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Managing Technological Leaps: A Study of DEC's Alpha Design Team

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ABSTRACT

R&D organizations are always trying to make those critical 'leaps' in technology that will give their products significant competitive advantages in the marketplace. The dilemma is not in identifying what these possibilities might be, but in getting the business organization to commit to one of them while there is still considerable uncertainty as to whether they have chosen the 'right' path or its feasibility. The development of the Alpha chip at Digital shows how a maverick group of technologists was able to overcome management's initial cancellation of its efforts and build the political base that allowed them to achieve their significant technical advances. Only when the team learned to integrate their technical goals with the company's strategic business interests were they successful at shifting management's attention from relying on their 'core' technology to relying on promised, but unproven, advancements in a much less familiar technology.

All you had to do was attend the 1992 International Solid-State Circuit Conference (ISSCC) in San Francisco to know that something special had happened. Dan Dobberpuhl, the technical leader of Digital Equipment's Alpha Chip design team, was simply being mobbed after his presentation. In the words of one German reporter, "Dan was under siege!" Technologists from many of the world's most respected organizations, including Intel, Sun, HP, IBM, Hitachi, Motorola, Siemens, and Apple, were pressed around him, anxious to get or at least overhear his responses to their follow-up questions. As one of the chip's lead designers described the conference scene to his colleagues back at Digital, "You'd have thought they'd found Elvis!" Clearly, the Alpha chip was being heralded as one of the more significant technical developments in the microprocessor industry in recent years[1].

But how did this team of designers accomplish such a noteworthy advancement? Why were they successful? There were many other excellent microprocessor design teams throughout the world; there were even other chip design teams within Digital. From a managerial and organizational perspective, what enabled <u>this</u> group of designers to make <u>this</u> technological leap? Was this technical achievement a deliberately planned, well-managed, well-organized effort; or was it more accidental, mostly a matter of luck in that the right people happened to come together at the right time to work on the right project for several years?

ALPHA - A HIGH PERFORMING TEAM

One could easily argue that the Alpha team was successful because it possessed all the elements normally attributed to a high performing team. After all, the team members had a clear goal with a shared sense of purpose to design a Reduced Instruction Set Computer chip (i.e., a RISC chip) that would be twice as fast as any comparable commercially available chip. The team leadership was strongly committed, highly respected, and very credible both technically and organizationally. The team members were also extremely motivated, dedicated, technically competent, and tenacious about solving problems. More importantly, the individuals functioned as a cohesive unit, characterized by a collaborative climate of mutual support and trust, team spirit, and strong feelings of involvement and freedom of expression. They became "psychologically close," communicating effectively with one another, working hard together, and valuing each other's ideas and contributions.

While it is certainly useful to generate such a descriptive list of high performing team characteristics, the more critical questions surround the creation and management of these attributes. How, in fact, does one establish and manage these characteristics over time? How did the Alpha team initially achieve and ultimately maintain its strong, unified sense of purpose and commitment to such difficult and risky technical objectives? Why were these very creative engineers able to work, trust, and communicate with each other so effectively?

In addition to this focus on team dynamics, it may also be constructive to learn how the Alpha team related to other outside organizational and managerial areas, especially since so many other technical teams that have enjoyed these same high performing characteristics have ended up unsuccessful in their efforts. For example, although the Alpha design team was strongly committed to delivering its technical advances within an extremely tight and aggressive development schedule, the team did not have the strong, unqualified support of senior management, many of whom were very skeptical about what the Alpha team was trying to do. Furthermore, Digital management did not give the team any additional outside resource support from other technical or system development groups. For the most part, the team was not viewed by management or by many other groups within Digital as a well-disciplined, high-performing team. To the contrary, these individuals were often perceived as a somewhat arrogant, albeit respected, "band of high-powered technical renegades." The Alpha team members may have trusted each other - they did not, however, trust management. Yet, despite these apparent obstacles, the team was incredibly successful! How come?

HISTORICAL BACKGROUND - A CHIP CALLED PRISM

To fully appreciate the success of the Alpha design team, one has to understand more completely the historical context in which this technical effort took place. Many key members of the Alpha team had originally worked together for many years, under the leadership of Dan Dobberpuhl and Rich Witek, the chip's chief designer and chief architect, respectively, to design a new RISC/UNIX architecture that would be the fastest in the industry. They had hoped that the design of this new microprocessor would provide Digital the basis for developing and commercializing a new, more powerful line of computer products. Having been the major technical designer behind the first PDP and the first VAX on a single chip, two of Digital's most successful product platforms, Dobberpuhl had been able to attract some of the best technical minds to work with him and Witek on the design of this new RISC chip, including Jim Montanaro, one of the chip's lead designers, and David Cutler, the technical leader behind the development of a new operating system for the chip. Given his history of success within Digital, Dobberpuhl was highly credible within both the technical and managerial communities. His informal, reasonable, but pacesetting technical leadership also made working for him very appealing to other competent technologists.

This developmental effort was not the only attempt at getting Digital into RISC technology, but after several years, the various competitive activities conceded to Dobberpuhl and Witek's RISC design and microprocessor architecture code named PRISM. This convergence around PRISM, however, did not end the team's difficulties. Since DEC's VAX technology was still flying high, the need for this new RISC architecture was not very great. And as long as DEC's computers were selling well enough to meet projected revenues, the case for developing a whole new RISC-based line of computers to complement DEC's already successful VAX-based machines could not be made convincingly to Digital's senior executives. Moreover, one of the major assumptions within management was that CISC (Complex Instruction Set Computer) technology would always be better and more preferred than RISC technology. As a result, it was hard to marshal much managerial interest in or support for PRISM. The design team felt that it was constantly being "battered around," having been stopped and redirected many times over the course of several years.

Over this time period, however, as RISC technology became more proven and accepted within the marketplace, especially in workstations, Digital's management became increasingly interested in having its own RISC machines. Senior managers were also being heavily lobbied by representatives from MIPS Computer Systems, Inc. to license its existing and future family of RISC chips rather than having Digital spend more time and money to develop its own proprietary RISC architecture, i.e., PRISM. Although PRISM was a cleaner, better engineered design that had significantly higher performance potential than the

MIPS chip, the Digital team had not completely finished its design work; nor had the chip been fabricated. More importantly, the associated computer and operating systems software were still in the development stage. MIPS, on the other hand, was much further along both in terms of hardware and software. Digital's senior executive committee decided it was more important for them to get a quick foothold in the open systems market than to wait for PRISM's more elegant but late design. Based on this rationale, Digital's management not only agreed to adopt the RISC architecture from MIPS, they also decided to cancel PRISM!

ALPHA - LIFE AFTER PRISM

The decision to cancel PRISM shocked Dobberpuhl, Witek and the team. They refused to accept management's explanation and became somewhat hostile towards them. After several years of hard work and effort, the team simply felt betrayed by management. To give up their own technology and architecture and rely completely on a small outside company made no sense to them. In the words of one designer, "MIPS must have sold management a real 'bill of goods' - it was all politics!"

This reaction is understandable in light of what is known about such kinds of win/lose situations (Schein, 1988). Given the strong feelings and commitments that are reinforced within a team as its work progresses, the losing team refuses to believe it legitimately lost. Instead, it searches for outside explanations, excuses, and scapegoats upon which to blame the purported "fair" decision. Interestingly enough, however, if the losing group remains intact and is given a new opportunity to "win," the team will often become even more motivated, ready to work harder to succeed on this next round. In such a situation, the losing group tends to learn more about itself and is likely to become even more cohesive and effective as the loss is put to rest and the members begin to plan and organize for their next attempt. They can even become more savvy about what it takes to succeed if they work together to identify previous obstacles and mistakes that they either have to overcome or don't want to see reoccur.

This scenario is very similar to what seems to have happened to the PRISM team. Because of his high credibility and history of success, Dobberpuhl was able to negotiate an agreement with management to move his hardware team to the Advanced Development area where they would conduct advanced "clocking" studies, but where they could also discretely finish the RISC design and test it even though the project had been officially cancelled. Within a few months, the design was completed and a fabricated PRISM chip was produced. It worked even better than the PRISM team had expected, almost three times faster than the comparable MIPS chip being licensed by DEC. Armed with this new evidence, Dobberpuhl distributed throughout Digital a scathing memo indicating that management had just decided to throw away a technology that was two to three times better than what they were purchasing from MIPS. He had hoped to start a dialogue that might get management to reconsider its cancellation decision but this did not occur. Although a great many engineers responded positively to his memo, management was not impressed, most likely seeing it as "sour grapes."

Dobberpuhl's memo did succeed, however, in arousing the interest of Nancy Kronenberg, a senior VMS expert (VMS is the software operating system for VAX machines). Kronenberg called Dobberpuhl to discuss the status of PRISM which was working but had no computer operating system that could utilize it[2]. She suggested that if PRISM's RISC architecture could be modified to 'port' (i.e., 'work with') VMS, then management might be convinced to use the new RISC chip as the basis for developing new machines. The limits of VAX technology were being reached faster than expected and new products would be needed as quickly as possible to increase sales revenue. Kronenberg was part of a high-level committee that had recently been chartered to examine alternative strategies for prolonging or rejuvenating VAX technology. The possiblity of using a modified RISC chip that was VMS compatible was <u>not</u> one of the committee's current considerations, especially since Dobberpuhl and Witek were sufficiently upset with the cancellation of PRISM that they had declined to be members of this task force.

The more Dobberpuhl thought about Kronenberg's option, the more appealing it became. He convinced Witek that they could bring RISC speed to the VAX customer base and once they were back in business, they might even be able to supplant the MIPS deal. After several weeks of discussion, Dobberpuhl, Witek, and Kronenberg were sufficiently excited that they were ready to present a proposal to the VAX strategy task force. Dick Sites, one of the key task force members, was very skeptical about the feasibility of the proposed option. He just didn't think it could work - it would be too hard to move CISC software to RISC - to port VMS customer applications. When challenged, however, Sites could not clearly demonstrate why it wouldn't work, and after several weeks of working on the problem, he slowly realized that it really was feasible! Sites had become a "convert."

With this new basis of support, the VAX task force was now more inclined to endorse the proposal to design a new RISC chip that would port VMS. This new RISC architecture could then be used to extend the life of VAX technology; hence, the original code name for the Alpha chip was EVAX (i.e., Extended VAX). The Budgeting Review Committee formally approved the proposal in principal but left the objectives and specific details to the Vice Presidents and the project team. Furthermore, since Sites' own project on cooled chips had recently been cancelled, he and his small design group were very anxious to join Dobberpuhl and Witek's team to design a new RISC architecture that would be the foundation for some of Digital's new computer systems. As a result, the Alpha team was essentially formed through the merging of two small groups of extremely talented individuals whose recent projects had been suddenly cancelled and who were determined not to get cancelled again!

STRATEGIZING AND ORGANIZING FOR SUCCESS

Even though they had been blessed by senior management, the Alpha team remained skeptical. From their prior experiences with PRISM, however, Dobberpuhl, Witek, and their team had learned some very valuable lessons. Technical advances and achievements per se would not be sufficiently convincing to shift Digital's base architecture from VAX to RISC. The Alpha team would need a real demonstration vehicle to truly win support for their architecture. As pointed out by Montanaro, "You could talk technical, but you needed to put on a true test." Senior management had never seen PRISM 'boot' (i.e., 'bring to life') a computer system.

The team also realized they could not rely on the official systems to build a test computer for the chip within the project's tight schedule. The Alpha project was a relatively small semiconductor effort that did not have sufficient clout or sponsorship to capture the immediate attention or interest of the large system development groups. The team would have to learn how to control its own destiny.

To accomplish this, Dobberpuhl and Witek agreed that they would have to build their own computer system, i.e., their own test vehicle. Using their informal networks of technical contacts, they successfully enrolled three very gifted technologists, namely, Conroy, Thacker, and Stewert, to develop on their own an Alpha Development Unit (ADU) that would be based on the new RISC architecture. Since no computer system had ever been designed to the kind of speeds projected for Alpha, management was incredulous as to whether a computer system could be built easily and inexpensively that could keep up with such a fast processor. The real challenge to the ADU group, therefore, was to build such a computer system using only off-the-shelf components.

The Alpha team also learned that it would be very risky to go too long without showing management tangible results. As indicated by one designer, "You had to show them something exciting - something that would capture their imagination." As a result, the team would need to develop as quickly as possible a prototype version of the chip that could be demonstrated on the ADU test vehicle. This led to a two-tier approach in which the team would first design and fabricate an early version, i.e., EVAX-3, that did not include Alpha's full functionality but which could be convincingly validated. A fully functioning Alpha chip, EVAX-4, would then be designed and fabricated using Digital's more advanced CMOS-4 process technology.

FUNCTIONING FOR SUCCESS

In addition to paying close attention to these outside management and organizational issues, the Alpha team members functioned incredibly effectively as a unit. The design group was comprised of individuals whose values, motivations, and work interests were of a very similar nature. Because the objectives of the Alpha chip were left ambiguous by senior management, it was up to the design team as to how ambitious they were going to be. Extrapolating from the significant technical advances they had made on the PRISM chip, the team was confident that a 200 MHz chip was feasible even though they really didn't know how they would accomplish it. Nevertheless, they were driven to design a chip that would be at least twice as fast as anything that might be available within the industry by the end of the project's 3-year development schedule[3].

They were also individuals who did not complain about hard work, long hours, or midnight E-mail as long as they were doing "neat things." No one had been assigned; they had all voluntarily agreed to work on Alpha because they'd be "testing the fringes" and "pushing frontiers," which were fun and neat things to do! The Alpha design team even recruited and interviewed its own members as they scaled up in size or replaced individuals who had to leave. In the words of Conroy, "They looked for people with fire in the belly, people who did not try to 'snow' you but who knew what they were talking about, and people who would not panic or get discouraged when they found themselves in over their heads."

Members of Alpha were experienced individuals who could function independently and who did not need a lot direction, hand-holding, or cheerleading. They were not preoccupied with their individual careers; they were more interested in having their peers within the engineering community see them as being one of the world's best design teams. Ambition, promotion, and monetary rewards were not the principal driving forces. Recognition and acceptance of their accomplishments by their technical peers and by society was, for them, the true test of their creative abilities.

Although team members had very different backgrounds, experiences, and technical strengths, they were stimulated and motivated by common criteria. In the words of one Alpha member, "We see eye-to-eye on so many things." This diversity of talent but singular mindset materialized within Alpha not through any formalized staffing process but as a consequence of Digital's fluid boundaries and self-selection to projects. It is an organic process that may look messy and may lead to many unproductive outcomes; but it can also result in synergistic groups where the individual talents become greatly amplified through mutual stimulation and challenge.

The intensity of the Alpha team's motivation not only stemmed from its desire to do "firsts," i.e., to make the world's fastest chip, but also from fear that management could cancel them at any time, as they had done with PRISM. They stuck to aggressive goals and schedules not only because it was the right thing to do but also because they perceived the possibility of cancellation as real. This "creative tension" between the team and management kept the group working "on the edge," making them even more close-knit with a "we'll show them attitude." The group became resentful of management and normal management practices, seeing them all as one big bureaucratic obstacle. No one on the team claimed to be a manager or wanted to be one. The group even kidded among themselves that "Dobberpuhl is a great manager to have as long as you don't need one." Just as the team members had a kindred spirit about technical work, they developed a uniform perspective about managerial practices and philosophies. This "anti-management" viewpoint allowed the Alpha group to rely less on formal management structures and procedures for carrying out their task activities, and concentrate more on creating the team environment in which self-directed professionals could interact and problem solve together quickly and effectively.

Without the normal managerial roles, plans, and reviews, the Alpha team knew its success depended greatly on its ability to communicate openly and honestly among themselves. Because the team was relatively small and physically co-located, there was constant passing of information and decisions in the hallways. People didn't "squirrel" away; instead, each member was cognizant of what the other team members were doing. Since the team also had to discover new circuit techniques, all kinds of wild and creative ideas had to be tried. To aid in this effort, the group itself instituted a series of weekly "circuit chats." In these 1-hour long meetings, an individual would be given 10 minutes of preparation to present his or her work in progress. This was not meant to be a formal status report or rehearsed presentation, rather it was an opportunity to see each others' problems, solution approaches, and mistakes. As explained by Montanaro, "The intent was to establish an atmosphere where half-baked options could be freely presented and critiqued in a friendly manner and allow all team members to steal clever ideas from each other."

The Alpha team also realized that to get the performance speed they had targeted, the circuit design would have to be optimized across levels and boundaries rather than the suboptimizations that typically characterized previous designs. From their experience in designing PRISM, the Alpha team already knew where a lot of compromises had been made that may not have been necessary. Members would have to understand more fully the consequences of their individual design efforts on each other's work to overcome such compromises. The initial Alpha documentation, therefore, was not so much one of detailed descriptions and design rules, but one of intentions, guidelines, and assumptions. By knowing more about the intentions and what was trying to be accomplished, it was hoped that designers would have a broader exposure to both the microarchitecture of the chip and the circuit implementation from which the best tradeoffs could then be made. In the absence of management, members would have to be trusted to resolve their design conflicts by themselves. On the chance that it might be needed, a "Critical Path Appeals Board, was also created within the team to resolve intractable conflicts. The Alpha team even discussed the advantages of holding "Circuit Design Confessionals" during which members could admit to some error or design compromise and then solicit clever suggestions for fixing or repairing the problem.

The team's effectiveness was also facilitated by certain normative and egalitarian behaviors. The group was conscious not to allow status or hierarchical differences to interfere with their joint problem solving activities. Even though there were some very high power senior people on the team, they were all senior people involved in technical work. They did not just fill out forms and tell people what they wanted; they were also doing it, from performing power and resistance calculations to designing fancy circuitry. When team members had to stay late during particular crunch times, it was the custom that good dinners (not pizza) be brought in and served to them by the senior people. This degree of involvement and support helped solidify the group's confidence and trust in each other and prevented technical intimidation from becoming a problem.

A number of important behavioral norms were also established and reinforced by the Alpha team. It was expected, for example, that one would inform other members as soon as one realized that one could not make a given deadline or milestone. It was okay to be in trouble; it was not okay to surprise people. Individuals were not expected to "grind away" but to go for help. There was zero tolerance for trying to "bull" your way through a problem or discussion. It was important to be tenacious and not to give up easily, but it was also essential to realize when you were no longer being productive. Pushing and working hard were okay, but it was also important to have fun. Humor and good-natured teasing were commonplace occurrences.

Dobberpuhl was also instrumental in keeping the group strongly committed to its aggressive goals. Generally speaking, when a group gets in trouble, there is a tendency for the members to want to change the nature of their commitments either by extending the schedule, enlarging the team, reducing the specified functionality, reducing features, accepting higher costs, etc. People would prefer to play it safe by saying "I'll do my best" or "I'll try harder" rather than voluntarily recommitting to achieve the difficult result. By not allowing these kinds of slack alternatives, Dobberpuhl challenged the team to search for creative solutions to very difficult problems. When management suddenly discovered, for example, that the Alpha chip and its associated new products would be needed as much as a year earlier than originally scheduled, Dobberpuhl knew that by simply working harder, the team could not possibly reduce the schedule by that much. By committing to the speeded up schedule, however, the team was forced to find and incorporate what turned out to be some very creative breakthrough modifications in the design of the microprocessor and in the way it was being developed. This steadfast commitment not only ensured that the project would not be cancelled; it energized the technologists to stretch their creative abilities for extraordinary results[4]. As so many high performing projects have discovered, breakthrough advances cannot be achieved by playing it safe (e.g., Nayak and Kettering, 1986; Pinchot, 1985).

Finally, it is important to realize that a project like Alpha must have considerable support from other groups if it is to be successfully completed in such an aggressive timeframe. Following the persistent lead of Montanaro, the Alpha team found ways to work around the management bureaucracy to get the help it needed from other areas. The CAD group was especially critical for providing very advanced design and verification tools that were not generally available. They were also willing to modify and extend the software to the requirements of the new circuit design. The CAD group was responsive because they assumed that the Alpha team was probably working on something very important and because they were an interesting and unusual group of "techies" who delivered on their promises.

There were also a number of other design groups within Digital with good-natured rivalries taking place among them. Montanaro and other team members were sufficiently well-connected to individuals within these other groups that they could temporarily borrow (not raid or steal) additional personnel, resources, and even design documents to help the Alpha team complete its design.

Even though it was common practice within Digital to beg, borrow, and scrounge for resources, Montanaro soon realized that it was also important for him and the team to find a way to say "thank you." Using adult-type toys he purchased from a mail-order catalogue, Montanaro started to give people phosphorescent insects and fishes, or floating eyeballs, etc., as a means of thanking them for their assistance. For example, if someone found a bug in the design, Montanaro would give them a phosphorescent roach or fish; if they found a bigger bug, then he would give them a bigger bug or fish, e.g., a phosphorescent squid. For the Alpha team, these toys became a fantastic way for getting around the "us vs. them" turf problem or for stepping on people's toes. They became a great ice-breaking vehicle and as people collected them, they took on strong symbolic value. So many phosphorescent toys were distributed that when the Hudson plant had a sudden blackout, many of the employees discovered that they did not have to leave the darkened building as they could easily continue their work by the glows of light from their fish toys!

SOME CONCLUDING OBSERVATIONS

Digital Equipment is banking very heavily on Alpha technology to lead its resurgence. Not only is DEC marketing its own line of Alpha computers, but other vendors are starting to use Alpha in their product offerings. Microsoft is using an Alpha machine to tout its new Windows operating system called Windows NT. Cray Computer has announced that its next generation of parallel processing supercomputers will be designed around large arrays of Alpha chips. In addition, Mitsubishi has recently agreed to become a second manufacturing source, thereby, adding substantial credibility to the Alpha product's viability. DEC is even hoping that Alpha can eventually be used and adopted as a PC standard, replacing Intel's dominant 486 chip and its successor 586 design called Pentium.

Why, then, was the Alpha chip effort a success? Clearly, the fact that a very high-power group of individual technologists had come together through self-selection and natural evolution processes to work towards a singular-minded objective is a strong contributing factor. <u>These were not team-playing individuals - they were a collection of talented</u>

individual contributors willing to play together as a team! For previously explained reasons, they were all eager to commit to a very aggressive set of goals and very willing to accept the risks that such a commitment entailed. There were no artificial barriers in the design process and the creative juices that flowed from the group's communication and problem solving interactions were critical. At times they worked like maniacs, totally immersed in their project activities and buffered successfully from the normal managerial and bureaucratic demands and disruptions by Dobberpuhl. Because of their singular purpose and common motivational interests around technology, there was little of the in-fighting and turf-related issues that often characterize other teams. There was a genuine and unified team feeling of ownership in having contributed to the technical achievements as can be seen by the large number of names that have appeared on the technical publications and patent applications.

All of the afore-mentioned characteristics focus primarily on the group's internal dynamics and were probably very instrumental in allowing the group to achieve its strong "technical" success. It is less likely, however, that these dynamics contributed to the "organizational" success of the product. PRISM was also a successful technical achievement and the PRISM team was very similar to Alpha in terms of group membership and process. Yet, the Alpha chip and not the PRISM chip will be commercialized.

Only when the Alpha team shifted its emphasis from concentrating on its internal group process to worrying about how it should relate to other organizational constituents did the seeds for organizational success get planted. Unlike the PRISM episode, Alpha was able to gain and strengthen, over time, its sponsorship within the organization. By sending out an irate memo, Dobberpuhl had taken a risk, albeit he had a strong basis from which to take this risk, but he managed to capture the attention of a few senior sponsors who helped link his technical interests to the strategic interests of the company. By making sure they had an ADU machine ready to demonstrate the new RISC architecture, the Alpha team was able to increase its sponsorship even further. Neither Ken Olsen nor Robert Palmer, Digital's former and current CEO's respectively, had seen PRISM in action. They did, however, see a true demonstration of the EVAX-3 version of Alpha and were sufficiently excited that they soon wanted Alpha to become an open systems platform product that could run both VMS and UNIX operating systems. Dobberpuhl, Witek, and the Alpha team had learned not only the importance of developing new technology but the importance of protecting and marketing it within a large organization so that the technological leaps and decisions get integrated and effectively connected with the strategic interests and decisions of the established businesses, products, and services.

IMPLICATIONS FOR SUCCESSFUL CHANGE

As a discipline, organizational development has always been concerned not only with how organizational change takes place, but more importantly, with how organizational change can be planned and implemented effectively. While a great deal has been written about organizational change and innovation, most recently about cultural changes, not much is known about how to manage and plan for those key technological changes and breakthroughs that could become the basis for significantly new product lines or businesses[5]. One of the missions of the research and advanced development functions, as was true for Digital Equipment, is to experiment and learn about those critical 'leaps' in technology that could give the company's products a significant competitive advantage in the marketplace. Cooper's research over the last decade, for example, has convincingly confirmed that the most important factor accounting for new product success lies in the development of a new product that customers perceive as having a substantial performance advantage (Cooper, 1986).

The real problem for the research and advanced development functions is not identifying such technological possibilities, but in getting the broader organization to invest in some specific alternatives while there is still considerable uncertainty as to whether they have picked or committed to the 'right' technological paths (Katz and Allen, 1988). Roberts (1988), emphasizes this by pointing out that it is the ability to <u>move</u> technological advancements out of the research laboratory and into commercialized products that is the true test of effective technological change and innovation in an organization - and not just the creation of ideas and suggestions, for there is usually a 'ton' of ideas. As a result, whether one is dealing with organizational change or technological change, the most critical part of the change process lies not in the generation of ideas and possibilities but in their implementation! The key dilemma for the Alpha team, as previously described, was not so much in creating a new technology per se (RISC was well-known, having been worked on and developed since IBM's John Cocke reported his original research in 1971), but in getting DEC's management to take their efforts seriously[6]. They had to shift management's attention from relying on improvements in the company's established technological base to relying on promised, but unproven, advancements in a much less familiar technology.

Based on his studies and consulting experiences with companies such as Citibank, Corning, and Xerox, Nadler (1988) argues that there are essentially three basic problems inherent in the management of any large change process[7]. First, there is the issue of motivation and resistance, i.e., the need to motivate people to find and internalize new ways of behaving and managing their organizational environments, relationships, and tasks. Rather than remaining comfortable in the status quo and resistant towards changes that threaten existing practices and procedures, individuals must become receptive towards the new methods or strategies if, in fact, the proposed changes are going to take hold and be implemented successfully.

A second issue, according to Nadler, involves the need to manage the transition effectively from what was the past to what will be the future. Since change disrupts the normal course of events, it is necessary to control the process by which the innovation or change takes place in order to avoid confusions, miscommunications, and misunderstandings. People must not only agree on where they are going but also on how they are going to get there!

Finally, there is the need to shape and influence the political dynamics of change. Since organizations with multiple products and multiple technologies are organized around groups of individuals with very different interests, backgrounds, resources, rewards, and responsibilities, then these organizations are, by their very nature, political entities in which certain power centers can develop either to support or impede the proposed change[8]. For a major innovation to move through the organization successfully, those leading the charge must find ways to garner the visible support of key power groups while trying to assuage or neutralize the arguments emerging from any opposition buildup.

Given the broad scope of these three generic problem issues, i.e., motivation, control, and power, it is understandable why there is so much frustration surrounding the effective implementation of change. In his recent book, Pfeffer (1992) describes three possible ways of getting things done. One alternative mechanism is through the use of the organization's formal structures and arrangements, i.e., through formally established relationships, roles, and procedures. For this method to work effectively, hierarchical direction, responsibility, and accountability not only have to be clear and unambiguous, they must also be seen as the legitimate basis of authority and decision-making.

Another way of getting things done is by developing a strong shared vision or organizational culture. As described by Pfeffer (1992), "if people share a common set of goals, a common perception of what to do and how to accomplish it, and a common vocabulary that allows them to coordinate their behaviors, then commands and hierarchical authority are of much less importance." Individuals can then communicate, share ideas, and problem-solve together more effectively without always waiting for orders and directions from those in higher-level positions.

The use of informal power and influence is a third process advocated by Pfeffer and others for getting things implemented in organizations. According to Pfeffer, it is possible, and even advisable given the political nature of organizations, to manipulate and influence without having to resort to the use of formal authority. This approach puts the emphasis on the use of informal influence methods rather than relying on formal structures and systems. To be effective, one has to decipher the organization's political terrain, build a strong and supportive political base, and determine which influence strategies and tactics are most likely to be successful given the particular context and situation.

While Pfeffer discusses the strengths and weaknesses of these three alternative approaches, emphasizing the importance of power and influence, the description and analysis of Digital's Alpha chip episode illustrate just how important it is to use all three of these methods for enhancing the likelihood of successful organizational and technological change. As summarized in Figure 1, the development of a shared vision and organizational culture within the Alpha team was vitally important for generating and sustaining the high levels of motivation and cooperative problem-solving activity. It was also essential that the efforts and advances of the Alpha team become strongly integrated with the transitional strategies and decisions being formulated and acted upon by those in positions of formal responsibility and accountability.

Problem Areas	Implementation Approaches		
	Shared Vision and Culture	Formal Structure and Authority	Power and Influence
Need to Motivate the Change	x		
Need to Manage the Transition		x	
Need to Shape the Political Dynamics			x

Figure 1. Relationships Between Problem Areas and the Implementation of Change (adapted from Nadler, 1988 and Pfeffer, 1992)

And finally and perhaps most critically, the members of the Alpha team learned just how necessary it was to be mindful of and active in the political processes that surround the attainment of sponsorship and the making of key strategic decisions, especially under uncertainty. Rather than simply commiserating with each other, isolating and buffering themselves even more from Digital's management, the Alpha team eventually emerged as a high performing team that was able to: (1) establish an incredibly high level of motivation; (2) control and coordinate effectively its developmental activities; and (3) deal successfully with the kinds of subjective judgements and political dynamics that take place in almost all organizations.

POSTSCRIPT

The story of Alpha is not that different from what has taken place in many other successful projects that have had to "push" against the organization's established technical base and strategic focus. Data General's "whiz kids" faced similar problems in their development of the industry's first 32-bit minicomputer, as described in Kidder's Pulitzer Prize winning book The Soul of A New Machine. Intel's first RISC and first 1-million-transistor chip was developed by a talented band of "escapees" in that they chose to 'escape' from working on the company's traditional product line. Motorola's current success in the paging business benefitted directly from the development efforts of their "bandits," a team that was willing to 'break the rules' and 'take' ideas from just about anywhere. Even Hewlett-Packard's huge success in their laserjet printer line can be attributed to a "maverick" group in Boise, Idaho while Sony's most successful computer machine, called News, was developed, according to Toshi Doi, the project leader, by an "oddball band of engineering misfits."

Projects like these do not originate in a 'top-down' fashion; instead, they evolve as pockets of individuals interact and excite each other about important technical developments, problems, and possibilities. Management is just too caught up in the pressures of running their businesses to be receptive to the many uncertainties and risks associated with 'leapfrog-type' efforts. If management is serious about fostering these kinds of accomplishments, it must do more than simply empower technologists to take risk and not fear failure. It must strategize by working jointly with the R&D organization to plan and actively sponsor those project developments that not only react to environmental changes but those that could help create or shape market changes. In some sense, the trick is to be like successful venture capitalists who have learned that when dealing with a great of uncertainty, they are primarily justifying their investments in the track records and talents of the individuals behind the ideas rather than in the ideas themselves.

This relationship is best achieved when strong linkages are built between the organization's R&D activities and the overall business strategies. And such connections, as in Alpha, are more readily established when the technical leadership discovers how to present their 'neat ideas,' not in technical terms per se, but in terms that are meaningful and real to those who are managing and running the businesses. Without this kind of partnership, the organization runs the risk of exacerbating differences between important technical and managerial parts of the organization rather than ameliorating them. For even if the project does become a success, the rifts and lack of supportive trust between these two distinct constituencies can endure such that the instances of the "good guys" versus the "bad guys" - "us versus them" become the images that the key players remember. And if these dispositions are allowed to linger and strengthen, especially if technical people feel that they are not being equitably recognized and rewarded as has happened in many of these cases, then the long term continuity of technical development can be seriously impaired through decreased morale and increased levels of turnover particularly among the key technical contributors[9]. An organization must not only sponsor the research projects that get it into the game; it must build the long term hierarchical and crossfunctional "people alliances" that keep it in the game!

NOTES

1. As DEC's first announced microprocessor in RISC (Reduced Instruction Set Computer) technology, the Alpha chip runs at more than two to three times the speed of its nearest competition; and it has now been included in the Guiness Book of World Records as the world's fastest microprocessor with a clock speed of more than 200 megahertz (MHz).

2. When PRISM was cancelled, the software group working to develop the new advanced operating system that would be used by this chip also became upset. As verbalized by David Cutler, the leader of this software development area, to his team: "We really got screwed - years of development work just went down the drain." As this effort was located in Seattle, most of the software team soon left Digital to work for Microsoft where they've succeeded in producing the software system known as Windows NT.

3. Although the PRISM chip ran at 75 MHz, the team had learned enough from their previous design efforts to feel confident that they could "drive the technology" way beyond what others in the industry were forecasting.

4. Management realized that the Alpha chip would be needed much sooner than expected in order to obtain substantial additional sales revenue from new products. If the Alpha chip was going to remain a viable option for filling this 'revenue gap', then the schedule would have to be speeded up; otherwise, the project would once again run the risk of being cancelled in favor of some other alternative product strategy.

5. For some of the most recent publications on organizational culture, see Beer, Eisenstat, and Spector (1990), Senge (1990),Martin (1992), and Kotter and Heskett (1992).

6. As with Digital, IBM also rejected the concept of a RISC-based computer, especially since revenues and profit margins from its mainframe business were still doing very well.

7. For a more in-depth description of the 7-year transformational change that took place within Xerox, see Kearns and Nadler (1992).

8. A start-up is a very different kind of organization, since in a start-up all of the functions and groupings are usually focusing on the same technology and end product. As a result, differences in backgrounds, resources, rewards, etc. are not as salient or as problematic.

9. What often happens is that the technical people see the non-participative, non-sponsoring managers, i.e., the "bad" guys, ending up with more exciting work and positions as a result of the project's success while they, i.e., the "good" guys, receive relatively little for their persevering efforts.

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