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ESTABLISHING A COMMUNICATIONS-INTENSIVE NETWORK TO RESOLVE ARTIFICIAL INTELLIGENCE ISSUES WITHIN NASA'S SPACE STATION FREEDOM RESEARCH CENTERS COMMUNITY

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ABSTRACT

MITRE Corporation's *A Review of Space Station Freedom Program Capabilities for the Development and Application of Advanced Automation* (1) cites as a critical issue the following situation, extant at the NASA facilities visited in the course of preparing the review:

> The major issues noted with regard to design and research facilities deal with cooperative problem solving, technology transfer, and communication between these facilities. While the authors were visiting lab and test beds to collect information, personnel at many of these facilities were interested in any information they could collect on activities at other facilities. A formal means of gathering this information could not be identified by these personnel. While communication between some facilities was taking place or was planned, for technology transfer or coordination of schedules (e.g., for SADP demonstrations), poor communication between these facilities could lead to a lack of technical standards, duplication of effort, poorly defined interfaces, scheduling problems, and increased cost. Formal mechanisms by which effective communication and cooperative problem solving can take place, and information can be disseminated, must be defined.

It is our purpose here to offer a proposed solution to the communications aspects of the issues addressed above; and, to offer at the same time a solution which can prove effective in dealing with some of the problems being encountered with expertise being lost via retirement or defection to the private sector. The proffered recommendations are recognizably cost-effective and tap the rising sector of expert knowledge being produced by the American academic community.

INTRODUCTION

It is well to note two factors at the outset of our examination of "communications" links among the various NASA research centers engaged in preparing for the launch of Space Station Freedom [SS Freedom]. The first is that "communications" as a concept in the artificial intelligence [AI] community has radically different implications than those toward which conventional management systems tend. The second is that developing trends in management science allow for this different notion of "communications"--indeed, the literature strongly encourages such differentiation of goals, via structural changes and adaptations.

Miles and Snow (8) trace the early benchmarks of mangement styles from 1800 to their belief of what organizations will look like in the year 2000. They have seen developments occur every 50 years from 1850, with the advent of functional structures to produce limited lines of goods, to the 1950's when, largely through military innovations as a result of World War II and the subsequent space explorations at NASA, the matrix form of management evolved to handle complex tasks associated with both standardized and highly innovative goods being produced by the same organization. Miles and Snow posit a new structure, the dynamic network, arising by 2000 in order to handle not only production but very specialized design of goods within the framework of a global marketplace. Structure itself will then become temporary, manifested by design problems, and will require immense levels of motivation of workers in order to obtain optimum performance.

In many ways, the work of Miles and Snow parallels the insights into the development of science from Newton [natural science, subject to laws] through the later discoveries of relativity and quantum mechanics and on into the current schools of epistemic priority of mind over nature [transcendental science]. (9) That is to say, that as technology advanced to a degree which allowed for an increasingly reductive view to be taken of nature, eventually all conventional observations became either known or predictable [Hawkings, quoted in Gleich (6)]. What is emerging is the study of the larger view taken of physical phenomena by scientists of chaos. Management theorists have gone so far as to "adopt" the highly scientific meaning of this new field taxonomically, as in Tom Peters's (10) latest work, *Thriving on Chaos.*

ISSUES

The purpose of this lengthly digression in a brief exposition is seminal: just as theoretical and experimental science have evolved into a more fluid study of chaos and the fundamental notion of a "grand unity" or "superstring" that encapsulates physical order completely, so management scientists and systems engineers, faced with the inevitability of global organizations, have sought out "dynamic networks" to enable them to cope with vast and changing complexities. Zee (12) goes so far as to diagram the "Drive Towards Unity" in physics.

From the 1950's onward, two forms of higher order programming languages have developed. One of these forms is the conventional, highly-driven, precisely-algorithmic and *computational* group of languages, FORTRAN, Pascal, C and Ada. These languages represent a kind of ideal in man's harnessing machines to take over the iterative tasks required for the further development of predictable technological models. The second group of languages is *knowledge-based* and *object-oriented* [vs. computational] to an extent that renders comparison of the two methodologies rather difficult.

While both are referred to as "computer languages,": the second category actually "reason" rather than taking sums or differentiating equations. Pagels (9) once asked Minsky, who with McCarthy is responsible for LISP, the language of AI endemic to American research facilities:

> why he...chose to call their enterprise "artificial intelligence" rather than "cognitive science," which [Pagels] thought more appropriate. [Minsky] replied characteristically, "If we ever called it anything other than artificial intelligence, we wouldn't have gotten into the universities. Now that we're in and the philosophers and psychologists know that we're the enemy, it's too late.

The point here is that two very different world views have been rather "jumbled" together into a single field called "computer science"; and, that when Pagels refers to computers as "the primary research instrument of the sciences of complexity" (9) he is referring to the devices of cognitive science and not the devices of computation.

This author was once asked by a distinguished professor under whom he was working if he had come across a good definition of "software engineering" in the course of research. After much investigation over a year's time, no really good definition that did not encompass some degree of skepticism (2) emerged. Clearly, most practitioners of software engineering are working in the fields of general government, military or industrial applications; and, this limits their viewpoints towards the algorithmic languages, which can certainly be structured, if not exactly constructed. And, because this author's professor works almost exclusively within the fields of simulation, robotics and other AI applications, there was no common ground.

That NASA is clearly aware of these differences is implicit in the amount of time, energy and brainpower, to say nothing of the dollars, that it has devoted to the further development of LISP cultures through such agencies as DARPA and the various research centers NASA and the Department of Defense [DoD] have scattered throughout the United States.

"Communications" among these centers is critical for three reasons. There exist within the mangementment of any enterprise, public or private, as America moves into the 1990's, three crises:

COMPETENCE: the loss of expertise that is not being replaced by technically-oriented majors in United States universities;

COMMUNICATIONS: in the broadest sense, management's ability to direct and motivate its workforce; and,

COST: the final critical issue, which entails getting the most effective output from every dollar of resources input with the aim of keeping a dynamic, project matrix organization afloat in a highly unstable and often unfriendly environment.

Of course, the paradigmatic solution to these issues of competence, communications and cost will be the knowledge-based [expert] modules, the inferencing engines and the neural networks [communication over a global span] inherent in the Fifth Generation of computers. The United States is uniquely placed to capitalize on the technologies that have arisen within its research laboratories [both governmental and private] and its academic circles. That NASA is keenly aware of the importance of the issue is evidenced by the findings of the *Space Station Advanced Automation Study: Final Report* (4) of 1988.

RECOMMENDATIONS

The first recommendation, in light of the foregoing analysis of SS Freedom as a dynamic organization, heavily tied to AI implementations, is that the structural design of the various research centers be investigated. Galbraith (5) recognizes the necessity for two types of structures within management frameworks of complex organizations. There must be first an "operating" side, which one might equate with the algorithmic philosophy of Ada, to handle the day-to-day iterative production; but, there needs to be a second group of "innovating" suborganizations to generate as well as to handle the implementation of new ideas. The innovating organization should be buffered from external pressures by an *orchestrator*: a power figure with the ability to enforce decisions that favor the changes, even when unpopular for reasons of politics or cost; they should be routinely managed by a *sponsor*: a management figure who handles budgets, recquisitions and the like; and, finally, they must be lead and inspired by a *champion*: the person whose first responsibility is to guide the production process from idea to complete and tangible innovation.

The necessity for a champion is recognized by the Friedland group (4) in its insistence that each considered project first and foremost own the "presence of a strong user champion for the application" before being given further study for implementation at Baseline. At the same time, the Friedland group deal with institutional issues that confront the success of implementing AI innovations into SS Freedom. The issues are either mythaic or political in nature; and, as such, could best be addressed effectively by an orchestrator.

Thus, the conclusions of the first recommendation here, that all AI research work structures be examined within the NASA networks, is that similar models be adopted throughout the NASA system in order to protect on-going knowledge-based systems [KBS] projects. There is the strong recommendation from the Friedland report that an Operations Management System [OMS] to eventually take control of the complete SS Freedom system be investigated. Further, the Bayer report establishes 1996 as a benchmark year for demonstration of a distributed system for SS Freedom. In light of NASA's experience with AI systems, which far outstrips that of any Japanese agency, for instance (11), particularly where innovation is held to be a primary factor, this should be an obtainable goal. But, it is key to establish separate AI cultures within conventional management structures in order to protect America's technological lead.

The second recommendation is the establishment of a program similar to the Presidential Management Internships which serve to attract graduates of MBA programs into government careers. The candidates for acceptance as "Presidential AI Interns at NASA" would be graduate scholars finishing their degrees with experience and strong LISP backgrounds. These scholars could be rotated on a three-month basis from one Research Center to another, each serving for the time in one of the innovating AI cells.

There would be established a central office for NASA to act as a clearing house for coordinating reports of on-going work and progress within each of the NASA centers and within each of the suborganizations engaged in an AI activity at those centers. As part of the rotational program, the scholars would meet for roundtable discusions at the end of their service time at each center. The bottom line for this idea is that AI does not operate algorithmically and cannot be transmitted by driven means. It is best expressed in the spirit of that which it emulates, the human intelligence; intelligent exchanges among experts in the LISP and AI fields will rectify the causes of concern that were evinced in the Mitre Corporation study. Until such time as the DMS and OMS are operational, this kind of program would not only ensure that a full level of communication of the state-of-the-art progress at the various NASA AI centers was in effect. It would also fill the gap of vanishing competence.

In terms of the cost effectiveness of such a program, the current level of adoption and experimentation with AI in the private sector is the clearest indication that AI is an imperative in the face of global competition. *The Rise of the Expert Company* (3) gives a fascinating account of developments within aerospace and computer firms as well as government agencies. Friedland cites several examples of improvement in operations for both cost savings and quality.

CONCLUSION

While it is impossible to fault the logic or the *politesse* of Friedland's group and their conclusions, the case for AI as an imperative rather than as an option on SS Freedom--if that enterprise is to flourish--has perhaps not been stated strongly enough. Elsewhere, this author has undertaken a comparative study of Ada, C and LISP (7). The conclusions from that study lead one to espouse the notion that if America maintains its current *innovative* lead in technology, it will do so through AI. NASA and DoD can find ready customers in the private sectors of the United States, the Pacific Rim countries and the new European group, for AI design innovations. Encouraging the sound management of current AI resources at NASA, and funding new efforts, is urgent. As Pagels (9) notes:

> ...the nations...who master the new sciences of complexity will become the economic, cultural and political superpowers of the next century.

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