinking about future products and how does technology play a role? How do you price knowledge work and technologies, and so on? I did a lot of economic, financial, strategic thinking for several companies, and I also helped SRI to do their own investments in high technology areas, like biotech, VLSI, advanced materials, AI, and so on. I was an internal consultant to the office of the president of SRI.

After doing that for three and a half years, I felt I should really take my knowledge and ideas and apply them to real-world high-tech investments, so I joined the venture capital business. I spent two years at a premier investment banking company in the Bay Area. I became part of a team of four senior people who were managing a portfolio of over sixty-seven companies, with over $100 million in investments. And for about a year and a half I developed a system for them for managing portfolios of companies and monitored investments in the artificial intelligence area.

DOWNEY: So first you went one direction, academia, then made a completely different move to consulting, and then to venture capital.

SHARIQ: Yes, I spent about two years in venture capital doing that, working on portfolio selection and investment decision-making methodology in the AI/software area. So after being there I realized that most of the venture investments, with over $110 million, had been made in the 1983–84 time frame. Those portfolio companies, over half of them, were doing so poorly that the fund would eventually collapse. There's no way anybody would be able to raise funds again, so I looked at the cards and decided that that's just not going to work out. I wanted to take some time out for personal reasons, just slow down, because venture capital had gotten to be more than two full-time jobs.

DOWNEY: I bet it was stressful.

SHARIQ: So I came to NASA to head their program in artificial intelligence, with no intention of doing what I am doing now at AmTech. But the director of Ames who hired me and a couple of other people thought that this idea of bringing NASA-industry-university joint ventures together is an interesting one.

In the wake of the Challenger accident and other problems with major projects, NASA was looking for new ways to legitimize its activities in commercial terms, contributing to America by enhancing its economic competitiveness.

SHARIQ: The legal people at Ames had done some research on the idea of using NASA's Space Act authority for carrying out joint R&D projects, and decided it was a nifty idea. They wanted to ask somebody who is well versed in the private sector and also understood academia to implement it. And so, I happened to be in the right place at the right time. When I reviewed the concept, I felt that I could do it and believed it would be a valuable innovation in our economy.

DOWNEY: And government. So you've got it all. You got it all.

Paul Gelhausen, 31, codirector of the ACSYNT Institute with Arvid Myklebust, is an aeronautical engineer working full-time at NASA Ames Research Center, California.

DOWNEY: Could you give me a sketch of your own history and involvement in ACSYNT and what you're doing currently? You're often characterized as someone who really has become a champion for the code.

GELHAUSEN: I don't really consider myself a champion. I've always considered myself more of a—see, I'm of German descent, and I think that Germans are the guys that are paid to fight for you. So I kind of consider myself more of a technical mercenary. I always find something technically challenging no matter what the job.

DOWNEY: You're a soldier. You're a soldier rather than a champion.

GELHAUSEN: I think so. I hope, that's what I'd like to be. Yeah, I am enthusiastic. I started as a co-op student working here on ACSYNT. [A co-op student alternates between school and work, taking more time to get a degree in order to gain experience and income.]

January of 1980 is when I started. Boy, my boss, George, hated me because I was a terrible typist and all we had were punch cards for writing programs. I kept screwing up the cards. I'm surprised he hired me back, except I work hard. But I thought ACSYNT was a great thing. I thought it was the way things ought to be done.

DOWNEY: George told me in an interview that you were an excellent student out of Michigan. In aeronautical engineering?

GELHAUSEN: Yeah. Aerospace is what the degree is, but I studied mostly aeronautics. But I came and I worked for George and we were doing research on the VSTOL airplane [vertical or short take-off and landing]. It was more in the line of advocacy. [Gelhausen elaborates in some detail how he did design research for several different types of aircraft while maintaining an interest in ACSYNT.]

DOWNEY: It sounds like you didn't want to limit your identity to any particular type of airplane but wanted to focus on the more general engineering issues.

GELHAUSEN: Yeah, I think it's all aerodynamics, when it all comes down to it. They all fly, so they're all flown. The other thing is that I would like to think that I'm making things that are most efficient. I'm interested in making the most efficient use of resources, getting the job done most efficiently.

DOWNEY: Where efficiency includes cost?

GELHAUSEN: Cost and minimum fuel use and things like that. I grew up in the seventies with the fuel crisis and things like that. It probably affected me more than, say, the folks who work on the National Aerospace Plane [NASP, a long-distance aircraft that will fly into space], which will really suck up gobs of fuel. One thing that I hope to be able to do is to look at alternate energy sources. Methanol, those kind of things, that have less impact, maybe more replenishable and clean energy sources.

DOWNEY: There might be money for that someday.

GELHAUSEN: Someday [*sighs*].

DOWNEY: Not right now, though, not in the last ten years, not since Reagan beat Carter.

GELHAUSEN: Yes, that was 1980. Well, anyway, the way that I ended up getting involved with ACSYNT is that I always knew that we could do a better job with it.

Gelhausen then describes a three-year design competition between the United States and United Kingdom, in which he used ACSYNT successfully to compare and evaluate the proposed designs. By this point, his own identity as an engineer at Ames had merged with the code, and he became principally responsible for managing its further development.

Arvid Myklebust, 45, codirector of the ACSYNT Institute with Gelhausen, is professor of mechanical engineering at Virginia Tech.

DOWNEY: Could you start with your education and work your way up through some jobs?

MYKLEBUST: All right. Well, I'll point out why I'm in this area of computers at all. It's because I began to study in a preengineering curriculum at Miami-Dade Community College in 1964, which was very active in computing at the time because they did computing for the state. I went to school at night for four years to finish two years work. During the day I was a purchasing agent for a printing company, and I was selected by the company to learn systems programming for a computing system that company was going to buy. In those days you had to write your own software. I had a year to prepare, so I started taking courses in electronic data processing, and got a great deal of basic background in the fundamentals of computing and assembly language. I wrote software for business machines, printing orders, and things like that. The company then lost its contract, so I went back to preengineering, finished, and transferred into engineering at the University of Florida. I wanted something related to computing software but nothing like that existed, so I switched to mechanical engineering because I had a very strong mechanical background.

DOWNEY: You've talked on occasion about working with engines.

MYKLEBUST: I did major overhauls on trucks and cars, about half and half. That's what my father did, and I was working with him. So that's why I switched to mechanical engineering, but I looked for computing applications all through my undergraduate years. Later, as a graduate student, I switched to a program in kinematics [mathematical modeling of mechanical linkages] simply because that was what was making the broadest and most intense use of computing at the time.

Myklebust then goes on to describe his master's and doctoral research on the computer-aided design of linkages, postdoctoral research in Norway, and then teaching positions at the University of Arkansas and Florida Atlantic University. He found himself caught up in software design for microprocessors and director of an engineering computer laboratory. I wondered what kept him in the university.

DOWNEY: Did you think about jumping ship and going after the money in industry?

MYKLEBUST: I wasn't interested in the money. Never have been. I think the reason was that the companies I worked for while I was working through the first four years really soured me on working for companies. I'm sure there are many good companies to work for, but I didn't like the approach that some of these companies took toward their employees.

Also, I was so idealistic then, I didn't think about the money at all. As a matter of fact, I only wanted to do the research on linkages to help stimulate a research area in computer-aided design.

DOWNEY: When you say you were so idealistic, what were the ideals you were pursuing?

MYKLEBUST: I wanted to be able to accomplish something that was worthwhile, to make my presence here have some meaning. Just to go out and sell software to make a buck didn't seem to me to be too satisfying.

When I conducted this interview in 1990, I did not pursue this point further, and never realized how Myklebust connected computer-aided design to having meaning in his life until I did a follow-up interview to prepare this paper. I had visited Myklebust's farm and knew that he was passionately committed to farming with horses, but never imagined that his work at home with horses was linked to his work in the lab with computers. After discussing the series of job changes and grants that led to his positions as faculty member at Virginia Tech and codirector of the budding ACSYNT Institute, we began talking about problems in America's new emphasis in the 1980s on manufacturing.

MYKLEBUST: For me the important thing is to improve the quality of things rather than to reduce their cost. I want things to get better. I think we should pay attention to improving things for our own benefit, not just for the sake of producing stuff to sell to people. Because we want to improve the situation. Because the price of quality can't be measured. It's orthogonal to cost [perpendicular to or at odds with cost]. When we think about the things we do, the things we eat, and how we live, then what's more important than cost is the quality, the quality of our food, the quality of our life. The cost to me doesn't mean beans.

Out of a group of twenty-seven new products, we probable need zero of them. I haven't had a television for thirteen years and many times I've considered getting rid of my telephone. It's not because I'm an oddball, it's because I don't find any good reason to have it except to call people on emergencies. If you take yourself away from pop culture for a period of time, for a year or two, all of a sudden you begin to realize that the things people think are important, the goods they buy, aren't so important. But it's hard to see that when you are plugged into it.

I try and let our students know that we don't need to manufacture stuff just for the sake of manufacturing to make a profit. Even if you take every company in the U.S. or in the world and make them socially responsible, that still isn't going to stop the impact on the environment from constantly taking resources and producing stuff that always generates wastes. Somehow you have to change the philosophy of what we mean by corporations and the production of goods to be able to stop this destruction of our environment. We are doing it at an ever-increasing rate. It is horrifying. And I guess people are not going to notice it until it starts showing up on the television.

The connection between computing and horse-drawn farming became clear to me for the first time: both promise benefits to society with minimal cost to the environment.

MYKLEBUST: I was going to say the same thing about computing. If computing does anything, it helps us to, gives us time to do things better, at a very small environmental cost. Or at least it used to be a small environmental cost. Now its getting to be an enormous one because there are ten PCs in every home, just like there are ten televisions. But in terms of electricity and impact on the environment, it probably has a much smaller impact than most other machines we use. The computer can amplify our abilities not to think but to evaluate possibilities for things by computing them much more rapidly. And it ought to be used to help us instead of to make things worse for us.

DOWNEY: That's my career goal, to inject a sense of global citizenship into the corporation.

MYKLEBUST: But you need to be able to act locally. [*Hesitates, points at tape recorder.*] Could you turn that thing off for a minute?

David Grose, 43, is the leader of a design research group at Boeing Commercial Airplane Company.

DOWNEY: Could you give me a little background on your career?

GROSE: I got my bachelor's degree at the University of Kansas in engineering. I was in that first draft lottery. It was the only thing in my life that I have ever won. I got drafted out of college and spent two years as a prison guard at Leavenworth. I had a chance, because of the duty hours, to take a couple courses each semester at Kansas; it was only an hour drive away. So when I got out of the army, I went back to graduate school. By that time, I just had a few courses to finish my master's and then I started on my thesis. While I was there I got a lot of good advice from professors that "if you want to go farther, do it now because it's so tough to do later on."

So I went in and I started on a Ph.D. program in control sciences. Then I shifted to a doctor of engineering program, which NASA partly sponsored, that was design oriented as opposed to basic research oriented. It was more of a systems, system design, system analysis, that type of thing—the bigger picture. So I got a fellowship grant and went to NASA Dryden and did my research in active controls of flutter suppression, which had an interdisciplinary flavor. So when I finished up there I went to Gates Lear Jet in Wichita, where I headed an engineering group in flutter and vibration. I was there about three and a half years, I guess.

DOWNEY: When did you finish your doctor of engineering degree?

GROSE: I finished at NASA in 1978, with the degree effective in 1979, and I stayed at Gates for a little less than four years. I had the responsibility for the flutter certification of the Lear 55.

Then I got the courage to start a small company with some other guys trying to apply aerospace technology to alternative energy. Kansas was primarily oriented at that time to energy storage and wind energy because the wind blows all the time. We built a large prototype of the system and tested it until it was damaged in a wind storm, which are also common in Kansas. I guess I was in that a little over two years. Unfortunately, the timing was bad in the sense that when we started there was a lot of interest in alternative energy and after two years Reagan became president and the interest in funding for those type of things went downhill rather fast.

For monetary reasons I went to Boeing at that point. The first job I had there was program manager on an air force program on artificial intelligence. What they were trying to do was apply AI techniques to automate aircraft manufacturing.

DOWNEY: They were doing that ten years ago?

GROSE: Really wasn't what I wanted. I went there to actually apply some of the control background in robotics, which was kind of an emerging field at the time. I was there three days and literally got shanghaied on a proposal effort [seeking a defense contract], and when it was over I was hoping they wouldn't win it but they did. Well, I did that for about a year. The technology was not anywhere close to the point that the expectations were. And I actually recommended to the Air Force that they terminate that program and focus on some of the areas that needed to be matured before they try it. They cut the funding but they kept the same objectives [*laughs*]. They started to focus in an area that I really had no interest in, integrated database management and things like that. So I got them on schedule, under budget, and we got a deputy program manager that had a background in that to take it over. I went and took advantage of an opportunity to lead the flight controls research group at Boeing Military in Wichita.

Spinning Off AmTech from NASA

The first step in building this R&D world of industry-university-government was to establish a new form of organization to function within it. Establishing a new form of organization is no easy matter, because the organization must also be theorized in terms of the categories of law. A world of R&D that did not fit within the world of law could not exist.

SHARIQ: The idea of AmTech as such didn't come out of any of the congressional activities or any mandates from the president or from higher-ups at NASA. The Space Act has been around since 1958, when NASA was created. At the time, we were under the fear of Sputnik and there was tremendous pressure to build technology and compete head-on with the Soviets. The law was and is one of the strongest pieces of legislation, providing unprecedented authority for the agency to deploy resources and do things that other civilian agencies could not do.

Strangely, the way NASA chose to do most of its business was different than any other agency. So NASA really does business an old-fashioned way, even though the Space Act allows the agency broad authority to be innovative and pursue alternative strategies. The common mode is to use grants and procurement mechanisms [purchases]. NASA does distinguish activity outside of grants and procurement as Space Act agreements.

During the past thirty-two years, the Space Act agreements have been used only when NASA entered into an agreement without committing any funds. Because they felt there was a clear boundary—that, if you used money, you used grants and procurement. But for doing novel things—

leasing a facility, using a wind tunnel, or letting McDonnell-Douglas or Boeing or 3M use microgravity time on the shuttle—you can do joint endeavor agreements. But in all of these governments, federal funds are never involved.

So when I took on the challenge of developing the joint venture program in the fall of 1987, it was just an idea. We needed the Space Act to fund joint ventures, for the Space Act had never been used to pursue such a program.

The notion of venture is normally used to describe investments that are risky but promise big payoffs. A joint venture shares the risks and benefits.

R&D in the AmTech World: Market Oriented, yet Nonprofit

SHARIQ: During the early years (1987–88) we built a body of knowledge on intellectual property law, procurement law, laws on policies and procedures governing transactions among companies and universities and government. And all that led to a unique and unprecedented set of policies, guidelines, procedures for joint ventures.

After two years of work, back in last fall [1989], we realized that there is just a tremendous potential. The country needs this kind of transaction mechanism for R&D joint ventures among government, industry, and university. And the idea we were bringing to it, which is the market-based transaction mechanism, became stronger and stronger. The more I talked with people, the more I got support for it: "Good idea. This country needs it."

So what you see here is a market mechanism for doing three-way joint ventures, sharing property rights and resources for common R&D goals but different end uses for the resulting technologies. Nothing is new, but collecting them all in one package is new.

DOWNEY: Wait. How does it work, if you're going to be a venture capitalist in a joint venture? A joint-venture capitalist, that's what you are?

SHARIQ: That's what we've become. Nonprofit, too. We realized nobody would know us at first, so what I did was I used my contacts in business, industry, and within NASA to pull together a joint R&D project. The first joint R&D project came into being because I knew a colleague at Ames. She was the one who really wanted to do it. I said, "Hey, why are you spending $200,000 a year on a grant? Why don't you multiply that through the joint venture process?" And so the whole thing got started. The second institute, the ACSYNT Institute, is pretty much the same way. I talked to a few selected people I know.

We said to these people, "We're not open for business right now, because we're still trying to work the bugs out the system.'' But we want to have some enterprising souls to work with. We can provide benefits for them, because AmTech offers a lot of free services: legal and financial research, deal-making negotiations, and so on. All of the contract negotiation and the entire deal package was put together by AmTech staff at no cost to Virginia Tech or other participants.

What we are doing now is marketing. I looked at the NASA budget for 1991 and made presentations to people in Washington at NASA headquarters whose money eventually winds up at the NASA research centers: Ames, Langley, Lewis, Goddard. We're not looking for lots of projects, three or four this year at the most. Each joint venture package is currently done in a customized way. We are still learning from these experiences.

People I talked to in the Council on Competitiveness, on the Quayle Council, or in the White House, they'd like to use this as a prototype.

DOWNEY: To keep it small, but make sure it's good, so you can show it as an example, a successful example?

This was the first time I had heard of the Council on Competitiveness, an advisory group legislated by Congress and with members from industry and universities appointed by the president. As I read its reports, I began to worry about building economic nationalism into AmTech, for the Quayle Council had already established a reputation for conceptualizing national issues in business terms. Its influence during the Bush administration became an issue during the 1992 presidential campaign. No formal connections between AmTech and the Council on Competitiveness were ever established.

SHARIQ: So the idea of establishing a nonprofit came because when I was talking to many, many people, it was very obvious that this organization must be a contractual party to the whole agreement. I found through a year's worth of legwork, many trips to Washington, that a group of trustees would help establish this organization only if it was a nonprofit. These people were very enthusiastic, and they would say, "Okay, if you are going to build a nonprofit, we'll be happy to serve as trustees.''

At the time I asked them I had known each of them for about two years, and had maybe five or six meetings and phone conversations. And I said, "Look, we're moving toward a problem here. We need to create a new organization so it can have its own destiny. Its destiny cannot be tied to NASA, nor can it be tied to the university or to industry. I asked them to work with me to create a fourth sector of the economy.

DOWNEY: Yeah, that's what's happening here. That's why I'm interested.

SHARIQ: It's not so different. There are lots of nonprofits. In fact, the independent sector in Washington, it's been there for a while. Probably you know, you were there. But what's not there is the market orientation.

DOWNEY: The market orientation, no. A nonprofit, market-oriented sector. [*Hesitatingly.*] A national concern that is realized through the maximization of private interests.

The implications of the concept are dramatic. Once the nation is reconceptualized in economic terms, AmTech and other similar organizations in the world of IUG actually become more representative of America than the federal government. While AmTech functions solely as a national, economic actor, nothing more, the government has many other dimensions: political, military, police, and so on.

SHARIQ: AmTech combines the public and private interests.

DOWNEY: You are trying to encourage private interests to pursue a public benefit, and you need to have a vehicle. [*Pondering.*] It has to be, this I hadn't thought of before, a nonprofit organization. If it were a profit-making organization, then there would be some distrust of its activities.

SHARIQ: Absolutely. I couldn't go into Washington. I couldn't go to the White House. My trustees wouldn't donate their time.

At the same time, however, I have difficulty attracting staff members to a nonprofit organization. Because there's no bonus pools, no personal wealth to be made. This is not venture capital. This is not shared ownership. This is a privately managed nonprofit, and there is no membership. It is very much of an anomaly. There's no precedent that I know of for it. I looked high and low at nonprofits and congressionally chartered corporations. I looked at the institutional arrangements that we have in our society, the corporation, the idea of agency, beginning from the late eighteenth century down to today. There is no place for something quite like this.

As we proceed down this path, I am trying to figure out What we are really trying to do and innovate. And what I'm following is an instinct, which says that there's a need for an organizational contract that can make the area of public-private R&D transaction efficient. And nothing makes it efficient unless it's market oriented.

DOWNEY: I'm fascinated by this ideology, by this institutional innovation whose justification is very much particular to our historical circumstances. If we didn't have the Japanese out there, this would not exist.

SHARIQ: Yes, I'd have no reason to do it. There would be no market for my idea, or for that matter, I would be told, "We don't need it. We are doing everything fine."

DOWNEY: Also, if the Soviet Union had been competing against us successfully, there wouldn't have been a need for you either, because we would have seen the battle as one between capitalism and communism. But Americans tend to perceive the Japanese as beating us at our own game: "If they're beating us at our own game, then we need to change our game."

SHARIQ: Or some way for us to do better.

DOWNEY: But there's still antitrust law. I mean there's still the whole American cultural tradition of market competition among separate property holders that you have to confront, as we saw in the ACSYNT Institute meeting earlier today. I mean, the industry guys didn't want to share their data with one another. One guy choked on naming the computer program his design engineers use. He couldn't say it because there are still proprietary issues. And that's why I was thinking about the problems that you must run into structuring legal contracts, because you've got a mess of cultural issues that have to be resolved in formal language.

SHARIQ: Absolutely.

Writing the New World into the Computer Program

The world of IUG also depended on integrating the ACSYNT code into industry practices. Remember that NASA engineers originally wrote it for research purposes only, and university researchers improved it. Semiannual meetings of the ACSYNT Institute brought the government and university people together with the industry people to review progress in rewriting the code, primarily through visual demonstrations on computer workstations, and to define objectives for future versions, or releases. Observers from other companies were also permitted to attend during the first day. At the third meeting, held at Ames Research Center, in the heart of Silicon Valley, Paul Gelhausen and Arvid Myklebust, codirectors of the institute, were hoping both to get industry members to commit themselves to use the code and to attract some new members.

GELHAUSEN [*opening the meeting*]: Let me first say, "Welcome." We're waiting for software to show up for our workstations so we can show the demos here this afternoon. We were supposed to have that all here yesterday and, you know, everything had to go bad, and that's where I was this morning. It will be here at noon, and I'll think, I'll skip lunch and we'll get it up and running for the afternoon demos.

The objectives of this meeting, my overall objective, is try to get industry participants to really come together and start giving us more feedback, I guess, on what we've got going. We spent the first year kinda like our grant years, where we just have been going off a little bit unguided, I guess. [When NASA gives a grant, as opposed to a contract, it is not permitted to direct the research.] I'd like to get more guidance in from the industry people. It's healthier if there's more industry participation, because it will help ACSYNT to become more useful to all of us. So one of our main objectives, I guess, is to get more dialogue going, I guess, with the industry folks.

This morning Arvid's going to talk about the technical accomplishments, and show off in viewgraphs and words what we have done with an overview of the upcoming release. Then this afternoon we'll get to see a demonstration of the upcoming release and some of the tools that are now available. Then we're going to have time for member input, which will include myself, and then we have a special guest, Boeing Commercial, I hope, has got a little bit to say, maybe, and then anything else from other members that are here.

Engineers at Boeing Military and Commercial working under David Grose had done a great deal of work improving the code in order to use it. Gelhausen was hoping that Grose would influence other members and prospective members to get involved and work together. However, Gelhausen raised it very tentatively because all the Boeing work on the code was proprietary. Would they share it?

GELHAUSEN: Tomorrow morning, at our meeting for members only, we will have a discussion of upcoming research and new ideas for research. I think we really need to spend some time together to generate some communication, to generate dialogue between the different members. So hopefully that will happen during the demos this afternoon, during the cocktail hour at dinner tonight, and then tomorrow afternoon. There's a lot of open space in this agenda that I think is mostly for kind of getting the input. With that, I'll introduce Arvid.

MYKLEBUST: All right, I guess the central concept here is to improve computer-aided conceptual design. There have been many objectives, but I'll just list three here that we've concentrated on for some time. First, we want to have a highly interactive graphics interface for conceptual design of aircraft. That should be obvious.

The significance of a highly interactive graphics interface for conceptual design is probably not obvious to most readers. Having a graphics interface means making it possible to generate visual images of proposed designs. Making this interface highly interactive means that engineers could make changes to the design and then view the results quickly and easily. The world of IUG thus offers industry a technical capability it did not have previously.

MYKLEBUST: The second objective is that we want to enhance the analysis and design capabilities of ACSYNT. So that the kinds of things we do on the screen, graphically and geometrically, can immediately be analyzed and, likewise, the kinds of things that come out of an analysis will be immediately represented as a geometric aircraft model without all the intermediate steps of putting in points, lines, curves, and surfaces, and all that activity that takes so long. Of course, the reason for that is, we want to be able to

> have very rapid design cycles, and to give the best possible design feedback we can have by doing that.

Representing shapes visually on the computer in most industries means drawing them one line at a time. The idea here is to bypass this step and have the computer draw the aircraft images automatically from data taken from the analysis process. NASA engineers originally wrote the ACSYNT code to do analysis, which involves figuring out combinations of characteristics that will produce an aircraft design that should perform properly with minimum weight. Industry members want additional forms of analysis because, unlike NASA, the companies also build airplanes. In addition, since ACSYNT was originally a research code used by a small group of people, its authors did not always follow rigorous standards for programming, much to the consternation of industry. Achieving the world of IUG means that every member must be able to see itself in the code.

> MYKLEBUST: The third item, right here, is that you'd like device-independent computer graphics. As a result of that, we now have one version of code that runs on all our workstations, the only differences being a MAKE file at the beginning of it. The code is all the same.

The concept of device-independent computer graphics is a crucial one here. Industry engineers use many different kinds of computers. Writing a program that is device independent means that it will work on everybody's computers. This technical strategy helps construct IUG as a collaborative world by rendering insignificant one of the differences that separates the companies.

After giving his introduction, Myklebust launched into a half-hour lecture about how his university group is using the latest concepts in computer-aided design. These concepts included representing complex curves and surfaces, intersections between surfaces, various forms of color, shading, and lighting, and complex aircraft shapes. He also described changes that students had made so that the code might be easier for industry people to use. Except for Myklebust's colleagues and students, the audience of forty people knew very little about computer-aided design but loved being able to see visual images of aircraft designs. He then turned his attention to the half-dozen prospective members present.

> MYKLEBUST: All right, for those of you that are new, let me review a few words about the ACSYNT Institute. The intent, of course, is collaboration between NASA, industry, and the academic world in improving aircraft conceptual design. The participants share the technology developed by the institute and the source code is distributed under license to the participants. That's a rare occurrence these days, and it's a bit of an experiment here to see how well this works out. We're very strongly committed to supporting

this. Not only supporting what we're doing but supporting the source code itself. We need feedback, to know how we can help you, help the companies to be able to benefit by this.

This last paragraph reveals much about the technical strategy for producing a world of R&D that permits members to be both inside and outside at the same time. First, participants receive everything they need to modify the code for their own purposes because they get source code. Normally when one buys software, such as the WordPerfect I am using now, one can only interact with the code, not rewrite it. Giving the source code to all members brings everyone into the writing process, enabling them to write into the codes they possess both the collaborative world of the ACSYNT Institute and the local worlds of their companies.

Second, by providing maintenance support and assistance for the ACSYNT software, university faculty and graduate students blur the boundary around their activities and status as researchers. In exchange for accepting a new type of task, one that is normally an industry activity, they receive substantial financial support for their research. But, as Myklebust pointed out later in an interview, this arrangement is not without its costs, for AmTech takes ten percent off the top of everything.

MYKLEBUST: By forming this institute, we do get a great deal better leverage, a better return on your investment, than you would yourself in the companies. If you doubt that, you should talk to David Grose at Boeing Commercial Airplane now. He can talk to you about the advantages of doing it this way. We get support from the Commonwealth of Virginia, and we have much lower research and development rates at the university than you do in companies. All three of us working together can make significant strides at a much faster rate than companies can, I believe.

At present, it's open to U.S. businesses, universities, and government agencies only. We've had a lot of inquiries from people outside, but that's currently the policy.

Rolls Royce, for example, sought membership for some time but was denied on the grounds that it is based in Great Britain. I never heard any discussion about how to define the nationality of a multinational corporation.

Why Industry Engineers Participate

The industry engineers participating in ACSYNT are trying to enhance the influence of conceptual design, the earliest stage in the design process. Conceptual designers generally already have one foot inside the company and one foot outside it, in the sense that they are nonconformists, the "cowboys" lost in the world of aircraft design. Conceptual design groups are small, in sharp contrast with the more powerful groups in the subsequent stages of preliminary design and detailed design, where the groups number in the hundreds or even the thousands. Using an enhanced ACSYNT program that synthesizes considerations from different disciplines while also producing visual images may help conceptual designers better justify their choices of proposed designs to company managers. But integrating ACSYNT into aircraft companies also requires blurring some established internal boundaries.

GROSE: They asked me to head up a concept development group in advance product development and the biggest fundamental problem we had was what they wanted to do Boeing did not have tools to do it with in a timely manner. I was familiar with ACSYNT from when I was with NASA from the early seventies. We started to get into it and that's when we started to see how scrambled the code was. You know it was originally never really intended to be anything but an analysis tool at NASA and so there was really no configuration control or those type of things involved. The programming was representative of the era of fifteen years ago. So we bit the bullet and fixed it to the point that we could maintain it and work from there. I guess we started on it right about the first part of 1988.

I think it was around September of 1989 that Boeing made the decision to reduce the military part of the company. They had just finished about a ten-year, $2-billion expansion of the headquarters for military R&D in Wichita, facilities and everything, laboratories, the whole bit. It is not being utilized in the way it was intended. You hate to see that kind of an effort and then just kind of walk away from it, but the realities, I guess, for Boeing were that wasn't the place to invest their money—in the military side. They had about a fifty-fifty balance five or six years ago between military and commercial, and now it's ninety-three percent commercial, seven percent military.

DOWNEY: Could you give me a quick sense of the organizational structure that you're in?

GROSE: It's configuration development and engineering analysis for airplane design, and the conceptual design work is scattered all over the place. Each airplane project really does things totally different from every other project. When you have people spread out, you know, they are unfamiliar with how it gets done in different projects. So Boeing Commercial decided to create Configuration Development and Engineering Analysis as a group in its own right in the engineering technology staff.

DOWNEY: How big is the configuration development and engineering analysis group?

GROSE: It's got about 150 people in it.

DOWNEY: How big is the whole engineering technology staff?

GROSE: Oh my. Let's see, what's the population of Seattle? I would guess probably four to five thousand are involved in R&D work. Aerodynamics, propulsion, avionics [electronics and flight systems], and structures are the largest of the specialist R&D groups.

Now, they started a core group, which is supposed to focus on not what's going on now but what we anticipate in the future. We're trying to find a way of not only doing a better job of that initial definition of the design, which all the disciplines now work with and analyze, but also trying to find a way of integrating all those disciplines to where the work that's done is consistent.

A few minutes earlier, the head of a conceptual design group at Lockheed, Dalton Sherwood, had walked into the room and was listening to the interview. He jumped in to explain the major barrier that conceptual design faces in seeking a higher profile and greater authority in the design process.

SHERWOOD: This requires a culture change because each of these technology specialist groups are all used to keeping control of their numbers very closely, saying, You tell me what you want, I'll work on it and give you the numbers back. They did not want you to know how they did their study and what their assumptions were and they couldn't care less what the impact was on the overall study.

GROSE: I would say that very thing right there is the thing that hampers trying to do what we're doing more than anything. Because one thing computer-aided design or analysis has done is that it's integrating the data. The trouble is, some disciplines want to avoid that because they feel they're losing control of their own destiny. For example, in Wichita, the propulsion group was really opposed to what we were doing with ACSYNT, and yet in Seattle they're one of the biggest supporters of it.

Some want to get their software activity integrated into this thing, some don't; they are not going to give you their software. You know, you just tell them what you want and they'll give you the data type of thing, and that's not the way to design.

SHERWOOD: I've had guys curse me because I was taking their job.

GROSE: In reality, he was making it better, they just didn't realize it.

Getting the Code into the Company and the Company into the Code

GROSE [*in a presentation at the institute meeting*]: The work that was being done at Boeing Military was trying to look at restructuring ACSYNT so it could be integrated into a larger setting in our system. The primary issue there was to identify explicitly what was in it [*general laughter, since ACSYNT contained many mysteries*], and provide some kind of rigor and structure so we'll be able to add to the software in more of an automatic sense.

We have basically gone through the program line by line [*laughter again,* *because the original code had 60,000 lines*]. What we tried to is, in every case where there's equations, through conversations with Paul Gelhausen, we found out the reference and got a copy. Cases where an equation showed up, that it was not in a referenceable document, we then derived it to ensure its correctness. And we're embedding all these comments in the code so that people can look at a section of code and see the reference material. We'll have a set of reference materials that then they can go look at if they want more details on the issues there.

Again, we're trying to deal with the fact that, when engineers get involved in a design project, they may have a pet way of calculating a particular parameter, and they'll say, Well, how's this doing it? And it's not an issue that you're trying to promote the one over any other, but you can simply now readily show them what is in there.

An important feature of the ACSYNT code is that it is divided into large building blocks of subprograms, called modules, that are particular to each discipline. Each module is roughly independent of other modules and can be used or ignored in particular projects. The very structure of the code thus makes it possible for industry members to work within the world of IUG while remaining within the world of the company. That is, individual members can write, maintain, and use proprietary modules while the institute produces modules that all members share collectively, writing their collaboration into the code. Organizing all of this, however, will not be easy.

GROSE: Now the key to the whole thing is that we have to decompose the analysis modules to where you have fundamental building blocks of code and then pull the appropriate one in at the appropriate time. I think with the realm of problems we can envision with lots of people in the company trying to work with this, what we were trying to do is add as much flexibility as possible to it at the conceptual design stage.

And this will help us to try and integrate this into other software systems downstream in the design process, to start to pick up the information in them and couple better with their models. So this is the direction we're trying to go now, so we don't find ourselves spending all our time trying to get the program to work the way we want to get the answers, but we have the opportunity to do the fun part and that's actually to work the design problem.

Other conceptual design codes frequently do not distinguish so clearly among the disciplines. Without the modular design in the ACSYNT code, then, the ACSYNT Institute and its collaborative world of IUG could probably not have been possible.

GELHAUSEN: Well, I think that's one of the real key features of ACSYNT now, its modular design. Nobody else has done that.

DOWNEY: How do others do it?

GELHAUSEN: I think it's like one guy that sits down and kind of puts things together, pulling together different types of methods.

DOWNEY: Puts the modules together?

GELHAUSEN: No, there's no code that's as modular as ACSYNT overall, from what I've seen; my experience is in helicopter codes. You know, the guy is going along and he's thinking about aerodynamics and then he sizes his engine in the middle of his aerodynamics for some reason, you know, it's not as well organized.

DOWNEY: It's not subdivided by discipline?

GELHAUSEN: Those codes tend to be very inflexible or if they're flexible it's because you've got to have the guy who wrote the code with you to be able to modify it. It think my generation is always saddled with somebody else's code.

DOWNEY: Well, I watched the guy from Boeing, David Grose, paint kind of a nasty picture of the structure of the code and its documentations.

GELHAUSEN: Well, it's true. I mean, ACSYNT's documentation is pretty thin, I think because it's research code, but it's easier to justify ACSYNT than probably any of these other codes, except that the other codes were developed in-house in the companies. You've got, you know, people who say, "I know that the results of this code predict this and I trust that because we've done this before and it's been right.'' ACSYNT, on the other hand, was never in Boeing before so they're trying to justify it.

How Blurring Boundaries Transforms Government and University

By participating in the ACSYNT Institute, NASA Ames engineers gain the opportunity to direct university research, which they cannot do in a grant relationship, while university researchers accept the burden of delivering products.

DOWNEY: At what time did NASA Ames people say, hey, it would be nice to have a graphical interface. How did that come into the picture?

GELHAUSEN: We had always been playing around with graphics and doing graphical things and trying to make pictures of what our airplanes looked like. We've got some interesting pictures of airplanes with the tail flying alongside the airplane because something the optimization code did or some other bit of code that somebody put in, that kind of thing. So we, we'd been working on doing the graphics stuff.

At one time ACSYNT actually did have graphics in it. Sometime after 1975 they lost the punchcards that the graphics routines were on.

DOWNEY: Really?

GELHAUSEN: Yeah. So that was kind of depressing. I kept seeing all these great three-dimensional pictures of airplanes that came from ACSYNT but weren't there anymore.

Gelhausen described the initial encounter between his boss, Sam Wilson, and Arvid Myklebust, that led to a grant to write the graphical interface for ACSYNT. This technical work, including an initial collaboration between NASA and Virginia Tech, took place before AmTech and the ACSYNT Institute were founded.

GELHAUSEN: I was skeptical at first because I didn't know, but I'm generally skeptical because no one knows ACSYNT as well as I do. Or me or George, or Gregory down the hall. But anyway, I think I was really pleased with the professionalism of Arvid's students in putting together that first version of the graphics code.

We need now to get more interaction with Virginia Tech. Mark, my assistant, and I need to get in the middle of the graphics development somehow so that we can make the aerodynamics be fully interactive.

Linking graphics and analysis is a key point for the world of IUG. The graphics portion of the code is located in a separate module, thereby embodying the distinction between NASA and Virginia Tech. Gelhausen was fantasizing about blurring that distinction in the code, which would somehow involve blurring the distinction organizationally as well, through "more interaction."

DOWNEY: Boy, I see! See, this is what I was talking about. If you look at the actual development of the code over the past several years, you can see the various groups in it. In the newest versions, for example, there's Gelhausen in there, for your interests are making their way into the code.

GELHAUSEN: Yeah, because the earlier work was all grant.

DOWNEY: All grant?

GELHAUSEN: See, a grant is where I'm not supposed to interact too heavily. I went back to Virginia Tech and gave talks about what I'd like to see and where I'd like to go, but it wasn't until the ACSYNT Institute came along that I could go back and say this is what we have got to do.

In contrast with Gelhausen's technical vision of more interaction, Syed Shariq understands problems and formulates solutions through a legal discourse.

SHARIQ: We learned some things that we didn't know before we wrote the contract between these three parties. For instance, that technology rights issues come up when a federal employee spends time at a commercial company. What happens is a joint invention can have two authors, one a federal employee, the other a company. What happens to those rights? How do you negotiate *a priori* the disposition of those rights? There are certain federal laws covering federal inventions. But what about a joint invention? We are coming into some things that are fascinating, where we can make some contributions.

One thing that's happening is that there's more management on the projects we do, because joint ventures are managed differently than grants. In government, the idea of grants means you give the money and hopefully something comes out of it. You may not get anything.

DOWNEY: You cannot ask for deliverables.

SHARIQ: In a joint venture it's not the same thing. It is an obligation on the part of industry to join hands with government to comanage the project. And the university has to take direction and be managed somewhat more than is customary.

DOWNEY: Which can raise a lot of tension within a university. I think Arvid Myklebust regularly has to justify how his work on the ACSYNT code and in the institute make legitimate contributions to engineering research. There always seems to be a tension there. Of course, it's a tension that most of his colleagues face in their own way by taking industry money. So it's not an unusual thing. This tension has been around in a big way at least since World War II.

SHARIQ: The industry investors in the ACSYNT Institute do get to manage the research somewhat. Also, students get exposed to real company people. They will probably have better jobs/contacts because of the institute. Plus, Virginia Tech gets rights to royalties that come out of commercializing this software. So, for the university, the benefit from accepting some outside management is there. In addition to normal teaching, research, publications, promotion, and tenure, it can expect to place its students quickly and can look forward to royalty revenues down the road.

Conclusion: Success in an Economic Idiom

My fears about the world of industry-university-government reinforcing national chauvinism stem from conceptualizing entirely in an economic idiom. But if the organization were defined otherwise, would it ever get off the ground?

DOWNEY: Will you be able to solve all these problems?

SHARIQ: See, we have taken a very basic approach. We really will not solve the ultimate question of ideology. We cannot solve even the many questions of law and policy. I think if I was standing today in front of Congress, I'm sure we would be shut down by somebody or other, for some reason or other. So we really need to take a more pragmatic attitude: Let's just hide and do it under the legal banner of the national authority that exists already. Let's get it to a point where it's working well enough. Let people come and kick tires and look at it. And then they can decide whether they want to do it or not.

But rather than trying to publicize it prematurely, or "before its time," we're just doing it, in a real world, with real projects. On the other hand, it's an opportunity. In the many studies that have been put together on U.S. competitiveness, written by bright, competent people at MIT or Stanford Research Institute or wherever, the big question is always implementation. Who's implementing these great ideas? What's being done? Not enough ever gets into implementation. In 1980, legislation came along that gave universities and nonprofits the rights to retain federal technology developed under federal grants. Then the Technology Transfer Act came in 1986, which gave some impetus for government to transfer technology to the commercial sector. But the mandate for implementation and specifically through the market orientation, the incentives that could really bring these parties together, are not there.

DOWNEY: So how do you define success?

SHARIQ: As yet there is no clear indication of how you measure success in technology transfer. Where's the benefit? How do you quantify it? Meanwhile, in our system of doing things, we have located success in the sharing of resources. We have built indicators of success into the design of the joint venture: the commitment of resources by industry in return for technology is a fundamental requirement for successful commercialization, assuming that the joint project produces good technologies.

Consider how a project looks at the beginning. From the government's point of view, if a project is doubled in scope the industry commitment ensures that twice the resources have been invested. So just by having additional parties in the deal means that the accomplishments will be much bigger than any one party could do by itself. So there's efficiency built in here, in that sense that, why duplicate the same research separately in a corporate lab and a federal lab? Why waste the R&D resources of the country? It's actually a triplication here, because the university is involved, too. So this way R&D resources can be conserved and dedicated for something else that is important. This in a sense is a justification for joint R&D and at the same time a built-in or designed-in implementation of the philosophy that ensures success at the start. That is where we measure it, not at the end.

The confidence in this measurement comes from the fact that the companies are putting their own earned income on these joint projects. We don't allow them to put in federal money they might receive from work on government contracts. They cannot subcontract this, either. None of the government money can flow right back into these joint projects. This is one of the essential requirements. So, as long as industry is putting their own hard-earned money on the table, they clearly would not do these joint projects unless they see opportunities for profits. Each joint project, therefore, becomes successful by definition, through a commitment to a transaction mechanism that is based minimally on the needs of parties to fulfill their specific self-interests—thereby creating a market-based collaboration between government, industry, and university.

I am not satisfied with this account of success for the world of industry-university-government. I am not happy simply if the R&D projects are well-supported and the participating companies see the opportunity for profit. I understand that economic returns constitute a minimum condition of existence for these organizations. But if success is limited to an economic idiom, then the ACSYNT Institute becomes nothing more than a convenient mechanism for pursuing the sectarian interests of industry, university, and government simultaneously. The underlying sense of citizenship that also motivates participants and the boundary-blurring vision they build into both their organization and their code become short-term rationalizations for the longer-term maximization of self-interest.

Instead, why not let it get really big? Why not allow membership from other countries and make the world of industry-university-government a place where conceptual designers work together to improve the tools for reducing costs, reducing fuel use, and reducing emissions into the environment? The step to a global world of industry-university-government is not that much harder to conceive than the step already taken.

SHARIQ [*responding to the author after reading a previous draft and unhappy with using the above passage to conclude*]: You are right, that's where we need to get to, eventually. However, given the enormity of this challenge, it really comes down to the fact that we don't know how to make giant strides. All we know is how to take modest steps: a journey of a thousand miles must begin with a first step. Socioeconomic innovations and the creation of market mechanisms are complex problems, as the struggles of countries in the former Soviet Union and Soviet bloc demonstrate. Reimagining R&D in America's future is a problem of the same complexity. Nevertheless, while we think of better ways to resolve these complex problems, we need to proceed with and encourage responsible innovation and experimentation to foster solutions through experience. AmTech is one small effort in that direction.

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