On Nov. 10. Dr. Warfield asked me to find a publisher to publish this book in China either in English or in Chinese. And the publisher should sign a contract with Dr. Warfield. — X. Sun

REVIEWER COPY, AUGUST, 1997

ESSAYS ON COMPLEXITY

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July, 1997

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"...Every work of science great enough to be well-remembered for a few generations affords some exemplification of the defective state of the art of reasoning of the time when it was written; and each chief step in science has been a lesson in logic."
---Charles Sanders Peirce (1877), "The Fixation of Belief", *Popular Science Monthly.*

"One singular [self]-deception..., which often occurs, is to mistake the sensation produced by our own unclearness of thought for a character of the object we are thinking. Instead of perceiving that the obscurity is purely subjective, we fancy that we contemplate a quality of the object which is essentially mysterious...".
---Charles Sanders Peirce (1878), "How to Make our Ideas Clear", *Popular Science Monthly.*

"A little learning is a dangerous thing; drink deep, or taste not the Pierian spring: there shallow draughts intoxicate the brain, and *drinking largely* sobers us again."
---Alexander Pope, *An Essay on Criticism*

Von Foerster's First Law. "The more the complexity that is ignored, the greater the prospects for fame and fortune."
---Heinz von Foerster

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1997

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PREFACE

I began to put this document together in March of 1997, with the intention only of putting some unpublished papers that were written in 1997 in one document for convenient reference. As this project moved along, I felt that I should support that work by putting another piece together that aggregated papers from 1995 and 1996. Then after doing that, I decided that there were a few more relevant pieces of work from the years 1988-1994 that could be appropriately added.

I decided that each of the three parts should have its own index. Because the various essays were written for different audiences, there is some significant duplication of figures and tables, and of some conceptual work as well. The integration of the material seemingly would require elimination of some of the redundancy, and the development of an integrated index. But I decided the document would be more useful to me and to readers just to leave it as it stands.

This work contains seven essays from each of the time periods mentioned. Some of them have been published, some are being reviewed now, and some have not been published.

I believe that the essays become more valuable when they are seen in relation to other essays. Otherwise, I would not put them under a common cover.

In reviewing their contents, I can see that I have targeted essays, roughly speaking, to the following groups of people:

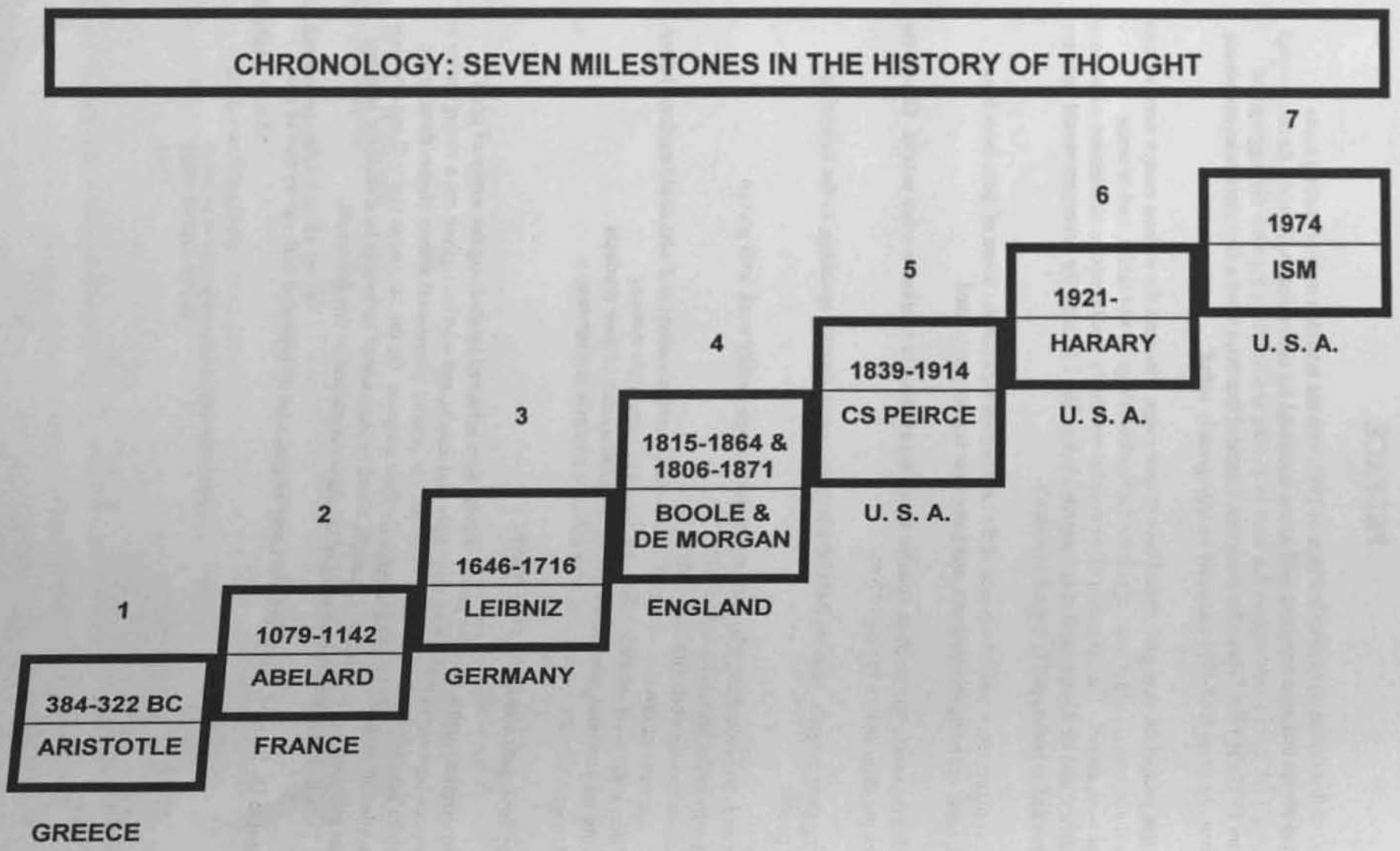
- Friends and colleagues, who share my interest in high-quality work with groups
- Faculty in the liberal arts and sciences
- Engineers who work with large systems
- Government bureaucrats, whose influence spreads across society, and who could perform better if they understood something about the design of large-scale systems
- Software personnel, who can benefit by enhanced quality of their products
- Managers who are interested in more effective products and services

Each of the three parts also has its own Preface.

I have tried to reflect in this work the great rewards I have achieved by studying the works of great thinkers, from whom I have drawn both inspiration and insight, and who have given me a strong desire to see that others benefit from them as well. I fear that our present educational system slights these great thinkers, while choosing less significant topics for their students. On the next page you will see my view about seven milestones in the history of thought, which reflects what I believe to be a valuable learning sequence. Details on this are given in some of the papers contained in this document.

I am grateful to Dr. Scott M. Staley and Ms. Carol Teigen, who collaborated with me on two of the essays.

John N. Warfield
August, 1997


CHRONOLOGY: SEVEN MILESTONES IN THE HISTORY OF THOUGHT
1
384-322 BC
ARISTOTLE
GREECE
2
1079-1142
ABELARD
FRANCE
3
1646-1716
LEIBNIZ
GERMANY
4
1815-1864 &
1806-1871
BOOLE &
DE MORGAN
ENGLAND
5
1839-1914
CS PEIRCE
U. S. A.
U. S. A.
6
1921-
HARARY
U. S. A.
7
1974
ISM

1988-1994 ESSAYS ON COMPLEXITY

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1988-94 FIGURES			
FIGURE NO	PAGE FIRST MENTIONED	APPEARS ON PAGE	FIGURE TITLE
1	80	81	The Linear (Precedence) Structure of English Prose (edv02.chp)
2	82	83	The Parallel (Inclusion) Structure of English Prose (edv03.chp)
3	84	85	AP Problematique (cav19.chp)
1	162	163	RRM Problematique Showing Problem Numbers and Scores
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1988-94 TABLES			
TABLE NO	PAGE FIRST MENTIONED	APPEARS ON PAGE	TABLE TITLE
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6	147	148	Groupthink, Ford, and the Automobile Industry
7	150	150	Clanthink, Ford, and the Automobile Industry
8	153	153	Groupthink and Nuclear Energy
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10	165	165	Results from a Ford Workshop Illustrating Spreadthink
11	165	166	Results from a Ford Workshop Illustrating Spreadthink
12	167	168	List of Problems Thought to Contribute to Pump Rejection
13	175	175	Summary: Relationships of Laws of Complexity to Group Activity
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15	180	180	Data on Nominal Group Technique Applications

PREFACE

This collection of essays is one of three collections prepared in 1997. The three monographs are laid out chronologically as follows:

- Pre-1995 (this one), mostly consisting of essays written between 1991 and 1994.
- 1995-1996
- 1997 (first half)

It is planned, tentatively, to publish the aggregate set as a single volume, if a reliable publisher can be found that wishes to publish them.

The present collection consists of seven documents, only two of which have been formally published. The others were privately distributed from my small institute called IASIS (the Institute for Advanced Study in the Integrative Sciences), which began at George Mason University in 1987, and has continued to the present.

The first paper ("Technomyopia...")was written to try to get people interested in upgrading the software industry, to try to move it to a higher plane of quality, What has come to be called "shrink wrap" software (a term representing a commercial product that is sold without guarantees) is slowly creating an image of an America that thrives on vigor, but does not choose to take advantage of available scientific knowledge to create higher-quality products. It seems that such an attitude is reminiscent of what went on a few decades back in the auto industry. (Readers of this essay might wish to review the behavior of the auto industry at the time, as detailed in the last essay in this collection.)

The second essay deals more with the behavior of the academic community in respect to blind acceptance of faddish concepts. What is sought here is a conscious revision of how academics choose to select what is deemed to be worthy of adulation. Such a change might be done, e.g., by creating a set of criteria for evaluation and assessing candidate concepts against those criteria in a public way; i.e., in the archival literature. To emphasize this a new word is coined, the "Trusel": something that is widely perceived to be true, but is largely useless, and may even have significant negative value to society, if it tends to stifle sensible activity.

The third essay discusses the presently popular "Learning Organization". As widely discussed, this concept has struck a responsive behavioral chord but, unfortunately, seems to be largely metaphorical in its being, as opposed to an achievable entity, created through systematic action. This is reminiscent of a quotation of Herbert Simon several decades back in which he was discussing the systems movement, and talked about creating "substance to go with the name".

The fourth essay discusses decision-making and describes some (apparent) subtleties that seem to be widely ignored by decision analysts and decision makers.

The fifth essay highlights the severe shortcomings of natural language (prose) as a means of precise communication or, more specifically, as a means of describing, diagnosing, and prescribing for large-scale systems. Prose language is described as a "Procrustean bed" for linguistics, and the exclusive focus of English departments on prose, as opposed to communication, highlights the faddish behavior of academics, who are content to let their products leave the university with degrees and without capacity to communicate about complexity.

The sixth essay is a short prescription for how organizations can become more productive, in respect to how they work with complexity.

The seventh and last essay (co-authored with Carol Teigen) is a set of carefully-documented case studies. The focus in these cases is intended to be on human behavior, as opposed to industrial or government organizations. But the real organizations furnish the context for the cases, because it is only in that way that a level of credibility can be gained which might help focus the dark side of human behavior when complexity is involved. I would like for people to begin to think of complexity as the enemy or villain, rather than individuals or organizations. But where individuals and organizations can be justly criticized is when they have an opportunity to learn how to correct bad behavior, and choose not to take advantage of it.

TECHNOMYOPIA THREATENS OUR NATIONAL SECURITY

A Critique of the Defense Science Board
Military Software Task Report

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April 14, 1997

TECHNOMYOPIA THREATENS OUR NATIONAL SECURITY[1]:

A Critique of the Defense Science Board
Military Software Task Report

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ABSTRACT

The United States Department of Defense is wasting very large sums of money on systems that exceed the scale of human comprehension. These expenditures, together with the diversion of talent into areas that are not very productive, are helping to make us a second-rate economic power, threatening thereby our national security.

While many case studies could, individually, illustrate the situation just mentioned, the **1987 Report of the Defense Science Board--Military Software Task Force** serves as an example to illustrate how our system is not serving us well.

Some of the contents of the Report are excerpted, and the 38 recommendations are examined as a way to deal first with the Report in its own constrained context. Then the Report is critiqued in respect to that context, and some priorities are proposed for the Board's recommendations, using categories that I identify.

A set of what appear to be implicit assumptions behind the Report is offered. I suggest that these assumptions provide a partial basis for assigning the term "technomyopia" to refer to the Report and the surrounding situation with regard to defense systems acquisition.

Matters relating to the dilemmas of software design and management are discussed, with reference to prior nationally-significant institutional foulups in the steel and auto industries, which are historical versions of myopic vision that has cost us dearly.

Some of the major problems related to current practices of the Department of Defense are then discussed, and a few new recommendations are offered. These are believed to be more fundamental than the recommendations in the subject Report.

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[1] Most of this paper was delivered at a joint session of the Northern Virginia Chapters of the IEEE Computer Society and the IEEE Society on Social Implications of Technology in the summer of 1988. The first written version was prepared about the same time as the talk was delivered. Then the paper was updated in 1992, by adding Appendix C. Now, in 1997, a Postscript has been added to give additional updating. Why keep updating? I hope this paper can be a kind of prototype case study that will be helpful in similar situations.

1.0 INTRODUCTION

The United States Department of Defense is wasting very large sums of money on systems that exceed the scale of human comprehension. As a result, taxpayers are going into debt to pay for very expensive products that are ill-conceived, ill-developed, ill-produced, and frequently unworkable. This situation is placing great strains on our national economy, and it is diverting significant amounts of talent from areas that require it in order to maintain national competitiveness. It has also been a major factor in making us the world's largest debtor nation.

The Competitiveness Index gives the public a clearer method of understanding how America stacks up against our competitors and how our competitive position affects every American worker's well-being. The bad news is that the Index reveals the United States is losing its competitive edge, threatening this nation's future wealth and prosperity," said John H. Young, president and chief executive officer of Hewlett Packard Corporation, and chairman of the Council on Competitiveness."

—The Washington Post, Friday, June 3, 1988, page G1.

The eighties may be viewed by history as a period when the United States started moving from being economically dominant in world affairs to becoming a second-rate economic power. And history will certainly perceive the mammoth budget deficits incurred during this period both as a response to what otherwise would have been a collapse of the dollar altogether, and as a major contributing factor to the loss of competitiveness in international markets.

During this period, many of the best and brightest young American scholars have been attracted into two areas where their potential contributions to our economic strength have been severely diluted. I refer to the work that is being done in the defense industry and that done in the legal profession. In the defense industry, huge amounts of our national talent are engaged in producing things that often don't work, but even if they did work, many of them would almost certainly never be used. And in the legal profession, many people are working to do such things as transfer assets back and forth from one management to another at considerable expense, support financial transactions that create no values other than for the legal profession, and slow down efforts to be competitive in the international arena. It is well-known, for example that the U. S. has about 20 times as many lawyers per capita as Japan. A value-added tax imposed on most of the activity described would produce no tax revenue.

The causes of these situations are, no doubt, multiple. But certainly the dearth of insightful leadership at both national and state levels is a major factor. The twin abuses of poor investments in national defense and in educating far too many lawyers reinforce each other to weaken our national productivity. Many thousands of small, uncoordinated governmental decisions that may look fine from a local point of view, add up to an integrated, creeping disaster for the country.

My topic tonight, the Defense Science Board Military Software Task Report, is just one of many examples of how our system is not serving us well. Unfortunately this Report is not unique in standing out from many others of its ilk as being unusually poor. It is just one timely example of

many that could equally well be chosen to illustrate a kind of technomyopia that threatens our national security. To see this Report as an isolated event in our lives is to miss the opportunity to exploit its highly-representative example of what needs to be corrected by strong action at the federal level. Yet one must see it first in its own specific context, and on its own terms. After that is done, one can draw on it as a way of illustrating the larger malaise within the Department of Defense, and especially within its system acquisition activities.

I seek to present an overview of the Report as dispassionately as I can in Sections 2-6 inclusive of this paper. Then in Sections 7 and 8 I comment on it in its specific context and propose priorities on the Recommendations in the Report (which the Report does not do). In Section 9, I offer some reasons for using the word "technomyopia" to characterize the Report. In Section 10, I review briefly matters related to managing the software dilemma. In Section 11 I discuss briefly problems of the Department of Defense, especially related to acquisition of systems. I conclude in Section 12 by offering a few recommendations for ways to make improvements, not just in the software arena, but in the general area of defense systems acquisition and design. Three Appendices complete the 1992 version. A Postscript, written in 1997, updates the paper.

2.0 THE GENESIS OF THE BROOKS REPORT

In November of 1984, a memorandum was sent from the Department of Defense (DoD) to its Defense Science Board (DSB), requesting that a Task Force on Software be formed to carry out certain activities to assist DoD to improve productivity in software development. About three years later (!), in July of 1987, the Chairman of the Task Force on Military Software (Professor Fred Brooks of the University of North Carolina, and a former high-level IBM executive), forwarded the Report to the Under Secretary of Defense for Acquisition. The report was titled "Report of the Defense Science Board Task Force on Military Software," but in this paper it will henceforth be referred to as the "Brooks Report," in honor of its Chairman.

3.0 AN INITIAL REACTION TO THE BROOKS REPORT

The Brooks Report has three major attributes:

- **38 Recommendations.** A set of 38 recommendations that vary from reasonable to unreasonable, which are neither mutually consistent nor consistent with what is said in the Report
- **No Scientific Content.** Essentially no scientific content, even though one would presume that a report submitted by a Task Force of a Defense *Science* Board ought to reflect some science
- **Prototypical Technomyopia.** Certain generic characteristics that qualify it to be viewed as an illustrative example of one of the major problems that DoD presents to the nation: inability to provide sound management to systems acquisition, leading to excessive costs that threaten the fiscal security and thereby the national security of the United States.

The presence of this last attribute is ironic, when one believes that a major purpose of DoD is to defend us.

In the light of this interpretation, I sent a letter to the IEEE Institute newspaper in which I expressed some views about the Report. The letter I sent was edited down somewhat by IEEE to meet space requirements, but its essential content was preserved. As a result of that published version of the letter, an invitation was issued to me to discuss it at an IEEE Chapter meeting.

4.0 THE EXECUTIVE SUMMARY OF THE BROOKS REPORT

I will highlight selected material from the Executive Summary of the Brooks Report. According to the Report:

HIGHLIGHTS FROM EXECUTIVE SUMMARY

A. Many **PREVIOUS STUDIES** have provided an abundance of valid conclusions and detailed recommendations regarding military software, but most remain unimplemented.

B. Few fields have such a **LARGE GAP** between best current practice and average current practice.

C. The **FIVE CURRENT DoD MAJOR SOFTWARE INITIATIVES (Ada, STARS, SCI, SEI, and SDI)** are uncoordinated. Two of them are characterized as follows:

i) STARS: "little progress . . . vague and ill-focused plans for the future . . . recommend that the STARS JPO be moved from OSD to USAF Electronic Systems Division."

ii) Ada: " . . . by far the strongest [standard programming] language in sight . . . state of Ada compiling technology is now such that it is time to commit vigorously and whole-heartedly . . . development of unified programming environments is required . . . recommend that [AJPO] be moved from OSD to . . . USAF Electronics Systems Command . . ."

D. Concerning **DEFENSE ACQUISITION PRACTICES**: buy in the civilian market; get a new life-cycle model (dispense with the waterfall model and embody the early specification in a prototype which the intended users can themselves drive in order to see the consequence of their imagining); overhaul DoD STD 2167; revise Directive 5000.29; let several contracts to develop requirements and early prototypes, then a single contract for construction; provide incentives; encourage reuse of software; establish a public market in reusable software parts; and phase out substantial software-building efforts underway within the Services in order to concentrate the available knowledgeable officers upon acquisition.

5.0 THE INTRODUCTION TO THE BROOKS REPORT

I will excerpt selected material from the Introduction to the Brooks Report. The introduction contains the following:

EXCERPTS FROM THE INTRODUCTION

A. **CHARGE TO THE TASK FORCE**. Assess and unify various recent studies; examine why software costs are high; assess STARS; recommend how to enlist industry, Service, and university efforts in a productivity thrust; recommend how to apply R&D funds to get the most increase in military software capability; recommend how to implement an evolutionary approach to use of R&D funds; assess the wisdom of the Ada plan, including fourth-generation languages.

B. **WHAT THE REPORT SAYS THE TASK FORCE DID NOT ADDRESS**. Problem seriousness sizing, non-mission-critical software, Service-specific personnel problems, SEI, SDI, SCI, and new technological initiatives.

C. **MILITARY SOFTWARE**. Has a major role in today's weapons systems; cost $9 billion in 1985, and is projected to cost $30 billion by 1990. Deficiencies in software affect overall weapons systems performance and cost quite out of proportion to the software cost itself; timeliness and reliability are more important issues than cost; requirements-setting is the hardest part; the big problems are not technical.

D. **WHY SOFTWARE TECHNOLOGY GROWS SO SLOWLY**. Hardware technology is so fast-growing, software is labor-intensive; the essence is designing intricate conceptual structures rigorously and correctly; further methodological improvements will have to attack the

essence--conceptual design itself.

E. **CURRENT SOFTWARE TRENDS.** Microcomputer and personal computer; mass-market for software; technology for software modularization and reuse, rapid prototyping and iterative development; professional humility and evolutionary development.

F. **MANY RECENT RELATED SOFTWARE STUDIES.** The 1982 Druffel study summarized 26 previous studies. Appendix A4 to the Report lists the recent studies (including a speech by former Secretary Weinberger).

6.0 RECOMMENDATIONS OF THE BROOKS REPORT

The Brooks Report contains 38 recommendations. These were not placed in any categories, nor were they prioritized. In order to make it easier to discuss them, I placed them in categories. The eleven categories and the essence of the recommendations under each category are as follows:

RECOMMENDATIONS BY CATEGORIES

A. **PROVIDE COMMERCIAL/BUSINESS INCENTIVES.** Encourage or mandate that DoD buy commercial software whenever possible, and provide economic incentives to do so *(21% of all recommendations deal with this subject).*

B. **IMPROVE SYSTEMS ENGINEERING PRACTICES.** Strive to change the DoD paperwork that encourages outdated practices and encourage the use of newer practices with new paperwork *(13% of all recommendations deal with this subject).*

C. **DO PERSONNEL PLANNING AND EDUCATION.** The Secretary's level in DoD should do personnel planning to reallocate existing personnel, to provide more education for current software personnel, and to emphasize training in Ada *(13% of all recommendations deal with this subject).*

D. **REDEPLOY PEOPLE AND PROGRAMS.** Move at least two of the five DoD software initiatives to a new physical location, and put them under a unified command or coordinator. Those now writing software in DoD should be taken off such assignments and moved into software acquisition positions *(8% of all recommendations deal with this subject).*

E. **PREPARE PROGRAM PLANS.** A coordinated program plan for the five DoD software programs should be cooperatively prepared, and used to bring coherence to the total effort. Also the role of User Commands in this plan should be defined *(8% of all recommendations deal with this subject).*

F. **PUSH ADA.** The thinking on Ada has all been sound, except possibly for the timing of its introduction, and it should be pushed by top DoD management. A "module market" should be developed for Ada and used to encourage reuse of Ada software *(13% of all recommendations deal with this subject).*

G. **REVISE ACQUISITION POLICY.** Four software categories are offered as a basis for formulating new acquisition policy. Acquisition should be sensitive to the differences among these categories. Risk management should be used, with evolutionary acquisition to reduce risk *(8% of all recommendations deal with this subject).*

H. **MANAGE BY SOFTWARE CATEGORY.** In line with item G, manage software acquisition using the four categories *(3% of all recommendations deal with this subject).*

I. **DEVELOP METRICS.** Develop metrics to measure software quality, completeness, and implementation progress *(5% of all recommendations deal with this subject).*

J. **ENHANCE CAPABILITIES OF THE SERVICES.** Give the Services capability for rapid prototyping, and facilities for comprehensive testing and life cycle evaluation of software extensions and changes *(5% of all recommendations deal with this subject).*

K. **DO RESEARCH ON THE STRATEGIC DEFENSE INITIATIVE.** A critical research mass should be focused on software that is unique to SDI objectives *(3% of all recommendations deal with this subject).*

7.0 COMMENTS

- ***The Task Force did not address fully its charge.*** It did not say, for example, "how to enlist industry, service, and university efforts in a productivity thrust," nor did it say "how to apply R&D funds to get the most increase in military software capability." The Task Force had 20 members, and only one or two appear to have had any longevity in an academic position.
- ***The Report misrepresents its own content.*** While the Report states that it did not address the items listed in 5.0, Excerpts From the Introduction, Item B, the report clearly did so as follows:
  - Item C (Military Software) is clearly oriented toward sizing the seriousness of the problem
  - The recommendations to buy civilian software certainly seem directed more to "non-mission-critical software" than to mission-critical software. For example, one does not imagine that a missile would be guided with a commercial word processor.
  - Recommendations were made about SEI (a total of four, i.e., 11% of all recommendations) and about SDI (just one, i.e., 3% of the recommendations)
  - Although the Report says that the Task Force did not address new technological initiatives, their statement that they do not recommend any is the most negative possible way to address them. One may readily note, however, that the Report did not even mention the concept of "scientific initiatives" (as distinct from technological).
- ***The Report has nothing positive to say about science.*** Amazingly, the Task Force has virtually nothing to say on science, even though the Task Force directed its report to the Defense ***Science*** Board. The Board itself was also silent on science in its letter of transmittal to the Under Secretary. One might conclude from this that science has nothing to offer to improve productivity in software development. Is it unreasonable to suppose that perhaps the Task Force had no scientists on it or, possibly, that it does not comprehend the difference between science and technology?

8.0 PRIORITIES

Although 38 recommendations appear in the Report (which I organized into the 11 categories that appear in Section 6 of this paper), there appears to be no prioritization of them in the Report. Prioritization can be viewed (in the words of the Report) as oriented toward "designing intricate conceptual structures rigorously and correctly" [which Ref. 1 deals with rigorously and correctly]. In the absence of any priority structure for the recommendations, I have prepared one myself which, perhaps, is flawed, but is certainly definite and backed up by comments. My priority structure prioritizes the 11 categories rather than the 38 recommendations. Appendix B shows the priority structure. It reflects the view that some recommendations are much better than others, as well as the fact that success with some of them would be dependent on prior achievement of others of them. I will now discuss the priority structure, beginning with the category of recommendations that I favor most, namely metrics.

- ***The software field has consistently lacked sensible metrics to measure productivity or quality.*** I have proposed a metric for measuring software complexity (Ref. 2). The absence of metrics or the failure to use metrics means that many decisions being made in software development and in acceptance are undisciplined by any effective standard. This is one of the truly major distinctions between software and hardware. Hardware benefits from the discipline imposed on engineers and designers by the metrics of physical science, which govern the way people specify, measure, and report on hardware and its performance.

- ***The four recommended software categories are interesting, and the intent behind their proposed use is commendable, though the Report may not be sufficiently specific to permit effective categorization.*** The desirability of developing program plans for the programs, as well as some overall, coherent, integrating plan seems self evident. One is forced to wonder why Congress is willing to provide so much money for these programs in the absence of good plans. Perhaps the absence of respectable metrics is the key to this as well.

- ***The need to revise acquisition policies is clear to anyone who interacts with the acquisition system, whether it involves just software or other acquisitions.*** Also it certainly seems advisable to provide training for people in administering acquisition. It is surprising that the Report does not mention the Defense Systems Management College. This College has had responsibility for training program managers for years. It would be a natural place for such training to be done. Yet this College is presently budget-limited to one or two people to do all the software acquisition training related to what is likely to be 10% of the entire defense budget!

- ***The revision of systems engineering practice, while clearly needed, is not likely to be helpful unless higher priority items are carried out.***

- ***Purchase of commercial software and provision of business incentives is a matter for discussion that goes beyond the seemingly authoritative (but not backed up with any detail) statements in this respect in the Report.*** The Report seems to presume that software vendors can actually describe their commercial software in sufficient detail that acquisition program managers can make informed judgments about the potential utility of the software in the so-called mission-critical areas. Yet it is hard to believe that when software design is uninformed about how to design "intricate conceptual structures," reliable explanations of software can be furnished. Without such reliable explanations based on good understanding of the "intricate conceptual structures," it is hard to see how critical defense missions could be tied to such software (or for that matter to **any** software). As the Report itself indicates, the production of such intricate conceptual structures seems to be beyond the capacity of the whole industry at this time, and no suggestions are offered for ways that science might shed light on how to do this.

  One wonders just what the Report means by "intricate conceptual structures." Maybe this is a metaphor that is deliberately vague. Many would interpret this literally to mean graphical representations of the structure of large programs (and system concepts). However Brooks himself has stated in his now rather well-known "silver bullet" paper that he sees no merit in graphical representations. Without graphics, we are left only with prose or

mathematics as vehicles for communicating structure. It is hard to see how complex concepts which, in engineering, traditionally have benefited substantially from the use of graphics, can be communicated without them--but this is only one of the mysteries surrounding this Report. Anyone who has looked at a patent can surely understand not only why graphics are valuable, but also can see why it is important to do a first class job on them in order to gain the most from their aid in explaining things precisely. Similarly, anyone who has read the support literature provided by software vendors knows that such vendors do not provide such graphics.

- ***While the Ada language has devotees, or some would say fanatical adherents, the Brooks Report acknowledges its complexity as one of the factors that has prevented more use of it.*** The criterion used to assess the timeliness of Ada-pushing is the state-of-the-art of Ada compilers. Recent data suggest that taxpayers have supported the development of more than 120 Ada compilers. A private communication from a person intimately involved in this area suggests that only two of these are reasonably adequate. One might ask whether there are not other indicators of readiness for Ada besides the availability of compilers.

  The philosophy that the use of a standardized, single language has much to offer the DoD is commendable. However this philosophy alone is not sufficient to recommend the use of Ada. What is flawed in this arena is the concept that people should adjust to and work with whatever level of complexity is bureaucratically imposed upon them, without any clear evidence that people can handle such levels, rather than that one should design systems that take into account human limitations (Ref. 3).

- ***Presenting recommendations for redeployment of programs and people seems like an easy way to avoid thinking about how to solve the problems of low software productivity and high cost.***

- ***No area has seen more informed criticism in recent years than the Strategic Defense Initiative (SDI).*** The software part of this conceptual system has had the most informed, outstanding criticism. Nonetheless the Report ignores the criticism, and simply urges more focus upon software issues. Perhaps this shows most clearly the limitations of the Task Force. As long as science and scientific knowledge are ignored, such "political inventions" as SDI will continue to attract funds. Perhaps Albert Einstein, John von Neumann, Norbert Wiener, and other great scientists who have had such constructive influences on American technology are turning over in their graves as a consequence of present management of SDI.

9. SOME IMPLICIT ASSUMPTIONS BEHIND THE BROOKS REPORT

It appears that there are some implicit assumptions behind the Brooks Report which can be seen as symptoms of the disease called "technomyopia." The following are suggested as some of them.

- ***Assumptions about the community external to the software community.***
  - There is no knowledge lying outside the software community that can benefit it significantly.
  - There is no relevant science that can be brought to bear on software development.

- Science has no role to play in software development, in cutting software costs.
- Science has no role to play in enhancing productivity.
- There is great software available outside the defense community. DoD ought to be buying that in large quantities.
- The only motivation working for Americans is profit, therefore the profit motivation should be used to make DoD buy the commercial software.

- ***Assumptions about responsibility for the current software mess.***
  - Whomever is responsible for the current software mess, they are not around now to scapegoat (or if they are, they should not be criticized), and certainly they are not the people involved in the Task Force.
  - The practice of substituting personal (expert) opinion gained through experience in a defective field for science is not responsible for the mess.
  - The defense business split between hardware system design and software system design (i.e., having some companies who do one and other companies who do the other) has proved to be a good idea. The practice is irrelevant with respect to software productivity.
  - It is more important to honor sacred cows than it is to solve the software mess and help rescue the national economy (and sustain the software business internationally).

- ***Assumed management principles.***
  - Any time you have several organizations that seem individually to be inept or unproductive, that don't plan, and that don't produce, the solution is to put them all together under one management.
  - The only operative incentive for good management is profit, which is sufficient to overcome inadequate knowledge and training.
  - Management is a fine substitute for science, just as "growing" or "building" software is a fine substitute for designing software.

- ***Assumptions about recommendations.***
  - Never prioritize recommendations.
  - If you're not sure about a recommendation, make the broad claim that you are not addressing the issue to which it pertains, then go ahead and make the recommendation anyway.

10. MANAGING THE SOFTWARE DILEMMAS

A total conceptual solution to the software dilemmaS exists, which the present establishment is not prepared to recognize or to implement. This is not an unprecedented situation in America.

Some years ago, the Washington Monthly published an article in which they clearly explained

the demise of the American steel industry. It was a joint (though relatively uncoordinated) outcome of the actions of three major institutional actors: the steel unions, the steel company managements, and the federal government. Each actor in its own way, each in its own time, took actions aimed to protect its narrow interests or its own perceived mission, which collectively decimated this industry.

In the American auto industry, one can recall when General Motors had 54% of the domestic market. Financial observers said that the only thing preventing General Motors from getting a larger market share was fear of anti-trust action by the federal government. Now General Motors has less than 30% of the market. How times have changed! Is it possible that the same kind of adversarial coalition, each acting to protect its immediate interests, each acting on its own perceived legitimate behalf, is also responsible for the demise of this domestic industry? The same science of quality control made available to Japanese industrial management was readily available to American industrial managers ever since its presentation by Shewhart of the Bell Laboratories in the 1930's. These managers chose to ignore it, partly because they were convinced that quality products could not be made in America at a reasonable price.

Dr. Louis T. Rader, formerly President of Sperry Univac and Vice President of General Electric Company and now Professor Emeritus in the Darden School of Business at the University of Virginia, told me that when a Japanese firm bought the Motorola Quasar television plant, American management was convinced that the product failure rate could not be improved. Yet Japanese management brought the failure rate down substantially, partly by requiring that if any television set that came off the production line failed any tests, the Manager of Quality Control was required to fix it himself. The skillful use of incentives is something that should be familiar to American managers, but pay is not the only incentive available. Of course it is much easier for managers to blame shoddy workmanship for bad product, rather than to institute effective systems of quality management.

The information industries, with international competitors openly declaring that they intend to dominate this market, are not immune to the kind of behavior mentioned in the foregoing. They owe the nation something better than what is offered in the Brooks Report.

Not long ago I met Dr. Ryo Hirasawa who was then the chair of the Department of General Systems Science at the University of Tokyo. That Department, with a faculty of about 35 people, is part of the College of Arts and Sciences. The Department began after the Prime Minister of Japan and his colleagues identified seven areas that were judged critical to the future of Japan.

This area was one of the seven. By contrast, in America, universities are still displaying confusion about how to organize the information area and where to place the administrative power. The use of the word "system" is fairly common, but it is a very restricted concept, as interpreted in the typical American university. As the late Sir Geoffrey Vickers wrote, ". . . throughout almost the whole of human history, technology has progressed with an uncanny ignorance of the scientific principles which were guiding it," and as he further stated, ". . . it [the word 'system'] has, however, become so closely associated with man-made systems, technological design and computer science that the word 'system' is in danger of becoming

unusable in the context of human history and human culture. I seek to contribute something to its rescue and restoration. For we need it for understanding and for action in human and social contexts far too complex and imprecise to admit of formal modeling." Conceptual stewardship is not a goal in most engineering schools, but restriction of the language to narrow contexts is common practice.

Dr. Harlan Mills, a prominent U. S. computer scientist, told me in a conversation that a book on software that he and two colleagues produced in the late 1970's[2] was judged to be too mathematical for American college faculty and students. Yet the first printing in the U. S. S. R. was 40,000 copies. One of his principal recent suggestions is that, on the basis of available data on software failures, government-procured software should be required to pass rigorous statistical quality control tests, very similar to those to which hardware is subjected, before being accepted. While evidence exists to suggest that this is a meritorious suggestion, no attention is given in the Brooks report to this idea. Absence of it from the Report is reminiscent of the insensitivity to quality control that has long prevailed in much of American industry and which, even today, is still dominant in much of this industry. This is true in spite of the long efforts to give prominence to this idea on the part of individuals such as the late Professor W. Edwards Deming[3] and Professor Emeritus Myron Tribus[4].

The availability of a conceptual solution to the software dilemma is of little interest to the software establishment. It has a built-in aversion to listening, understanding, and integrating new ideas into the practice because:

- **Vested Interests.** Existing management has a vested interest in the state of the art as it is currently practiced.
- **Not Listening.** Existing management does not know how to listen long enough and organize the information well enough in their heads to prepare themselves to do the integration [See Ref. 4].
- **Unprepared.** If existing management accepted the solution, they would be faced with major management issues relating to implementation with which they have no

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[2] R. C. Linger, H. D. Mills, and B. I. Witt (1979), **Structured Programming: Theory and Practice**, Reading: Addison-Wesley.

[3] Deming is very well-known. His death took place after the 1992 revision of this paper. Still many of his ideas have not been adopted in U. S. companies. He spent his last years as a faculty member at the George Washington University. A local science reporter told me that he could be found there on Saturday mornings answering his own telephone.

[4] Tribus probably is not as well-known as Deming, but he pursued a varied and active career which, as far as I know, is still running at full speed. He had been an engineering dean at Dartmouth and UCLA, and later a vice president of research at the Xerox Company. Still later he ran an advanced engineering program at MIT, where he was a strong advocate of Deming's ideas, giving occasional testimony to Congress, and supplying his own writings relevant to Deming's work. The last time I corresponded with him, he had moved to the San Francisco area where he was doing research on thermodynamic engines.

experience, and with which they are unprepared to cope.[5]

- **Too Shallow.** As Dr. Paul Gray observed in the Chronicle of Higher Education, and as was observed some years ago by the late James Bryant Conant, the American public has insufficient insight into the difference between science and technology and the need to become educated concerning this difference in order to preserve our national heritage; and, given this handicap, some would insist that the problem is not management's problem, but a problem of the nation as a whole--and leadership (Ref. 5) is so busy with other things that it can't deal with this issue.

Finally, implementation of what is really needed requires more courage than has been evident in most bureaucracies in recent memory. If the ratio of arrogance to courage for today's management in the software arena could be brought from its present large value to somewhere around 1.0, major steps could be taken toward resolving the software dilemma.

The primary focus in the solution would be placed on the theory of relations--that body of knowledge formally introduced into scientific thought by Augustus De Morgan in 1847, and honed further by famous scholars such as Frege and Charles S. Peirce (a now famous graduate of Harvard University whom the then-president of Harvard refused to hire in Peirce's declining poverty-stricken years in spite of William James' impassioned written request, because Peirce was seen by the administration as a trouble-maker). It is that fundamental branch of mathematical logic that furnishes the firm basis for "designing intricate conceptual structures rigorously and correctly" and which provides the basis for a science of design. It is ironic that this scholarly body of knowledge which is not even mentioned in the Brooks Report is the same body of knowledge that underlies the entire information field, including the design of hardware to support information operations. It is the field that underlies the book co-authored by Mills which was mentioned above. And it is a branch of knowledge that can contribute corrective measures in a major, unique, and fundamental way to the rigorous and correct design of conceptual structures in the information field and any other field of knowledge.

11. PROBLEMS OF THE DEPARTMENT OF DEFENSE

The Brooks Report reflects many problems that have been endemic to the Department of Defense. The system acquisition area alone could be the subject of an encyclopedia. A few aspects will be highlighted briefly. The first such aspect is the lack of management continuity, especially in the area of systems acquisition.

THE LACK OF MANAGEMENT CONTINUITY

I know of no business and, especially of no $300 billion dollar business, that would be permitted to operate without management continuity. Yet this mammoth budget is administered by people who move in and out of government, often lacking management ability, and who are chosen for political reasons. This situation is intolerable, but it offers a simple explanation why that part of DoD that is specifically charged

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[5] This situation was described in detail in a report prepared by Dr. Harlan Mills for the military managers of the Strategic Defense Initiative, but it seems to have neither been understood nor acted upon.

with the education of people for systems acquisition would have a budget of about $250,000 for education in software acquisition, This is less than one hundredth of one percent of the annual expenditures by DoD on software, which speaks for itself. Lack of continuity of management prevents dealing properly with such overriding matters as these.

To correct this situation, salaries need to be raised well above what is presently being paid for top management, and the Congress (a legislative body without much management know-how) has to learn how to put strong leadership in place for a significant period of time, and stop micromanaging. Continuity of leadership, co-location of responsibility and authority for system design and development, and depoliticization of defense systems acquisition will be traumatic, but it is necessary. The only body that can correct the situation is Congress, and it will never do so unless the American people can somehow learn to comprehend the magnitude and consequences of the waste, as well as the threat posed to the future health of the industry.

The second aspect to be discussed is the terrible decision-making system.

A TERRIBLE DECISIONMAKING SYSTEM

Can you imagine waiting **three years** for the results of a study to try to cut waste and improve productivity? Can you imagine receiving the Brooks Report after such a long time? How can continuity and effective management be found with such indifference to timeliness of information? Can you imagine the situation with regard to Ada, where vested interests are constantly promoting this cognitive nightmare, this camel designed by a committee, and that there is not enough scientific strength applied to this area of decision to allow timely definition of issues and study of decisions? Can you imagine a system that allows continued misallocation of tax funds to the Strategic Defense Initiative, where voices of self-appointed authority tell scientists that this system will work because they say so?

The third aspect to be discussed is the terrible people-calibration problems.

TERRIBLE PEOPLE-CALIBRATION PROBLEMS

It is very wrong to suppose that technologists have the fundamental understanding to guide long-range, large system developments independently of science. It is not the fault of technologists that they are now trying to do so. They have been put in this position by politicians. At one time it was said that "engineers ought to be on tap, but not on top," and this is now more than just a slogan. It is a verifiable statement, when seen in the light of what is being delivered in return for mammoth expenditures. Yet, as Fisher [6] has made clear, there is really nobody in charge. When things are so bad that the IEEE Spectrum itself publishes articles on how bad the designs are, you know that whoever is making the high level decisions is not self-calibrated against any sensible standard. People are being put in positions for which they are totally unprepared by education or experience, and thereby get the message that they are ready to perform. But one must learn to distinguish between feats of intellectual and physical heroism, and activities that are beyond human intellect to carry out at the time and under the prevailing cultural limitations.

The fourth aspect to be discussed is the inappropriate high-level personnel situation.

INAPPROPRIATE HIGH-LEVEL PERSONNEL SITUATION

The military puts its general officers into untenable positions. They are given short-term rotational assignments (one or two years) in positions where several years would be needed to gain the knowledge required to make sound system changes. They are given incentives to make system changes while they are in these short-term positions that will demonstrate their suitability for promotion when, in truth, they cannot possibly make the appropriate changes in such fields as systems acquisition and software development and training. Something has to be done to redesign the on-the-job training of military officers for some kinds of positions. While the health of the services does require that officers be rotated in their assignments, mindless rotation is worse than no rotation. If the length of assignments and the prior education and training cannot be adjusted properly, then high-level management continuity must be turned over to a civilian executive, and the role of the general officers and others who are rotated into assignments requiring long-term understandings must be changed. They should be seen as primarily in learning roles, not in roles that provide incentives for quick reorganizations. There must also be some requirement for communicating with higher-level management boards concerning their achievements in learning what is going on and contributing to it in a staff role, rather than in a command role.

In the absence of such a change, we can expect to continue down the road of trying and failing to compete successfully with people in other nations who value long-term thinking and meticulous learning, as well as systems education and systems thinking, and who have a dedication to thoughtfully articulated long-term national developmental objectives, as well as their own short-term personal advancement.

Finally, at the root of many of the problems of the DoD one finds defective understanding. This is the fifth and last of the problems of DoD to be highlighted in this paper.

DEFECTIVE PHILOSOPHY CONCERNING SCIENCE AND TECHNOLOGY

Somehow the Department of Defense has to learn at the highest levels the differences among science, technology, management, administration, and leadership. These are all valuable concepts, and their integration in one mind places strenuous demands on human learning--especially when our educational institutions compartmentalize the subjects. Somehow we have to find or develop more people in the mold of Generals Marshall and Bradley from World War II, and somehow we have to find a way to get people who have led the software field into its current quagmire out of roles where they cause national productivity to stagnate.

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12. A FEW ALTERNATIVES

At the beginning of this article, I said that I would suggest a few alternatives to the recommendations in the Brooks Report. Now I will deliver on this statement, limited by the time available in the presentation and the space available in a paper.

12.1 Generic Design Science and Interactive Management. During the past twenty-two years, my colleagues and I have developed a generic design science that explains how to study, design alternatives, and choose an alternative for a proposed large and complex system. In parallel with that development, there has been a development of Interactive Management, a system that shows how to implement the generic design science in practice.

Design science itself can be broken into three categories:

- the ***specific design sciences,*** which underpin disciplinary design, such as electrical design, mechanical design, chemical design, organization design, etc. These specific design sciences embody the fundamental underpinning to modern technology at the detailed level.

- the ***generic design science,*** which is virtually orthogonal to the specific design sciences. Its content is founded in anthropological and logical concepts. It is a science focused on conceptualization and representation, involving concepts about human behavior, human beings, their capacities and limitations; involving philosophy and the history of development of logic throughout the almost 2,500 years of its formal existence and evolution; and involving concepts of language and the criteria to be met by language in order to make it compatible with the human mind and its performance in working with complexity.

- the ***general design science,*** envisioned as the ultimate integrated body of knowledge bringing together generic design science and the specific design sciences, and which does not presently exist.

The generic design science has been repeatedly tested with real problems and issues, and with people who are engaged with such problems and issues. It works. It provides self-documenting processes that enable people to do exactly what the Brooks Report (correctly) says must ultimately be done: "attack the essence--conceptual design itself." This science enables users to carry out just what the Brooks Report (correctly) says is most critical: "designing intricate conceptual structures rigorously and correctly." With this in mind, an alternative or supplement to the recommendations of the Brooks Report is the following:

> ***That the Department of Defense and/or its defense industry companies dedicate some resources to studying what is already available in this area, and carrying out a carefully designed test of the use of the generic design science through its implementation system called Interactive Management, in the design and development of high-quality software.***

Since this recommendation was first made in 1988, it has become possible to report that while this recommendation has not been given any attention, some things have happened that are notable in respect to it. Specifically, the Defense Systems Management College, with the blessing of its Provost, Greg Wierzbiecki, and with aggressive leadership from Professor Henry Alberts, has applied Interactive Management repeatedly in a series of workshops to problems of defense acquisition in general. A list of titles of the workshops appears in Appendix C to this paper. The early workshops were held at George Mason University in the then-existing Center for Interactive Management. Almost all the later workshops have been held at the Defense Systems Management College, and have involved numerous well-informed participants from the acquisition community, including both federal government and industrial persons. As a result of these workshops, a redesign of the acquisition system has been largely carried out, and various components of this redesign have been instituted. Perhaps the results of this activity will lend more credibility to the software recommendation, and it may ultimately become possible to see it carried out as intended.

12.2 The Defense Science Board. The Defense Science Board is really a defense technology board. There is a need for a defense technology board, but there is no need to call it a defense science board. Instead, it is necessary to construct a true defense science board comprised of very well informed, practicing, scientists. The roles played by Albert Einstein and John von Neumann in assisting the federal government in moments of dire need can be models for the kind of roles that are required for a defense science board. Very likely it would be desirable to have a small amount of cross membership between a true science board and a technology board.

Not too long ago, DoD had both a Defense Science Board and a Defense Manufacturing Board. The latter was eliminated. What is required is to recognize what is needed and then design the DoD organization so it can benefit from the board deliberations. A true science board would never have

accepted the Brooks Report, and would not have forwarded it to higher authority. A true science board would not have been willing to tolerate three years of delay in producing the Brooks Report, no matter what the reasons for its delay.

In the series of workshops carried out by the Defense Systems Management College, reports comparable in scope and complexity to the Brooks Report have been developed repeatedly in less than a month. A nation whose productivity is known to compare very unfavorably with those of its principal international competition cannot afford to ignore this situation, no matter how painful its implications may be.

12.3 The Presidency. Much of the decline in American science and technology in those areas where America is weak has occurred because the President has not accorded to science its proper role in decision making. While it is true that scientists do not speak with a single voice, the role of scientists in the federal administration is murky at best. It is ironic, when viewed in the light of history and images of nations that, in Germany, the scientific community elects to three-year terms the scientists who will advise the government on the allocation of scientific funds; while in America political appointments determine who will offer advice and who will administer the government's principal scientific funding agencies. In recent years, the Congress has chosen to provide funds to local constituencies without regard to qualifications or even interest, establishing operations in critical areas that are staffed with people who are not scientists and who are unknown to the scientific community, and who often will remain so in the future.

It would be appropriate to begin to democratize American science, and to establish and apply honestly criteria for the selection of persons to fill leadership positions in science. One criterion would be that the individuals would have to be scientists. If this criterion alone had been enforced, many of those appointed in past decades would never have qualified for the positions.

12.4 Incentives. An alternative to the cash incentives recommended in the Brooks Report for federal managers to buy commercial software might be to pursue a policy effective in Japan. There, cash bonuses paid to industrial managers of technology are computed from a formula that includes the national productivity of Japan. Perhaps if federal contracts reflected a similar policy, and if boards of directors incorporated such a practice in determining executive salaries (not to mention the requirement that the individual industries themselves show some increases in productivity), the incentive system could work to upgrade effectiveness. Who can presently find any criteria that are applied in setting large salary amounts for corporate top executives in the defense industry (or other American industry) which relate to results?

The front page of the Business Section of the New York Times dated February 9, 1992, shows that between 1960 and 1990 productivity grew in Japan by a factor of 450%. For the same period, in Germany productivity grew by a factor of 220%. In the United States, for the same period, productivity grew by a factor of 145%. These figures are based on data from the Bureau of Labor Statistics. Every indication is that these rates of growth will continue for the foreseeable future, in the absence of some significant change agents.

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APPENDIX A

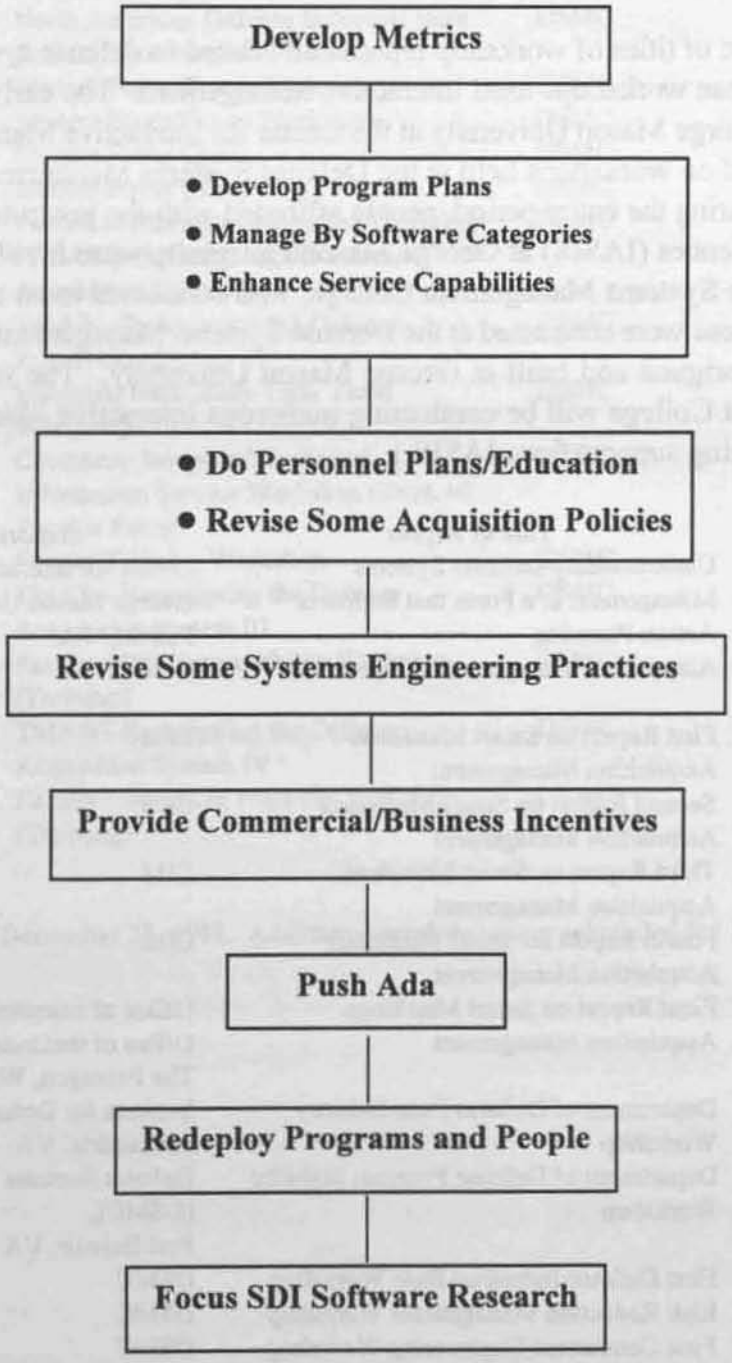
Field Representation Of Task Force Recommendations

A. COMMERCIAL and BUSINESS INCENTIVES	B. SYSTEMS ENGINEERING PRACTICES	C. PERSONNEL PLANNING and EDUCATION
15. Off-the-shelf subsystems, components	4. STARS should incorporate modern practices and tools in several model programs	9. More Ada training, both technical and managerial
16. Off-the-shelf software tools	10. Allow 4th generation languages, where cost-effective	34. Plan how to live with software personnel shortages and how best to use available people
17. Productivity incentives	21. Require use of modern commercial practices	36. Track personnel skills and project personnel needs
18. Profit incentives	23. Mandate iterative setting of specs, rapid prototyping, and incremental development	37. Structure officer careers to get managers with deep technical mastery and broad operational overview
22. Modify intellectual property regulations	24. Eliminate use of waterfall model, institutionalize rapid prototyping and incremental development	38. Enhance software education
29. Economic incentives for reusable software marketing	**D. REDEPLOY PROGRAMS and PEOPLE**	**E. PRODUCE PROGRAM PLANS**
30. Economic incentives to buy modules rather than build them	1. Move STARS and rebuild it	2 Task STARS, Ada JPO, SEI, SDI, and DARPA SCI to produce joint plan.
31. Identify subsystem components, modules that can be acquired, and reward such acquisition	6. Move Ada JPO into organization with STARS and SEI	3. Task new STARS director to define program goals, and plan to achieve early results
I. DEVELOP METRICS	35. Use DoD people for acquisition instead of construction	28. Spell out role of using commands in evolutionary and incremental software development
19. For software quality and completeness		
20. To measure implementation progress		

G. REVISE ACQUISITION POLICY	F. PUSH ADA	H. MANAGE BY SOFTWARE CATEGORY
12. Use evolutionary acquisition to reduce risk	5. Commit DoD management to push Ada	14. As followup to Recommendation 13, develop policy, procedures, and guidance for each category
13.Adopt new categories as basis for acquisition policy	7. Keep Ada JPO as DoD staff support	
25. Mandate use of risk management techniques in software acquisition	8. Forbid subsetting of ADA	**J. ENHANCE SERVICES CAPABILITIES**
	32. SEI should establish prototype Ada modules/tools market, then spin off	26. Rapid prototyping
K. SDI	33. SEI and Ada JPO set standards for Ada modules for trhe market	27. Test and evaluation
11. Focus		

APPENDIX B

A Suggested Priority Structure for Categories of Recommendations



The highest priority (best) item is at the top, and the lowest priority item (worst) is at the bottom. Some categories appear as lower than others because they depend on achievement of higher ones to be successful. Categories in the same box are of equal priority.

Appendix C

Defense Systems Management Or Acquisition Reports

[The following is a list of titles of workshop reports, all related to defense systems management or acquisition. All of these workshops used Interactive Management. The early reports are based on workshops held at George Mason University at the Center for Interactive Management (CIM). The later reports are based on workshops held at the Defense Systems Management College (DSMC), Fort Belvoir, VA. During the entire period, people affiliated with the Institute for Advanced Study in the Integrative Sciences (IASIS) at George Mason University were involved in supporting the faculty of the Defense Systems Management College, who conducted most of the workshops held in 1990 and 1991. These were conducted at the Defense Systems Management College in a situation room like the one designed and built at George Mason University. The faculty of the Defense Systems Management College will be conducting numerous Interactive Management Workshops in 1992, with continuing support from IASIS.]

Date	*Title of Report*	*Report Prepared By:*
December 15-16, 1986	Understanding Defense Systems Management in a Form that Supports Action Planning	Center for Interactive Management George Mason University Fairfax, VA
November 30- December 4, 1987	Acquisition Management Alternatives	CIM
August 1-3, 1988	First Report on Smart Munitions Acquisition Management	CIM
September 12-14, 1988	Second Report on Smart Munitions Acquisition Management	CIM
September 19-21, 1988	Third Report on Smart Munitions Acquisition Management	CIM
September 27-29, 1988	Fourth Report on Smart Munitions Acquisition Management	CIM
February, 1989	Final Report on Smart Munitions Acquisition Management	Office of Munitions, Office of theUnder Secretary of Defense The Pentagon, Washington, DC
March 7-9, 1990	Department of Defense Fuze Industry Workshop	Institute for Defense Analyses, Alexandria, VA
March 14-15, 1990	Department of Defense Program Stability Workshop	Defense Systems Management College (DSMC), Fort Belvoir, VA
July 17-19, 1990	First Defense Industrial Base Workshop	DSMC
November 6-7, 1990	Risk Reduction Management Workshop	DSMC
November 14-15, 1990	First Concurrent Engineering Workshop	DSMC
November 27-28, 1990	Requirements/Resource Allocation/ Acquisition Process Alignment Workshop	DSMC

Date	*Title of Report*	*Report Prepared By:*
December 17-21, 1990	Second Concurrent Engineering Workshop	DSMC
January 22-25, 1991	Contractor Integrated Technical Information Service (CITIS) Workshop	DSMC
January 28-29, t991	Summary Report on DoD Workshops on Concurrent Engineering	DSMC
February 27-March 1, 1991	North American Defense Industrial Base Critical Technologies Workshop	DSMC
April 18, 1991	Student Focus Group Workshop	DSMC
May 16, 1991	Student Focus Group Workshop	DSMC
May 20, 1991	Student Focus Group	DSMC
June 3, 1991	Student Focus Group	DSMC
June 17-21, 1991	Technical Managers Advanced Workshop (TMAW)--Redesigning the Defense Acquisition System I	DSMC
July 23-24, 1991	TMAW--Redesigning the Defense Acquisition System 11	DSMC
August 19-21, 1991	Industrial Base Study Tiger Team Workshop	DSMC
August 28-30, 1991	Contractor Integrated Technical Information Service Workshop (Dept. of The Air Force)	DSMC
October 15-16	Faculty Training Workshop	DSMC
November 18-22, 1991	TMAW--Redesigning the Defense Acquisition System III	DSMC
December 2, 5, 1991	Faculty PHD Comparability Workshop (Training)	DSMC
December 10-12, 1991	TMAW--Redesigning the Defense Acquisition System IV	DSMC
December 15-16, 1991	Faculty Consulting Practices Workshop (Training)	DSMC

This list is current as of December 22, 1991. Additional workshops are scheduled for 1992.

POSTSCRIPT

Much has occurred since the last update. The work at the Defense Systems Management College continued, and was quite successful. That work is discussed in later volumes of "Essays".

The so-called Millennium problem has surfaced, in which a myopic decision was made to use only the last two digits to represent a year; so that all of the old COBOL documents become useless at the beginning of the year 2,000 unless corrections are made before then. Some people believe this error will bring down the whole government system. If the hundreds of millions of dollars needed to fix this problem do not produce a fix, some believe that the lawsuits filed as a consequence will cost even more than the cost of fixing it.

Others believe that the personnel are not available to do the fix, since the old COBOL programmers have largely retired, and there are not enough around to do the fix.

A recent newscast suggested that the US software establishment is following the same path as the auto industry following world war 2.

SOME MAGNIFICENT ACADEMIC TRUSELS AND THEIR SOCIAL CONSEQUENCES

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ABSTRACT

A "trusel" is an idea or a finding that is widely perceived to be true, but which is largely useless (or even of negative value). (The idea that a truth may lack value may be disturbing, but it is true, although it is not a trusel.)

A "Magnificent Academic Trusel" is one that has been widely acknowledged for its intellectual content (explicitly or implicitly), but without a corresponding amount of attention being given to its utility or even to its potential negative value for society. The negative value may come from commission or omission. It may deal with the content of a discipline, with the way a discipline is perceived, with knowledge that cuts across disciplines, and even with "integrative studies". Some selected trusels with possibly serious social consequences will be discussed. Among these are Gödel's Theorem about incompleteness of languages, the idea that "interdisciplinarity" should have an important place in the language of academia, the thought that in teaching language the prose form alone is of great value and should command most of the teaching attention and resources, the idea that mathematics is a science instead of a language, the idea that it is all right to use the name "science" indiscriminately to name academic programs (such as "management science" and "computer science") without any stated criteria whereby this nomenclature is validated, and that people with little or no "academic track record" should be given significant power to allocate academic and research resources, or to make key public decisions affecting higher education.

Examples of serious and inappropriate consequences that have ensued from such trusels will be discussed, and a strategy for dealing with them in the future will be offered.

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1.0 FOCUS AND ASSUMPTIONS.

This paper focuses upon the status of formal academic programs, suggesting that these programs can be dramatically improved.

I begin this discussion by providing a set of assumptions (i.e., suppositions made consciously for the sake of argument) that activate the analysis to be given in the paper.

Assumption 1. **Bounded Content.** The content of formal academic programs is bounded, and cannot possibly include all proposed or candidate material.
Assumption 1 is equivalent to (i.e., interchangeable with) the following Assumption.

Assumption 1A. **Choice is Essential.** Necessarily the content of formal academic programs involves choices of what to incorporate and what to leave out.

Assumption 2. **The Academic Establishment Chooses.** The content of formal academic programs is determined by faculty and administrators, operating under various criteria, some of which are imposed by legal systems, but most of which are imposed by the faculty-administration complex (hereafter designated by the term "***academic establishment***").

Assumption 3. **Some Content is Displaceable.** Formal academic programs ***include*** some content that is inferior to other content that is ***excluded***. (The inferior included content hereafter is designated as "***displaceable***".)

Assumption 4. **Excessive Displaceable Content.** The displaceable component of included content is excessively high.

Assumption 5. **Changing the Establishment's Thinking.** Displaceable content appears in academic programs for a significant variety of reasons. If this content is going to be displaced it will be necessary that the academic establishment embrace at least some of the following ideas:

a. It is appropriate to carry out ***systemic analysis*** of content to determine whether it is displaceable or not
b. It is appropriate to consider candidate ***bases*** for such analysis.
c. It is appropriate to consider candidate ***processes*** for performing such analyses, and to evaluate candidate processes in relation to candidate bases.
d. One of the key reasons for the presence of excessive displaceable content is ***failure by the academic establishment*** to embrace items (a,b, and c).
e. Another key reason for the presence of displaceable content is the ***absence of processes*** for evaluation tied to bases for such evaluation that have academic credibility. (The absence of such processes is one way to account for failure of the establishment.)

Assumption 6. **Change is Possible.** If processes can be set forth that have credible bases, and if it is feasible to carry out these processes in academia, the establishment will be responsive to such processes, and will apply them to replace displaceable content with superior content.

Assumption 7. **Unrecognized Relevant Options are Available.** Certain relevant scholarly domains contain the necessary bases and describe relevant processes.

2.0 DIAGNOSES.

Various diagnoses and prescriptions emanate from the literature. Because discussions of the type to follow often may lack appeal stemming, in part, from dryness, an effort will be made to liven up the presentation with some moderately colorful language. From among the various diagnoses, the following four account for much of the displaceable content of formal academic programs.

2.1 Diagnosis #1: Kenneth Boulding and the PIPS. Part of the diagnosis pertaining to displaceable content of formal academic programs can be found in Kenneth Boulding's discussion of Poor Intellectual Productivity (PIP). According to Boulding [1], poor intellectual productivity has three principal origins or Sources: unproductive emulation, spurious saliency, and cultural lag.

Unproductive emulation refers to what might be called "global academic groupthink" (GAG), a particular species of groupthink [2], in which one postulates that there are some truly outstanding academic institutions, and that those institutions who aspire to share in the greatness should emulate the outstanding ones.

Spurious saliency refers to what might be described as allocating importance to content that far exceeds the proper allocation.

Cultural lag refers to major time delays in assessing and implementing advances.

2.2 Diagnosis #2: Structural Incompetency Virus. Part of the diagnosis pertaining to displaceable content of academic programs is that academics (both faculty and administrators) suffer from SIV, the Structural Incompetency Virus. This affliction was discovered in group discussion extending over a prolonged period by a group of program managers from the U. S. Department of Defense. It refers to a situation where, no matter what talent a person has, no matter what intelligent action a person might bring to a problematic situation, no matter what insights could be applied to resolving crises, the individual is precluded from exercising those talents and insights by virtue of the organizational structure in which the individual is embedded. In the Department of Defense, a significant part of that organizational structure is the vast set of laws and regulations (confusing, contradictory, and almost unlimited in amount), along with the

unpredictable micromanagement imposed on the program managers by an overstaffed array of bureaucrats, legislators, auditors, and comptrollers. The extent of abuse of their various authority is commensurate only with the absence of responsibility for the mindless impact of their unpredictable and uncorrelated interventions.

2.3 Diagnosis #3: Underconceptualization Stemming from Defective Presuppositions. Part of the diagnosis pertaining to displaceable content of academic programs is that the application of power in making choices is based on ***underconceptualization*** stemming from defective ***presuppositions*** [3]. The application of defective presuppositions apparently is at the root of a great many bad decisions made by managers of all types, including those in the academic establishment. The defective presuppositions are quite frequently not articulated (often because they are buried in the subsconscious), and consequently cannot be corrected through discussion.

Underconceptualization is a kind of system concept in which matters of considerable importance to some particular content are ignored, leading to a sub-conceptualization originating in the defective presuppositions.

2.4 Diagnosis #4: The Attraction of Magnificent Academic Trusels. A "trusel" is an idea or a finding that is widely perceived to be true, but which is largely useless (or even of negative value). (The idea that a truth may lack value may be disturbing, but it is true, although it is not a trusel and probably will not be thought to be magnificent.)

A "Magnificent Academic Trusel" (MAT) is a trusel that has been widely acknowledged for its intellectual content (explicitly or implicitly), but ***without a corresponding amount of attention being given to its utility or even to its potential negative value for society.*** The negative value may come from commission or omission. It may deal with the content of a discipline, with the way a discipline is perceived, with knowledge that cuts across disciplines, and even with "integrative studies".

Academia is an environment where two main things go on as the defining part of the image that characterizes academia. These are: (a) faculty actions, involving the advancement of thousands of ideas to a student clientele (whether formally in the classroom or informally in the research environment) and (b) administrative actions involving the imposition of dozens of decisions that affect faculty-student performance and morale.

For reasons that are widely understood and accepted, the advancement of particular ideas is almost never subjected to prior scrutiny for evaluative purposes. Thus the concept of "quality control" in academia is weak, at best, and there is little likelihood that this situation will ever change through administrative action alone. Any attempt to "police" faculty utterances in the classroom will meet with deserving scorn.

Because the life of the faculty member in an academic institution is often hectic, and usually

involves high motivation and long hours, administrative decision making seldom is much affected by the busy faculty at large; although some token representation is usually to be had. Administrative rhetoric constantly reminds the faculty (much to the satisfaction of the faculty, who like to have this fiction sustained) that the faculty comprise the ruling body, when all the while the administration is making those decisions at will that often reflect biased and uninformed opinions about what is going on in the complex institution called a university.

In an environment of this kind, where a faculty member can say almost anything in a classroom without fear of being called to account; and where there is an administrative-faculty tacit agreement that the administration can rule indiscriminately where it counts the most (i.e., in budget allocations), it is inevitable that severe abuse can take place both with respect to the propagation of knowledge and to the individual faculty member.

If constructive change is ever to occur, it seemingly must involve a change in the mental models of the faculty leading eventually to a different view of academic administration, and a meeting of the minds that allows academia to evolve to a higher level of respectability.

3.0 PRESCRIPTIONS.

Just as there is variety in the diagnoses, also there is variety in the prescriptions.

3.1 Prescription #1: Thinking in Sets. It has been suggested that one of the major improvements in thinking about thinking is to begin to apply consciously what are called the "***golden triads***", i.e., sets of three ideas that are applied collectively and integratively [3,4]. One of the most valuable golden triads is the triad: {***CCP***: context, content, process}. Another is the triad: {***PPF***: past, present, future}.

The ***CCP*** Triad may be fruitfully applied in inspecting MATS. Many of the MATS derive their popularity and stature from their content alone. If, however, they are examined seriously in terms of context and process, and at the same time they are examined in terms of the ***PPF*** Triad, new perspectives may be gained that will displace them from formal academic programs. This idea will be illustrated later in this paper.

3.2 Prescription #2: A Conscious Attack on the PIPS. A conscious and continuous attack that defuses the PIPS will pay major dividends.

First of all, one observes that if those presumed outstanding institutions were really deserving of emulation, they would not have been major players in creating the problematic situations that require correction. To emulate institutions whose players have been active in producing major crises of the times cannot be a sound goal.

Second, one observes that spurious saliency can be systematically attacked if thinking in sets is practiced, wherein saliency can be systematically studied by comparing relative saliency of displacement candidates along with proposed new entries.

Finally, because the elimination of cultural lag requires action to effect future change, institutionalization of a part of academia that makes the study and design of the future its business (i.e., the "Horizons College"[11]) will help.

3.3 Prescription #3: Heeding The 3 P's. Three individuals whose names, coincidentally, start with the letter "P", have had a lot to say that is relevant to academic content. The three P's are Peirce [5,6,7], Percy [8], and Perry [9].

From the tremendous array of contributions by Peirce, one may note especially the Pragmatic Maxim. The Pragmatic Maxim assigns meaning to an idea based on its consequences. One of the many ways the Pragmatic Maxim can be applied is to the study of the likely consequences of keeping a particular MAT in formal academic programs. In using the Pragmatic Maxim in this way, its use may be combined with the use of the ***CCP*** golden triad, where the ***contexts*** pertinent to the MAT can be evoked along with ideas about the ***processes*** that relate to the MAT. Explorations of this type may change completely the way the MAT is viewed, and lead to its displacement and replacment with related but much more substantive content.

Walker Percy drew heavily on other aspects of Peirce's thought when he discussed the "San Andreas Fault in the Modern Mind", and tried to inject remedial thinking into the domain of the human sciences. Percy referred heavily to Peirce's ideas about the importance of triadic relationships, and especially to the **golden triad** {***HRN***: human, referent, name}. When combined with the discussions of human systems by Vickers [10], a new perspective can be gained on issues having to do with revision of human belief systems that account for the presence of displaceable content in formal academic programs. The contributions of Percy and Vickers relate to increasing human sensitivity to the impact of their use of language and to its role in sustaining the expectations that people have when they are in close association with one another in organizations.

Ralph Barton Perry provided a golden triad that asserts the three main objectives of education, very briefly described as: {***IPC***: "inheritance", "participation", and "contribution"}. These three objectives align precisely with the ***PPF*** triad. More importantly, they provide part of the critical basis for assigning value to content in formal academic programs. They have also been discussed in connection with the notion of "great university" [11].

3.4 Prescription #4: Salk Intellectual Vaccine. The Structural Incompetency Virus (SIV) can be treated successfully with the Salk Intellectual Vaccine (SIV). This treatment refers to the "merging of intuition and reason" that has been explained, motivated, and recommended by Salk [12].

The Salk Intellectual Vaccine amounts to a **silver dyad** {***IR***: intuition, reason}[3]; i.e., the normative idea of sustaining an inseparable connection between intuition and reason, whereby articulated steps are taken to ensure that each of these reinforces the other in conceptualizing, diagnosing, and prescribing change.

3.4.1 Western Logic. Reason, as distinct from intuition, has no apparent referent in the literature other than formal logic. It is probably inappropriate to insist that only Western logic be the basis for thought, but at the present time it is the only formal logic that is susceptible to application to complex systems with "bookkeeping" assistance from the computer that allows the formal construction of logical patterns [13]. In this way it enables the embedding of intuitive thinking in logical patterns which, in turn, allows the mental integration of intuition and reason.

Western logic is very closely allied with the study of linguistics and with the use of language to communicate between human beings of different backgrounds and talents. Many references are available that are germane to the merging of intuition and reason [14,15,16,17,18].

3.4.2 The Constrained Person. Freeing the individual from the deadly impact of organizationally-imposed constraints can be abetted by understanding better how those constraints can affect behavior. There are institutional shackles and there are problems imposed due to excessive cognitive burden. Downs [21] goes to great lengths to show how individual behavior is shaped in bureaucratic organizations, and Etzioni [22] discusses at length the impact of overload. Forewarned by these insightful sources, the individual can see the importance of building personal defensive shields against the intrusions of the organization that produce Global Academic Groupthink, and begin to edge into a more constructive behavioral pattern.

3.5 Prescription #5: Probing Ideas Systematically for Contextual Implications.
When a single concept is automatically accepted without analysis, or when a trusel is lifted up to a prominent position unwarranted by its attributes, a prescription is required that enables the individual to escape from these forms of behavior. Such a prescription is found in the study of contextual implication.

Contextual implication apparently was the principal province of the studies of the English philosopher Collingwood [21]. In his studies of questioning (i.e., of inquiry), Collingwood asserted:

> Whenever anybody states a thought in words, there are a great many more thoughts in his mind than there are expressed in his statement. Among these there are some which stand in a peculiar relation to the thought he has stated; they are not merely its context, they are its presuppositions.

Peirce asserted that all inquiry begins with doubt, the origin of inquiry. In Collingwood's reference frame, doubt can be entertained by exploring the contextual implications of the concept or statement about which doubt has been engendered.

In our present context, it is the mode of behavior that allows displaceable content into formal academic programs which is at the focus. Antidotes to this behavior are, in a sense, both technical and ethical. The technical aspect has to do with the integration of intuition and reason (through formal logic); while the ethical aspect has to do with the value base from which such behavior stems.

3.5.1 Logical Context. There is a logical context within which contextual implication can be explored, and there is also a humanistic context. The former has been explored by Ketner [22] and Dykstra [23]. The latter has been explored by Hungerford [24]. Together these explorations offer new insights into what might be called "establishing a high quality of communication".

3.5.2 Humanistic Context. Hungerford's analysis [24] is concerned not so much with the pure logical aspects of the presuppositions attached to a statement of question, but rather with what a human observer can legitimately be expected to take for granted in looking at an expression. She includes in her thinking the concept of a "normal act of stating", which introduces ethical considerations into the dialog.

4.0 INQUIRY CONCERNING SPECIFIC TRUSELS.

Trusels can be deeply examined in the light of the foregoing prescriptions.

4.1 Magnificent Academic Trusel Number One. Magnificant Academic Trusel Number One, is asserted to be **Gödel's Theorem concerning the incompleteness of language**. There may be a reader who has been imprisoned for 60 or 70 years and is only now returning to society. For this reader, let us say that this Theorem is about the incompleteness of a formal language. In superficial terms the Theorem states that ***any substantive formal language will enable propositions to be formulated in that language whose truth cannot be verified within it.***

Going beyond this statement, if one foolishly tries to deal with the unprovable statements by constructing a new formal language (which inherently must overlap the first one in order to enable the retention of the unproven statements) specifically in order to prove those statements, the adventurous researcher finds that now a new set of unprovable statements arises in the new formal language, and so on.

Thus academia is confronted with the thought that some ideas must always remain unproved. Rorty's [7] penetrating analysis shows how Peirce and Wittgenstein shared the point of view that "vagueness is irreducible", i.e., that "language is incurably vague, but perfectly real and inescapable." This argument is the key to the acceptance of formal logic without accepting logical positivism; for it is another way of saying "let's do the best we can, recognizing that there will always be an irreducible vagueness about our thinking; but that vagueness deserves no spec-

ial saliency or homage; only acceptance after we have done everything we can to minimize it."

[The magnificence of this trusel doubtless can be shaken somewhat if one observes that every object language in mathematics uses terms that are undefined in the language as the basis for proofs. Thus every proof is only as valid as the individual's interpretation of the undefined terms. Moreover, nothing can ever be proved about those undefined terms without leaving the language. These ideas were undoubtedly known to Euclid, who applied them in his geometry.]

What are some of the social consequences of this MAT?

To respond to this question, it is appropriate to report on the consequences of some research that was carried out to see what the status of high-level academic thought was before this theorem was reported, and to compare the status then with the status at the present time when this trusel is dug into the academic trenches.

Before the appearance of the trusel, Whitehead and Russell had produced the Principia Mathematica, as part of a quest to show that all of mathematics could be developed from a beginning in Western logic. After the publication, such distinguished scholars as Lewis and Langford [15] extolled the work and pronounced its great significance. Also after that time, the study of logic in relation to human reasoning attained much prominence in academia. (For example, at the University of Illinois in the twenties and early thirties, two courses in logic were required as prerequisites to graduation.)

After the Gödel Theorem attained its prominence, academics mentally downgraded the significance of the work of Whitehead and Russell, and courses in logic gradually disappeared from most academic programs.

Over time, as a result, what could have become a formal academic routine of integrating intuition and reason (especially in the human sciences) became instead a matter of largely ignoring the reason component and putting heavy emphasis on the intuitive. In this way many of the "experts" of today were allowed to emerge. Many of the social problems of today can be traced to intuitive decisions by these experts.

4.2 Magnificent Academic Trusel Number Two. Magnificent Academic Trusel Number Two (possibly it should be exchanged in "rank" with Number One) is this: ***The concept of "interdisciplinary studies" deserves to be at or near the top of academic priorities.*** For those who have been away, there is a considerable subset of academia that takes seriously the thought that learning which is hampered by rigid disciplinary boundaries is very unsatisfactory, leaving a huge undone task to the student which might better be handled by the faculty. That is to say, knowledge pieces that ought to be connected in order to help the student gain adequate understanding ought to be connected (at least in part) by faculty, not leaving the task entirely to the student. It is the goal of helping the learner integrate knowledge that gives this concept its status as "magnificent".

While it is probably always possible to find someone who will argue with any position, one suspects that the truth of MAT Number 2 will be acceptable to most people in academia, although those who are discipline-bound may be guerillas in the war to keep this trusel from being translated into widespread academic practice.

What are some social consequences of this MAT?

Unlike MAT Number 1, which produced bad social consequences because it engendered spurious saliency by downgrading the importance of logic in formal academic studies without any substantive reason for doing so, and based entirely on superficial thinking; MAT Number 2 produces bad social consequences because it sustains cultural lag and also because it tends to produce a culture of emulation founded in inadequate exploration of the contextual implications involved.

To be more specific, consider the contextual implications of the term "interdisciplinary". Here are some of the more evident contextual implications:

(1) The knowledge that is important is the knowledge in the disciplines.
(2) The "inter" portion of the term clearly implies some form of interaction, and since knowledge can't interact with knowledge without some form of human activity, it clearly implies that people from different disciplines interact.
(3) Testing to see whether the contextual implications are satisfied simply involves the interaction of people from different disciplines; something which can easily happen at a cocktail party, and which requires no articulated consequence beyond that.

The difficulties with the term stem from these contextual implications, as can be better understood by studying Hungerford's analysis.

The shortcomings of the term can be remedied by recognizing the following set of items:

(1) The knowledge that is important is the knowledge required to flesh out the context of whatever is being studied; and no one can afford to presume that that knowledge is available **only** from the disciplines; especially no one can afford to presume that for **all** of the many areas of inquiry.
(2) Interaction of persons from the separate disciplines (or from those, accompanied by persons from areas not formally recognized by academia) is meaningful (according to the Pragmatic Maxim) only in terms of its consequences; and if those consequences do not include the integration of knowledge into newly interpretable forms, only a tea-party type of consequence can be reasonably claimed.
(3) The measure of success in integration will generally be found by looking for ***subsumption***; i.e., for new categories that arise when knowledge from different origins is integrated.
(4) If interdisciplinary studies are to merit significant approval from the community at large, including the academic community, they must demonstrably generate new categories under which varied knowledge is subsumed; which lead to new interpretations not previously available.
(5) The **CCP golden triad** has to be given explicit consideration and status in all such work, because the integration of intuition and reason in content demands a process that can support that integration. Such a process will normally require electronic assistance in the organization of the knowledge into its new forms; and as long as such assistance is not invoked (i.e., cultural lag holds sway), the process of interdisciplinary or adisciplinary inquiry will be limited to those domains where the process of subsumption is elementary.

4.3 Magnificent Academic Trusel Number Three. The third MAT is: **in teaching language, the prose form alone is of great value and should command most of the attention and resources.** Clearly this trusel is accepted widely; but accepting it appears to preclude the idea that a certain **golden triad** {***PMG***: prose, mathematics, graphics} should be integratively seen as the basis for teaching people how to communicate. The social consequence of this is that liberal arts graduates can speak beautifully in metaphors while being unable to relate them to details; engineering graduates believe they can communicate with graphics and minimal and poorly-stated prose; most college graduates cannot communicate precisely; and wherever a complex issue arises in society it is likely to remain an issue for decades because effective definition and resolution of such an issue demands communication based in the ***PMG*** triad.

4.4 Magnificent Academic Trusel Number Four. The fourth MAT is: **mathematics is a science instead of a language.** It is generally recognized that there are theoretical and experimental sciences. The analog in philosophy involves metaphysics and empiricism. By invoking the MAT, mathematics can bask in the glow that comes from its importance in other sciences, as well as from its positioning with respect to those sciences. Consequently its merit as a set of object languages (not integrated into a language) that need to be integrated with prose and graphics gets lost in the shuffle.

4.5 Magnificent Academic Trusel Number Five. The fifth MAT is: **it is acceptable to use the name "science" indiscriminately to name academic programs (such as "management science" and "computer science") without any stated or invoked criteria whereby this nomenclature is validated.** There are very few quality measures that are ever applied in academia. One could hope that academia could get into the posture of applying measures that are congruent with the unique status of academia as knowledge custodian and entrepreneur, without confusing the knowledge entrepreneurship with business venture entrepreneurship. By calling new areas of study "sciences", without providing any basis for doing so, a linguistic degrading occurs that supports the continued inclusion of displaceable content in academic programs.

4.6 Magnificent Academic Trusel Number Six. The last MAT consider here is: **people with little or no "academic track record" should be given significant power to allocate academic and research resources and to make key public decisions affecting higher education.** A study of who wields power over academic resources conducted over a period of decades, will reveal that power has gradually devolved into the hands of people without significant academic track records. In one state, for example, a state-created institution aimed at developing technology innovation drew its administration from people that had no experience in technology development, and little if any record of contributing to scientific or technical developments. (One exception to this is the situation in Germany, where scientists elect the people who will represent science to the government from among their own ranks to three-year terms.)

A national institution ostensibly intended to upgrade the status of manufacturing nationwide drew its administration from hucksters who believe strongly in the importance of promotional

self-evaluation in lieu of outside evaluation against stated criteria.

People who make university budget allocations often lack any experience in research, and may have little or no experience in teaching. At the highest level, they may be ignorant of science and mathematics, and while they may recognize the importance of studies that cross organizational boundaries, they not only have no experience in such studies, but do not even know where to go to find people with such experience.

The consequences of such a situation are contextually implied in the foregoing.

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THE LEARNING ORGANIZATION: ITS RELEVANCE TO POLICYMAKING

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THE LEARNING ORGANIZATION: ITS RELEVANCE TO POLICYMAKING

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ABSTRACT

In his 1990 book, Peter Senge has defined the **"Learning Organization"** as an organization that practices effectively five disciplines:

- Building ***Shared Vision***
- Surfacing, Scrutinizing, and Correcting ***Mental Models***
- High-quality dialog for ***Team Learning***
- Individual development of ***Personal Mastery***
- ***Systems Thinking*** (the "Fifth Discipline" that integrates the other four disciplines)

While amplifying these concepts, motivating their adoption, and urging their incorporation into the fabric and practices of organizations, Senge is almost mute about how to accomplish these desirable ends. There is a kind of "let's bell the cat" atmosphere in his treatment.

The system of intermittent management practice called **"Interactive Management"**, which is based on a new science called the **"Science of Generic Design"**, has anticipated Senge's ideas. In developments that have extended over a 22-year period beginning in 1970, methods for practicing all of these disciplines in organizations have become well-defined and have been tested in several organizations. An extensive scientific literature is available that presents these developments. (Unfortunately, scientific literature as it relates to organizations and management in these times seems to be almost completely dominated in the United States by "venture literature"--a literature that forsakes careful research in favor of promotional activity designed to enhance financially a particular organization or organizational component, and to sustain long-outworn mystiques of prestigious omniscience. People have discovered that there is a lot of money to be found in merchandising management ideas, however incompletely studied. Much of this venture literature flows out of New England.)

Assuming that the time will eventually arrive when the full power of the new developments is widely applied in organizations, it will be possible to develop policies that are much superior to most of those that have been developed in the past. When that time comes, the full power of participative democracy will be seen--in contrast to its present severe limitations that are sustained by a combination of bad actors and ubiquitous processes that approach the democratic ideal only superficially.

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This paper is about how behavior in large organizations could relate to effective policymaking.

In my 1976 book SOCIETAL SYSTEMS: PLANNING, POLICY, AND COMPLEXITY, I furnished some definitions; and described some methods of studying policy, some dimensions of policymaking, and some comparative profiles of various metapolicies. An outline of the discussion in Chapter 4, "Policymaking" is given here to introduce the theme of this paper.

1.0 DEFINITIONS.

Some of the relevant definitions that I have constructed or accumulated from the literature are:

- ***Policymaking***: an exploration or inquiry aimed at the generation of policy
- ***Policy:*** a set of prescriptions for human behavior. The prescriptions may vary from being suggestions to being mandatory, with prescribed penalties for violations.
- Three ***functions*** of policy:
  - To *enable behavior* that would be difficult or impossible without the policy
  - To *regulate behavior* into routine patterns
  - To *inhibit behavior* that would be widespread or easy or both without policy
- ***Metapolicy:*** Policy about how to make policy (Dror)

2.0 METHODS OF STUDYING POLICY.

Some of the methods of studying policy that I have either constructed or accumulated from the literature are:

- The descriptive-behavioral approach (what do policymakers do? The common approach to the study of policymaking
- The rational actor model (like cost-benefit analysis; Allison)
- The bureaucratic politics model (many actors, with pulling and hauling; Allison)
- The organizational process model (units of the organization work on pieces of the policy problem; Allison)
- The normative model (how policymaking *ought* to occur, frameworks for policymaking)
- The critical approach (what is wrong with the way policy has been made?)
- The differential approach (how does policymaking differ from prescriptions?
- The tutorial approach (looks for better understanding of fundamental concepts, such as "rationality", "values", use of computer in policy development)
- The pragmatic-behavioral approach (looking for ways to improve policymaking environment and methodology)

3.0 FRAMEWORK FOR STUDYING ANYTHING.

As part of the conceptual work given in the Science of Generic Design, considerable emphasis has been given to the thought that, in studying **anything**, it will usually be very beneficial to consider the object of study under three headings, which are:

- Context
- Content
- Process

Context represents the overall knowledge-related milieu in which the subject is being approached. The principal merit of articulating context and being disciplined by it is that focus can be brought to the discussion or study, and the limitations of any conclusions can be circumscribed by relating them to the chosen context (instead of broadcasting them as universal).

Content represents the knowledge that is brought to bear directly on the subject of interest (but not with matters concerning how that knowledge is brought to bear. The latter is the domain of process).

Process defines (a) the physical milieu in which the subject is being approached, because the way in which it is appointed may either greatly enhance or subdue efficiency and effectiveness, depending on the arrangements, (b) the methodologies that are applied to produce, organize, display, interpret and apply relevant content pertaining to the subject or issue, and (c) the roles that actors must fill in order to make the process effective (most policymaking is like playing Hamlet without any script). Failure to comprehend the importance of collective considerations of these three categories would be apparent to anyone who considers, for example, how governing bodies operate.

4.0 DIMENSIONS OF POLICYMAKING.

Policymaking is viewed primarily as a process taking place in a working environment that affects the outcome considerably, in which the process is intended to develop (within some intellectual context) the content of the issues being considered in a form that meets the requirements of a policy.

Dimensions of policymaking refers to the conceptual rubrics that need to be discussed in order to approach an adequate description of policymaking, and they are identified much like a subway line; i.e., by identifying their extremes. The universal dimensions of context, content, and process have already been discussed. Policymaking-specific activity has at least six dimensions which are process-related (because policymaking is a process):

- ***Participation in the Process***, ranging from narrow to wide
- ***Observability of the Process***, ranging from highly closed to aggressively open
- ***Adaptivity of the Process***, ranging from low to high
- ***Documentation of the Process***, ranging from implicit to explicit
- ***Nature of the Choice Criteria*** for policy selection, ranging from peremptory to meliorative
- ***Final Choice of Policy***, ranging from choice by an individual to choice by consensus

These dimensions of policymaking process may be partly influenced by the specific nature of the issue, its context and its content, but the process itself should be explainable in generic terms without regard to what particular issue is being studied. If this were not the case, resolution of every single policy issue would be escalated to incorporate initial agreement on process design (as in the case of the recent back-and-forth pronouncements about debates among presidential contenders). Many would agree, I believe, that the public should not have constantly to bear the high cost of such escalation, but should only have to pay for what is done in an effective process environment, using proven, efficacious methodologies.

5.0 PROFILES OF METAPOLICY.

Profiles of metapolicy can be constructed using these dimensions, to describe a variety of hypothetical metapolicy types, such as:

- The Democratic Ideal (Jefferson, Lasswell)
- Arbitrary and Unaccountable Metapolicy (Authoritarian)
- Pure Rationality (Technocratic, Management Science, Operations Research)
- Disjointed Incrementalism (muddling through; Braybrooke & Lindblom, e.g.)

Example profiles appeared in Societal Systems.

6.0 THE LEARNING ORGANIZATION.

In my 1982 paper on *"Organizations and Systems Learning"*, I discussed the difficulties inherent in dealing with complexity in large organizations. [It was and remains my view that ***complexity*** is the primary descriptor of the problem of policymaking in large organizations. Some of the concomitants of the complexity are ***underconceptualization of policy issues***, policy steering based upon a mix of correct and incorrect suppositions (*articulated*) and ***management that drives and is driven by presuppositions*** *(in the subconscious, hence not articulated.)*]

In his 1990 book, The Fifth Discipline, Peter Senge has identified five "disciplines" that he believes must be put into play within organizations, in order to overcome the impacts of bad policy based on high-level presuppositions and other misperceptions. He has also illustrated the

benefits of awakening management to the subtle, pernicious aspects of their presuppositions; by describing how the petroleum giant Royal Dutch Shell was able to evolve from a poorly managed company to what is often regarded as the best-managed company of its ilk, if not one c the best-managed of any ilk.

My 1982 paper identified a set of processes that could be used in organizations to improve the quality of policymaking and the reasons why such processes were necessary. Senge's five disciplines and this set of processes complement each other. **GOOD POLICYMAKING PROCESSES HAVE TO SUPPORT STRONGLY THE CAPACITY OF THE ORGANIZATION TO INCORPORATE THE FIVE DISCIPLINES; AND THE FIVE DISCIPLINES HAVE TO BE SUPPORTED STRONGLY BY PROCESSES THAT ENABLE THEM TO BE INCORPORATED.**

The ***short version of the Senge five disciplines*** is:

- Mental Models
- Shared Vision
- Personal Mastery
- Team Learning
- Systems Thinking (The Fifth Discipline)

The system of processes described in my 1982 paper which provides the necessary support for the five disciplines is integrated into an approach to management of complexity called ***Interactive Management.*** (The laboratory study of Interactive Management began at the University of Virginia in 1982, with the construction of a facility specifically designed for the practice of Interactive Management. Before that time, work had to be done in makeshift environments, which caused difficulty in distinguishing the impact of the processes from the impact of the variable and poor working environments.)

7.0 ORGANIZATIONAL LINGUISTICS.

The term "organizational linguistics" refers to two aspects of language as it relates to organizations, which are:

- The ***particularization of language to a given organization,*** including such matters as extensive use of acronyms, use of terms from natural language that are understood to have different connotations than in ordinary speech, and the creation of particular ways of representing aggregate information in a given organization
- The ***stratification of language to accompany and support the organizational hierarchy,*** so that top management tends to speak only in terms of aggregate numbers and metaphors, while language becomes progressively more explicit and

detailed in descending the hierarchy; but the several layers of language that are active degrade vertical communication in the organization. Even lateral communication can readily be degraded by the impact of the linguistic dimension of groupthink, wherein people believe that the words others use are understood

The particularization and stratification build communication barriers within the organization and between the organization and the outside community. The impact of the randomly evolving language permeates and degrades all policymaking activity.

It is a primary benefit of Interactive Management that it incorporates antidotes for the ills of organizational linguistics, thus fulfilling the most basic requirement of the Learning Organization: ***that people become empowered to learn from one another through the effective use of language, as applied in high-quality interactive dialog.***

8.0 THE SENGE FIVE DISCIPLINES.

Table 1 shows an extended description of the Senge five disciplines required in the Learning Organization.

TABLE 1
THE FIVE DISCIPLINES REQUIRED IN THE LEARNING ORGANIZATION

Building ***Shared Vision***
Surfacing and Scrutinizing ***Mental Models***
Dialog for ***Team Learning***
Individual Development of ***Personal Mastery***
Systems Thinking that Integrates the Other Four Disciplines

This slightly-extended description of the five disciplines offers the minimum version that can be fruitfully applied to assess the linkages with the processes used in Interactive Management.

9.0 INTERACTIVE MANAGEMENT.

Interactive Management, as described in the Handbook of Interactive Management, has attributes shown in Table 2.

TABLE 2 ASPECTS OF INTERACTIVE MANAGEMENT (IM)	
IM OUTCOMES	■ Issue Definition ■ Alternative Designs ■ Choice of a Design ■ Surfacing and Scrutinizing Aspects of Mental Models ■ Dialog for Team Learning ■ Building Shared Vision ■ Helping Develop Individual Mastery ■ System Thinking that Integrates Factors Involved in Issues Examined
IM SUCCESS LEVELS	■ Level 1. Learning more about what is involved in approaching the issue (the lowest level of success) ■ Level 2. Learning more about the issueitself ■ Level 3. Achieving a good definition of the issue ■ Level 4. Finding good alternative designs for resolving the issue ■ Level 5. Arriving at a good action choice to resolve the issue
IM PHASES	■ Phase 1. The Planning Phase ■ Phase 2. The Workshop Phase ■ Phase 3. The Followup Phase (With necessary iteration through the Phases)
MAJOR IM ROLES	■ The IM Workshop Planner ■ The IM Broker ■ The IM Facilitator ■ The IM Client ■ The IM Sponsor ■ The IM Participant ■ The IM Pattern Interpreter ■ IM Support Staff
EXAMPLE IM PRODUCTS (APPLICATION STRUCTURAL TYPES, WHICH ARE QUALITATIVE RELATIONAL DIAGRAMS OR MAPS)	■ DELTA Chart ■ Problematique ■ Enhancement Structure ■ Intent Structure ■ Curriculum Structure ■ Priority Structure ■ Field Representation (Quad) ■ Triply-Structured Quad ■ Tapestry of Quads ■ Profile Representation (A Design Alternative) ■ Resolution Structure ■ Comparison Bar Charts ■ Unified Program Planning Linked Matrices ■ Others

IM PROCESSES	■ Ideawriting ■ Nominal Group Technique (NGT) ■ Interpretive Structural Modeling (ISM) ■ Field Development (e.g., Options Fields, Problems Fields, Attribute Fields) ■ Profile Development (e.g., Options Profiles, Attributes Profiles) ■ Tradeoff Analysis ■ DELPHI
OTHER IM ASPECTS	■ DEMOSOPHIA (a specially-designed and equipped situation room) ■ Observers at Workshops ■ IM Computer Software ■ Software Evaluation Factors ■ Facility Evaluation Factors ■ Evaluation Factors for Roles ■ Process Comparison Factors
PROCESS COMPARISON FACTORS	■ Information Generation Methodology ■ Information Organization Methodology ■ Information Display Methodology ■ Information Interpretation Methodology ■ Information Application Methodology
CENTERS OF PAST AND/OR PRESENT IM ACTIVITY	■ Tata Consultancy Services, Hyderabad, India ■ George Mason University, Fairfax, Virginia ■ Instituto Tecnologico y de Estudios Superiores de Monterrey, (ITESM), Mexico ■ CWA, Ltd., Berwyn, PA ■ Defense Systems Management College, Fort Belvoir, Virginia ■ City University (Department of Systems Science, London, England) ■ National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, California and Honolulu, Hawaii ■ Florida Division of Forestry, Tallahassee, Florida ■ Tandem Communications, Ottawa, Ontario, Canada ■ Pacific Telesis, San Francisco, California ■ Instituto de Administração, University of São Paulo, Brazil ■ Ford Motor Company, Dearborn, Michigan ■ National Railroad Passenger Corporation (AMTRAK) Washington, D. C. ■ Fairfax County Park Authority, Fairfax, Virginia ■ Americans for Indian Opportunity, Washington, D. C. ■ Office of the Inspector General, Department of Defense, Washington, D. C. ■ Schering-Plough Pharmaceuticals, New Jersey ■ Chihuahua, Mexico, Planning Authority ■ DeSyMa, Dunrobin, Ontario, Canada ■ U. S. Food and Drug Administration

The shortest route to a brief development of the mutually-reinforcing aspects of the five disciplines and Interactive Management is through the connection of the "Process Comparison Factors" given in Table 2 with the extended description of the five disciplines in Table 1.

10.0 POLICYMAKING RELEVANCE OF THE LEARNING ORGANIZATION.

The Learning Organization is highly relevant to effective policymaking. Effective policymaking is distinguished by (at least) these attributes:

- **Meaningful to Originators**. The meaning of a concept lies in its consequences (Peirce, the Pragmatic Maxim). To be meaningful, the consequences of a policy must be anticipated within the broadest possible context. Those who design and implement the policy should understand its consequences.
- **Understandable to The Impacted**. Those whose behavior is to be affected by the policy should understand it. If they do not understand it, they cannot adapt their behavior to the policy; hence the reason for having policy at all is lost
- **Free of Errors that Can be Anticipated.** If a policy is designed that institutionalizes errors, the predictable result is that the respect that might be accorded to policymakers will be lost, and the allegiance required for using policy effectively will be undermined
- **Acceptable to Constituency.** The policy should be acceptable to the constituency. If it is not, it will produce behaviors that are undesired, and therefore abrogate the reason for having policy
- **Economically Sensible.** The policy should be sensible from an economic perspective. All governance relies on an adequate financial base. If policy destroys or weakens the financial base, it threatens its own origins
- **Temporally Balanced.** The policy should balance short-term and long-term considerations. Almost all social forces favor short-term benefits at the expense of long-term costs. Policymakers must understand that their obligation is not merely to the short run.

10.1 Relevance of the Five Disciplines. Table 3 relates the six criteria just stated to the five disciplines. In preparing Table 3, ***it is assumed that the organization is a Learning Organization***; i.e., it has successfully adopted the five disciplines in depth. Because it has done so, the benefits of so doing can be taken for granted in assessing organizational policy against the six criteria given.

TABLE 3
HOW CRITERIA ARE SUPPORTED BY THE FIVE DISCIPLINES

	SHARED VISION	MENTAL MODELS	TEAM LEARNING	PERSONAL MASTERY	SYSTEMS THINKING
Meaningful	Provides a shared context in which to evaluate policy consequences	Facilitates correct judgments and helps avoid misjudgments	Facilitated the development of the shared vision and the correction of erroneous mental models	Provided the behavioral attributes to facilitate team learning which was necessary to develop the shared vision	Supported the achievement of the other disciplines, and recognized the need for them in order to develop meaningful policy
Understandable	Provides the context in which understanding could be sought through points of reference	Furnished the scenarios in which the context could be developed	Provided the essential opportunities for clarifying language and logical bases	Gave the self-discipline to allow for high-quality documentation of policy, suited to development of understanding	Supported presentation of policy in representational forms that facilitated understanding
Error-Free	Provides a context that had been purged of false images	Prevents ensconced misperceptions from riding high, while offering ideas to integrate into shared vision	Opens up dialog to correct mental models and to reinforce high-quality thinking	Negates shooting from the hip which guarantees errors will be incorporated into policy	Provides an evaluatIVE framework that forces opportunities for clarification and error-elimination
Acceptable	Allows policy viewing in a carefully-formulated, high-quality contextual perspective	Adds depth perception to superficial ideas	Allows for exorcism of past insults, which enables concentration on the future instead of the past	Enables thoughtful consideration, rather than reactive behavior	Anticipates what is needed to create acceptability
Economically Sensible	Gives a sense of responsible behavior that enhances the credibility	Embraces multidimensionality due to mixing of diverse mental models	Provides opportunity for gaining economic insights free of unclarified jargon	Diminishes undisciplined practices involving other peoples' resources	Integrates the economic with the social and other aspects of policy
Temporally Balanced	Inherently diminishes the constant impact of short-term at the expense of a vision of the future	All mental models get upgraded	Individual behaviors can be responsive to informed temporal balance	Makes social adjustments feasible by eliminating offensive excesses in individual behavior	Forces consideration of past, present, and future; of context, content, and process; in a common framework

10.2 Connection of Interactive Management to the Five Disciplines. Table 4 connects Inter-Active Management to the five disciplines.

TABLE 4
HOW INTERACTIVE MANAGEMENT ENABLES INSTITUTIONALIZATION OF THE SENGE FIVE DISCIPLINES

DISCIPLINE	*INTERACTIVE MANAGEMENT ENABLING FUNCTION*
Building ***Shared Vision***	The processes used in Interactive Management are all participatory and constructive. They provide the basis for the collective design of the shared vision. Videotaping of the participative activity provides a seen/heard record of the generation, clarification, organization, representation, and logic of the shared vision. This allows anyone to learn the shared vision and to comprehend its interpretation, as well as to offer any envisioned modifications to this vision. Written prose interpretation, based on the group products, enables a high-quality presentation of the shared vision to be documented for anyone's inspection.
Surfacing, Scrutinizing, and Correcting ***Mental Models***	Detailed data from application of Interactive Management in many applications involving many different groups reveals that virtually all mental models are in conflict, and that none of them are "correct". The processes including the dialog enables incorrect presuppositions and suppositions to be drawn out, discussed, and amended. The disciplined participatory processes enable discovery by the participants of new information, reinforcement of correct information, and amendment or elimination of incorrect information. Documentation allows for inspection by others who may have particular expertise that could be introduced to enhance quality.
High-quality Dialog for ***Team Learning***	Interactive Management processes focus, guide, and manage high-quality dialog. Data from past applications reveal the extensive learning that occurs from the in-depth investigations that are carried out participatively, using the Interactive Management processes.
Individual Development of ***Personal Mastery***	Behavior of individuals in groups is generally unsatisfactory and undisciplined; and is subject to individual abuse. The disciplined processes of Interactive Management are designed to eliminate the many kinds of abuse that trigger undesirable behaviors. The examples set for individual participation in group effort promote the development of individual discipline, and facilitate the exercise of personal ability and knowledge in an acceptable mode.
Systems Thinking (the "Fifth Discipline" that integrates the other four disciplines)	The entire framework of Interactive Management is consciously designed to provide the benefits of integrative systems thinking. The total permeation of the impact of systems thinking not only makes the processes effective, but enables the participants to contribute to integrative system products that exceed in quality what any individual's knowledge would singly support. The types of representations that are part of the product of Interactive Management activity offer unique ways to present integrative images of complex issues, showing the impact of systems thinking on what otherwise would be a disconnected or misconnected set of ideas.

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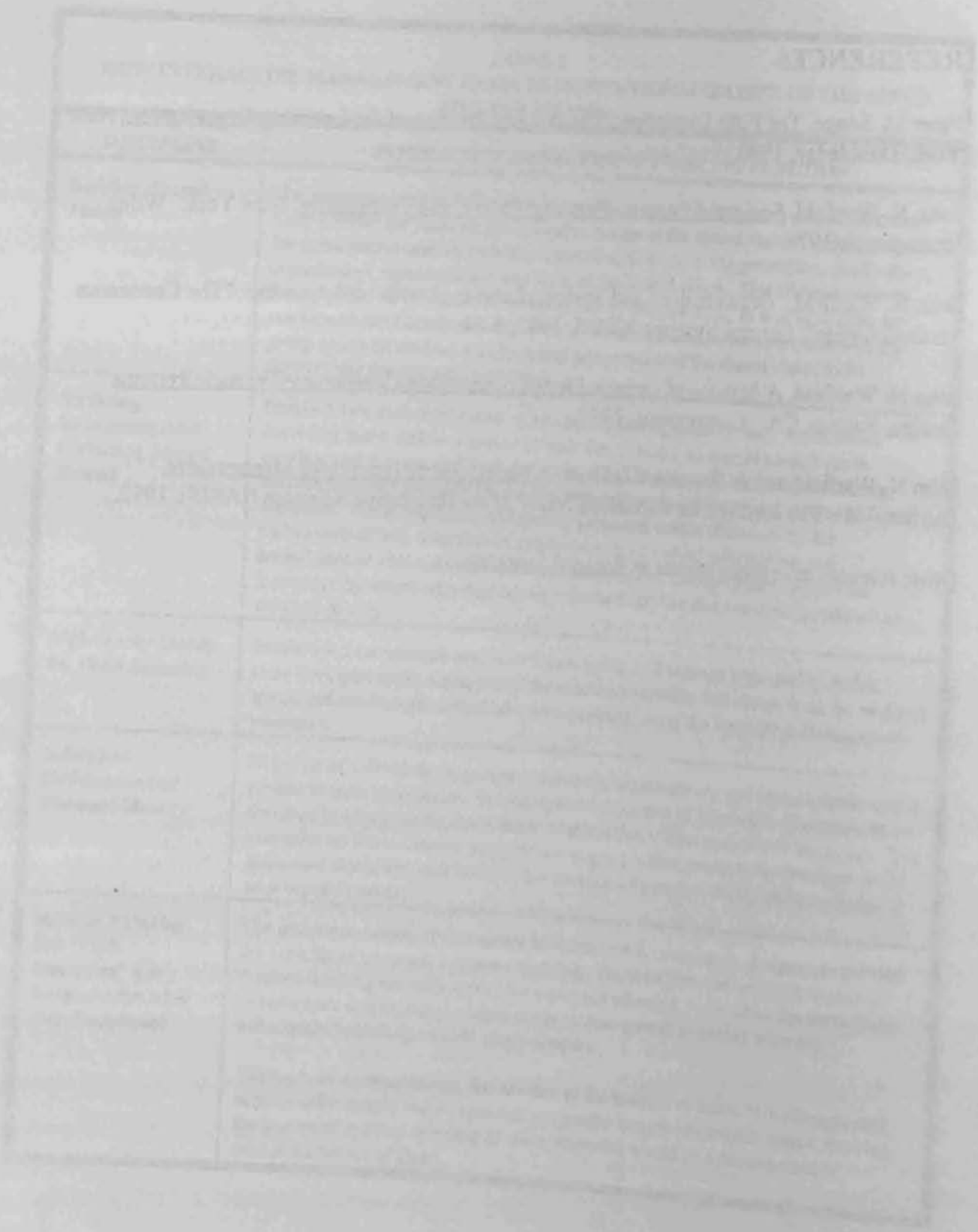

WIDELY-IGNORED SUBTLETIES THAT ARE CRITICAL TO DECISION-MAKING

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ABSTRACT

Decision-making theories and practice typically ignore several factors that are critical to decision-making about complex matters. This conclusion follows from analysis of extensive data on group work involving numerous organizations and a wide variety of issues.

Credibility of decisions may rest on combining these factors into an integrated process system for group support:

- The critical importance of learning during the processes
- The extent of framebreaking and remodeling that may be required
- The predominance of logic cycles in analyses and designs which seldom is recognized in the absence of the kind of support needed to produce them
- The extent to which remodeling can occur in a modest time period, if suitable processes are used
- The importance of integrative processes that combine organically the anthropological, the technological, and the formal logical

INTRODUCTION

It is clear that there is widespread interest in enhancing the process of decisionmaking. Not only is the literature growing rapidly, but also the spread of special-purpose facilities for supporting group decisionmaking is quite visible.

The author began his own work in what might be called "group decision support" in 1970. This work started as part of an in-house project at the Battelle Memorial Institute in Columbus, Ohio, as part of a program called "Science and Human Affairs." It was recognized that the scale and complexity of issues was growing rapidly, and that little attention had been given to how to approach such issues scientifically. It was clear that the knowledge of the issues was distributed, so that it would be necessary to involve **groups of actors** in efforts to resolve complex issues, rather than isolated investigators, if progress was to be made on a reasonable time scale.

The line of activity started in 1970 has continued until today, and is ongoing. This work produced many publications, including two books [2, 4] and two bibliographies [5, 6].

Virtually all of the source documents, along with many of the applications studies, have been placed in the IASIS Reserve File of the Fenwick Library[1] of George Mason University, which accepts orders for copies and makes the indexed file available for inspection by visitors to the Fenwick Library.

Dozens of sponsored projects using our research results have involved facilitated groups striving to come to grips with complex issues. Such issues typically are poorly organized, involve multiple objectives, involve multiple decision-making jurisdictions, and frequently reflect long-standing issues which grow more severe with time.

Having interacted with many such groups in the specially designed DEMOSOPHIA situation room, following clearly demarcated and rigorously-applied methodologies, it has been possible to collect significant amounts of data on the outcomes of this work that relate especially to the philosophy and conduct of it. These data allow comparisons to be made with other approaches that appear to be applying different philosophy and methodology.

Because many of the other approaches are not well-documented, and frequently are proprietary, and because they furnish little or no data on their results, such comparisons are necessarily anecdotal and subjective. Hopefully some day it may become possible to get better documentation and data on these other approaches, but until that time comes, subjective, anecdotal comparison is all that is possible.

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[1] The documents have since been moved. They are now located in two places: The Defense Systems Management College library, Fort Belvoir, VA; and the library of ITESM, Monterrey, Mexico.

What is the value in such a subjective comparison? At least it may serve to focus upon some issues that seem to be critical to good decision-making, yet seem to be ignored in many of the presently chronicled systems for providing group decision support.

In order to try to place this work in perspective, a four-cell matrix is used to break up the domain of consideration into four subdomains. The two headings for this matrix are: The Situation (taken as Coherent or Incoherent) and the Posture (taken as Descriptive or Prescriptive).

COHERENT SITUATIONS

Coherent situations are those for which the prevailing viewpoint is that the situation is well understood. This implies a good organization of the logic and the description of the situation.

Distinctions made for coherent situations have to do with whether the work to be done by the group involves both descriptive and prescriptive components. The latter is inherent if a decision is to be made, but the former may be optional.

- ***Descriptive Work Involving a Coherent Situation.*** If the situation with which the group is working is coherent, then the group may or may not feel any real need to provide a formal description of that situation. Instead, as is often the case, the situation will be replaced with a surrogate called a "problem" or a "decision", the assumption being that the situation is so well understood that no formality is needed with regard to its comprehensive definition. Instead, a formal statement of the problem or of the decision to be made will often be taken as adequate.

- ***Prescriptive Work Involving a Coherent Situation.*** It seems that most of today's decision analysis and decision support is tailored to the descriptive domain. The situation is generally taken as coherent, and the prescription consists of arriving at the particular decision to be adopted, through a process involving the use of data, numerical algorithms realized in computers, and discussion of the feasibility and approach to implementing the decision.

Work in this domain may often involve concepts from expert systems, wherein part of the presumption that the situation is coherent is that there exist experts whose knowledge (even if not yet articulated by them) can be extracted through expertise in probing, and reduced to formal information, whereupon it can be applied to decisionmaking.

INCOHERENT SITUATIONS

Incoherent situations are those for which the presumption is that the situation is not well

understood by anybody. It is generally true that there is a sense of dissatisfaction with the situation, often accompanied by a clearly expressed sense of need for change, but not necessarily accompanied by a clear image of possible alternatives from which choices could be made.

- ***Descriptive Work Involving an Incoherent Situation***. It is often true that, even when a situation is incoherent, the desire of the group is to try to reach a decision or resolution through a "short-cut" route that bypasses the descriptive work whereby that situation might be adequately and comprehensively articulated. Perhaps the greatest hazard demonstrated empirically in many cases of failing to do the descriptive work is that ***this omission precludes the opportunity for critical appraisal of the relevant conceptualization of the situation, thereby preventing possible corrections of errors to be made at early stages.*** In other words, if people can't be informed about the nature of the situation, they are likely to make significant errors in their presumptions about its nature.

- ***Prescriptive Work Involving an Incoherent Situation.*** Prescriptive work involving an incoherent situation is inherent in the decisionmaking process. The goal is to reach a decision about what to do to correct the dysfunctions perceived to be present in that situation.

Unfortunately, because the situation is incoherent, the concept of decision support itself may be too narrow. Experience and habits gained in working with coherent situations tend to be automatically carried over, without question, leading to attempts to formulate the incoherent situation in terms of a particular decision to be made. It may well be advised to replace the concept of group decision support with the broader concept of group design support. The latter has ***three advantages:*** (a) it provides a broader framework within which to advance ideas, (b) it focuses the work on the production of a broad concept that may be implementable, rather than just one decision, and (c) if the situation really can be dealt with by just making a decision, the "design" in question can be reduced conceptually to the special case of a decision or a response to a decision question.

DEFECTIVE STRATEGIES

Strategies for carrying out group decision support that do not reflect consideration of the four cells described above are likely to be responsible for very extensive difficulties in arriving at good decisions or designs.

Perhaps the most evident source of difficulty is ***to aggregate all decision or design questions into one category*** and to proceed as though what is being followed is applicable to all situations.

Perhaps the second most evident source of difficulty is ***to mistakenly assume that a situation is coherent, when it is truly incoherent.*** The effect of the miscalculation is likely to be the same as

the effect of lumping all situations into one aggregate category.

Even if the distinction is made between coherent and incoherent situations, and the strategy is adjusted accordingly, it may be that the third most evident source of difficulty is ***to bypass the descriptive work needed to congeal adequately the understanding of the situation.***

In any case, it is the incoherent situations where the most grievous mistakes get made, and where many important subtleties that relate to effective group work are ignored. Whether the situations are recognized as incoherent by the groups is largely irrelevant to this particular point, because the effects will be the same whether the situation is correctly categorized or not, unless attention is given to these subtleties.

FRAMEBREAKING

Case studies suggest strongly ***that the vast majority of decisions being made with respect to systems that are large in scale (and which are almost always incoherent) are bad.*** The reasons the decisions are mostly bad have been discussed under two headings: "underconceptualization" [7] and "presuppositions" [8]. Data from numerous workshops provide considerable insight into the origins of the bad decisions [7]. ***Usually the origins of the bad decisions are not what people seem intuitively to think they are.***

The initial point of attack is to break the frames of reference that furnish the information leading to bad decisions, for such frames are invariably too narrow and invariably contain bad information. ***Often they are based on generic misconceptions arising from what might be called "global groupthink".***

The consequence of overlooking the specific requirement of framebreaking is ***to erect a system of decisions founded in bad information.***

METHODOLOGY FOR REMODELING

If the multiple frames that animate multiple decisionmakers are successfully broken, then remodeling is required to develop a new and higher-quality frame. ***If this new, higher-quality frame is developed in a group process, the entire group may share a single frame.*** This has the great advantage that it will not be necessary to go through a new framebreaking exercise that would be required if the remodeling produced ***a new set of numerous different frames.***

EFFICIENT REMODELING

There is a great need for efficiency in remodeling. This need goes well beyond the normal idea that it is good if things are efficient. Instead, efficiency is needed because groups of people typically are not willing, not able, or not interested in working together long enough to do the necessary remodeling, once a frame has been broken. To overcome this destructive posture, it is necessary to apply processes that are extremely efficient in carrying out the remodeling. This has been made possible by the development, test, and application of the "consensus methodologies" [4] that are a set of methodologies associated with the practice of "Interactive Management." [3]

By using inefficient processes, remodeling cannot succeed, and people are left possibly with a broken framework and nothing substantive to replace it.

PREDOMINANCE OF LOGIC CYCLES

The data [4,7] from numerous workshops on complex issues show very clearly that the ***logic of complex issues is literally awash in logic cycles.*** Because of the predominance of these cycles, one would think that in every situation involving complex decisions about complex issues, the identification, analysis, and interpretation of cycles would be a key feature, if not the primary feature of such studies.

On the contrary, most decisionmaking ignores the possibility that cycles might exist, displays no stragegy for discovery of the cycles, offers no way to analyze them and interpret the larger logic in the light of the cycles and, in fact, proceeds merrily toward poorly-conceived outcomes in a responsibility-free posture of "what we don't know won't bother us."

CORRELATION OF BEFORE AND AFTER (MEASURING LEARNING)

When decisionmaking is largely keyed to predetermined quantitative algorithms, in effect most of the underlying framework has been taken as a given (in spite of the fact that it is usually wrong).

The possibility or significance of measuring logic frameworks and beliefs at the outset of a study, and doing the same thing at the end of a study (i.e., exploring the before and after views and structure of issues, the "extremes"), and then correlating these two extreme patterns of ideas is seldom considered and almost never done in working with complex issues.

Yet in numerous instances studied empirically, there is essentially ***no correlation between these extreme views***, illustrating that substantial learning has occurred enroute to the development of systems of decisions about issues as a consequence of the processes used [1].

Learning does not even seem to be construed as a major necessity for any process of decisionmaking that involves complex issues. (It's so wonderful to be an expert!) Rather the common posture is that there is an expert lurking somewhere (perhaps even the person who is in charge of the group activity), and all that has to be done is to activate that expert and articulate what the expert has, so far, left unarticulated.

TRIPLY-INTEGRATIVE PROCESSES

What accounts for the fact that most processes don't reflect any attention to the matters discussed above? A short answer is that the people who promote, advocate, or conduct such processes have a point of view which causes their thinking and their processes to reflect unidimensional reasoning. A longer answer is that "professional groupthink" permeates much of the technical literature that deals with decisionmaking, policy-setting, and related topics.

A more specific and longer answer is that their processes lack the feature of being triply-integrative. ***Triply integrative processes integrate three things: (a) the anthropological, (b) the technological, and (c) the formal logical.***

Most processes are based only in the anthropological, or only in the technological. Even those processes that somehow merge just these two can often be superior to the single-basis processes. ***However until the processes also integrate the formal logical components, as the evidence clearly shows, the outcomes cannot be expected to reflect adequate use of human knowledge.*** Even the integration must be done subject to a level of quality control that recognizes the depth of quality needed to get a suitable organic integration.

SUMMARY AND CONCLUSIONS

Decisionmaking can be disaggregated. It can be described in overview in terms of situations and postures. Situations may be coherent or incoherent. Postures may be descriptive or prescriptive. ***An approach to group decision support that disregards this disaggregation and lumps all such work into a single category assuredly will not provide adequate focus or definition to the requirements for high-quality group work.***

The tendency is to work with all situations as though they were coherent and only need to be dealt with prescriptively by experts who may or not be provided with any useful group decision support. Following this tendency will often lead to ignoring critically important aspects of group work, and lead to low-quality, ineffective outcomes.

Today, the large-scale system or large-scale issue typically should be approached through group activity ***as though it were incoherent, requiring careful descriptive work followed by***

prescriptive activity. A better way to describe the support system for such work may be in terms of group design support rather than group decision support.

Because of the nature of the situations being dealt with at this point in history, one must not overlook the importance of a number of critical factors in group work. These include framebreaking, remodeling (efficiently), discovery and interpretation of logic cycles relevant to issues, correlation of group perceptions before and after passage through discovery processes, and the informed choice of triply-integrative processes for carrying out facilitated group activity.

The newly-developed science of generic design provides a sound and tested basis for dealing with these and other often-overlooked factors in group work.

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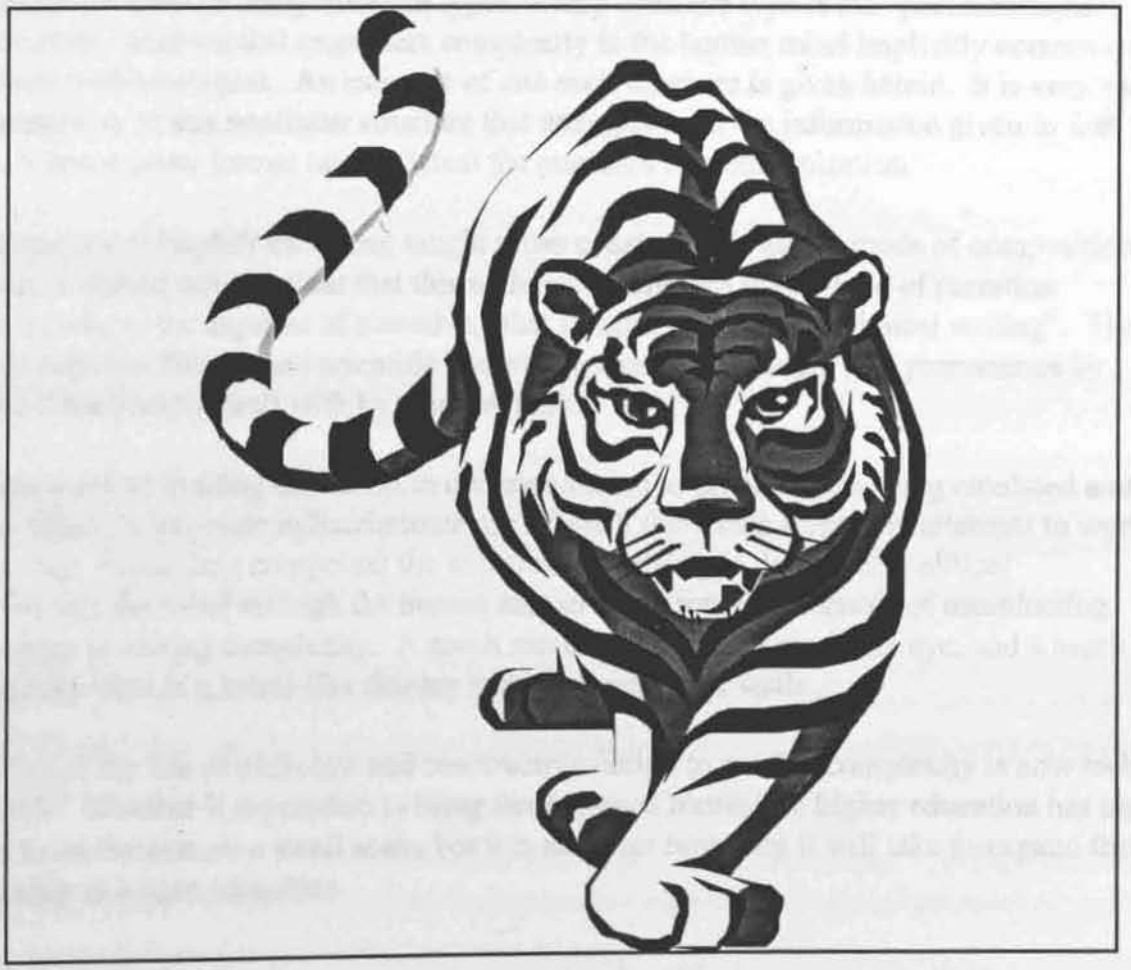
"Procrustes is Alive and Well and Teaching Composition in the English Department"

The above is the title of a paper presented at the annual meeting of the Association for Integrative Studies, Phoenix, Arizona, September 30, 1995.



ABSTRACT

The development and understanding of interpretable patterns involving complexity is incompatible with the structural constraints that are inherent in prose. This is true for all of the most common prose languages on earth. While the structural constraints of prose are sometimes stated metaphorically, they are best understood when seen in structural patterns based in De Morgan's fundamental Theory of Relations (1847).

Application of prose to narrative involves the intuitive constraints imposed by linguistic structure. Two key constraints are the "linearity" of prose and the "parallelism" of prose. That these can co-exist is graphically illustrated using two "interpretive structural models", which are given to illustrate linearity and parallelism separately.

Modern mathematics of logic and the development of "Interpretive Structural Modeling" (ISM), based in logic, enable computer-assisted production of non-linear structural models. While these structures can exist in many different types, a very common type is the "problematique". Every problematic situation that engenders complexity in the human mind implicitly corresponds to one or more problematiques. An example of one such structure is given herein. It is very easy to see by inspection of this nonlinear structure that attempts to fit the information given in that pattern into a linear prose format utterly defeat the purposes of communication.

While departments of English have long taught prose constructions as **the** mode of composition and narration, it should now be clear that this unduly concentrates on the type of narration involved in novels; at the expense of something that is more than mere "technical writing". The distinction is between fantasy and scientific communication, first brought into prominence by Leibniz; and subsequently dealt with by many writers.

The academic error of limiting education in communication to prose is now being emulated and amplified in efforts to promote indiscriminate use of small television screens in attempts to work with complexity. Politicians compound the situation by striving to drive their political communiques into the mind through the human ear; an organ totally incapable of transducting communications involving complexity. A much more appropriate organ is the eye, and a much more appropriate vista is a mural-like display extended onto large walls.

A combination of the use of exorcism and constructive design to resolve complexity is now technically feasible. Whether it is possible to bring these proven forms into higher education has also been shown to be feasible on a small scale, but it is not clear how long it will take to expand their use significantly in higher education.

PROCRUSTES IS ALIVE AND WELL AND TEACHING COMPOSITION IN THE ENGLISH DEPARTMENT

"Theseus...put an end to the criminal career of the giant Polypemon, known as Procrustes, who forced his victims to lie on a bed too short for them and then cut off whatever overlapped. Alternatively he would stretch them if the bed proved too long. Theseus made him undergo the same treatment"

---New Larousse Encyclopedia of Mythology, New York: Hamlyn, 1968, p. 176

Procrustes today is alive and well, teaching composition and exposition in English Departments everywhere.

To be convinced of this, one must appreciate the extent of the cognitive burden with which the mind is burdened when creating a composition ... and it helps to recognize the fundamental flaws in the nature of prose exposition which mitigate against effective exposition--at least for exposition involving complex subject matter.

It is much easier to develop a composition about complexity with the help of the computer-assisted structural modeling process than it is to try to do writing the way Professor Procrustes has been attempting to force you to do for lo these many years.

The approach just suggested might, at first sight, appear to pose a severe threat to the continued existence of that part of the English Department that deals in composition. While there might be a modest threat, it is not nearly as likely to devastate the faculty individual as one might think. After all, people do need to continue to study composition. So it is not as though the teaching of composition is going to go out of style and take the jobs of the teachers with it. No--the threat to them is much less. They simply have to take a little time **to learn what is really needed**, so that they can stop doing what is **not** needed.

In carrying out that task a computer software program designed especially to facilitate the development of structural models will be indispensible. Such a program can be the underpinning for most forms of composition involving complex subject matter.

Moreover, the graphics developed in applying this program can be used as an integral part of the exposition. And now the teachers will have to teach people how to read and interpret the

graphics but, after all, in doing this, they will simply (at long last) be taking advantage of the great liberal legacy of the philosophers and logicians who have shown us how to present complex relationships in ways that do not always, and inappropriately, force the presentation into the linear structure of prose.

THE LINEARITY OF PROSE

The "Procrustean Bed" of prose consists partly of its structural linearity. Structural linearity is independent of subject matter, but is inherent in the way prose is designed. In Figure 1, the linearity of prose is demonstrated graphically.

Beginning with the construction of the word "cat" from its constituent letters, one can construct the structural presentation ("map") portraying the relationship "directly precedes" as in the first graphical drawing in Figure 1. In reading the map, one notes that the arrow itself can be taken as the graphical substitute for the relationship, thus one can read from the map the following:

"c **directly precedes** a"

"a **directly precedes** t"

and one can infer, from these, the following relationships:

"c **precedes** a"

"a **precedes** t"

One can further infer from these two statements of relationship that

"c **precedes** t" (but <u>not</u> that c **directly precedes** t).

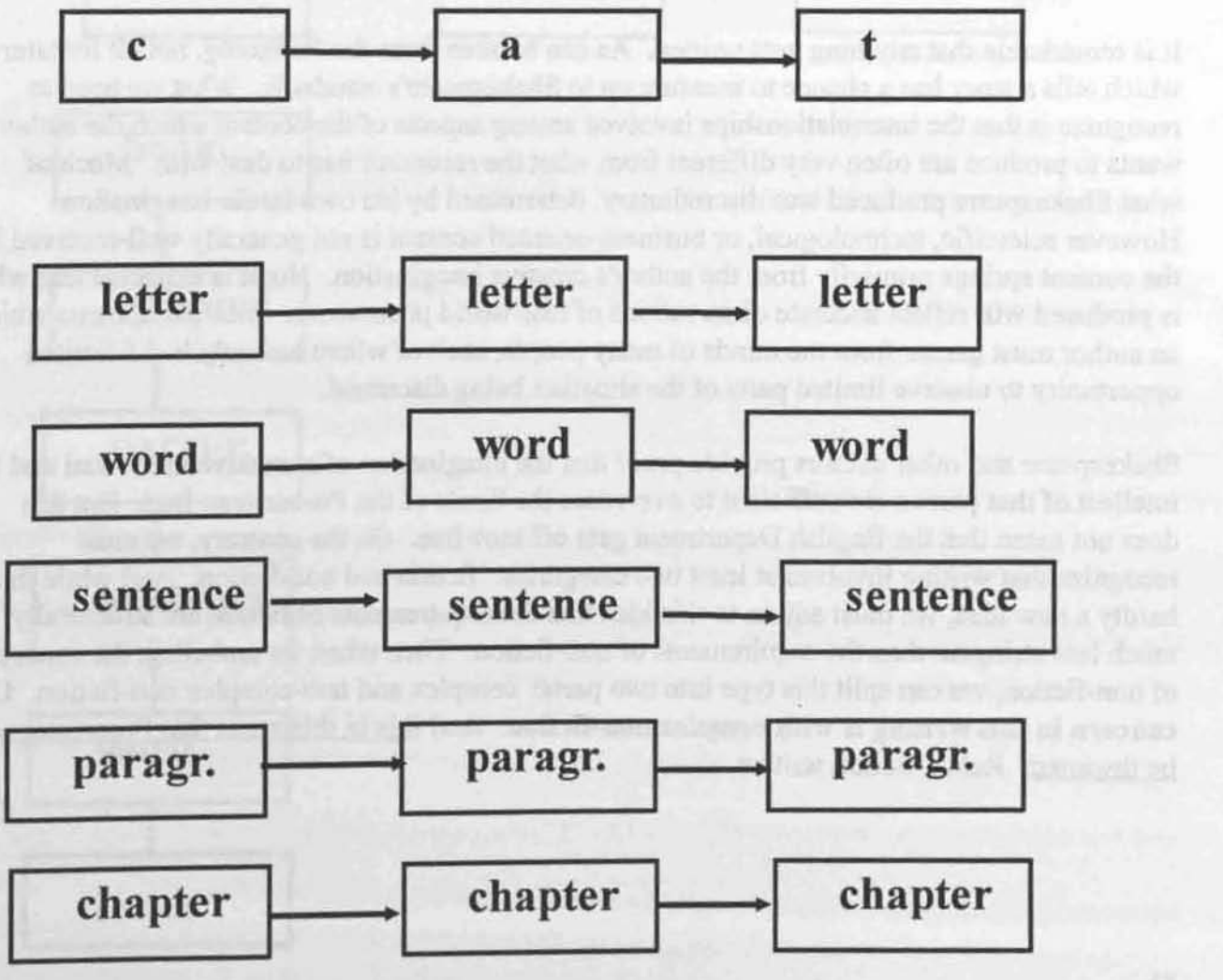
(In passing, one can note that all of the foregoing statements would apply equally well if the word "carat" were at issue instead of the word "cat". Don't worry about that.)

One can also observe the graphical basis for the use of the term "linearity". When the relationships are mapped, there is a straight line from the initial member of the map to the final member which touches every box and every arrow on the map. But the property of linearity is not limited to the relationships among letters in a word. Instead, as the other maps in Figure 1 demonstrate, this property applies to the relationships among words in a sentence, sentences in a paragraph, and paragraphs in a chapter. One could continue with chapters in a volume, and volumes, e. g., in an encyclopedia. <u>Prose is fundamentally linear</u>.

FIGURE 1
THE LINEAR (PRECEDENCE) STRUCTURE OF ENGLISH PROSE

EXAMPLE:

Letters: {c, a, t} **Relationship: "directly precedes" represented by →**



PROSE COMPOSITION DEMANDS COGNITIVE PARALLELISM FROM THE WRITER

The "Procrustean Bed" of prose consists, in part, of its demand for structural parallelism. Implicit in writing prose is the concept of structural parallelism, which must be an ingrained part of the writer's psyche. Figure 2 shows the nature of this structural concept. The three letters are each included in the word. As before, the relationship applies to all structural components of prose. Thus letters are included in words, words are included in sentences, sentences are included in paragraphs, and so on. But all of these inclusion relationships have to be remembered and/or developed by the writer during the act of writing. This is a major reason for bad spelling, misuse of words, incoherent sentences, bad paragraphs, bad organization, etc.; and one must also realize that in concert with the evocation of parallelism by the writer, simultaneous evocation of linearity in sequence must be carried out. But that's not all. The writer must deal concurrently with the structural restrictions inherent in prose, while trying to formulate the structural conditions involved in the content being created. ***In effect, Professor Procrustes insists that the writer force the frequently non-linear and non-parallel content that the writer is trying to create, into the Procrustean bed with a mattress consisting of the linearity of prose, and headboards involving the parallelism of multiple structures.***

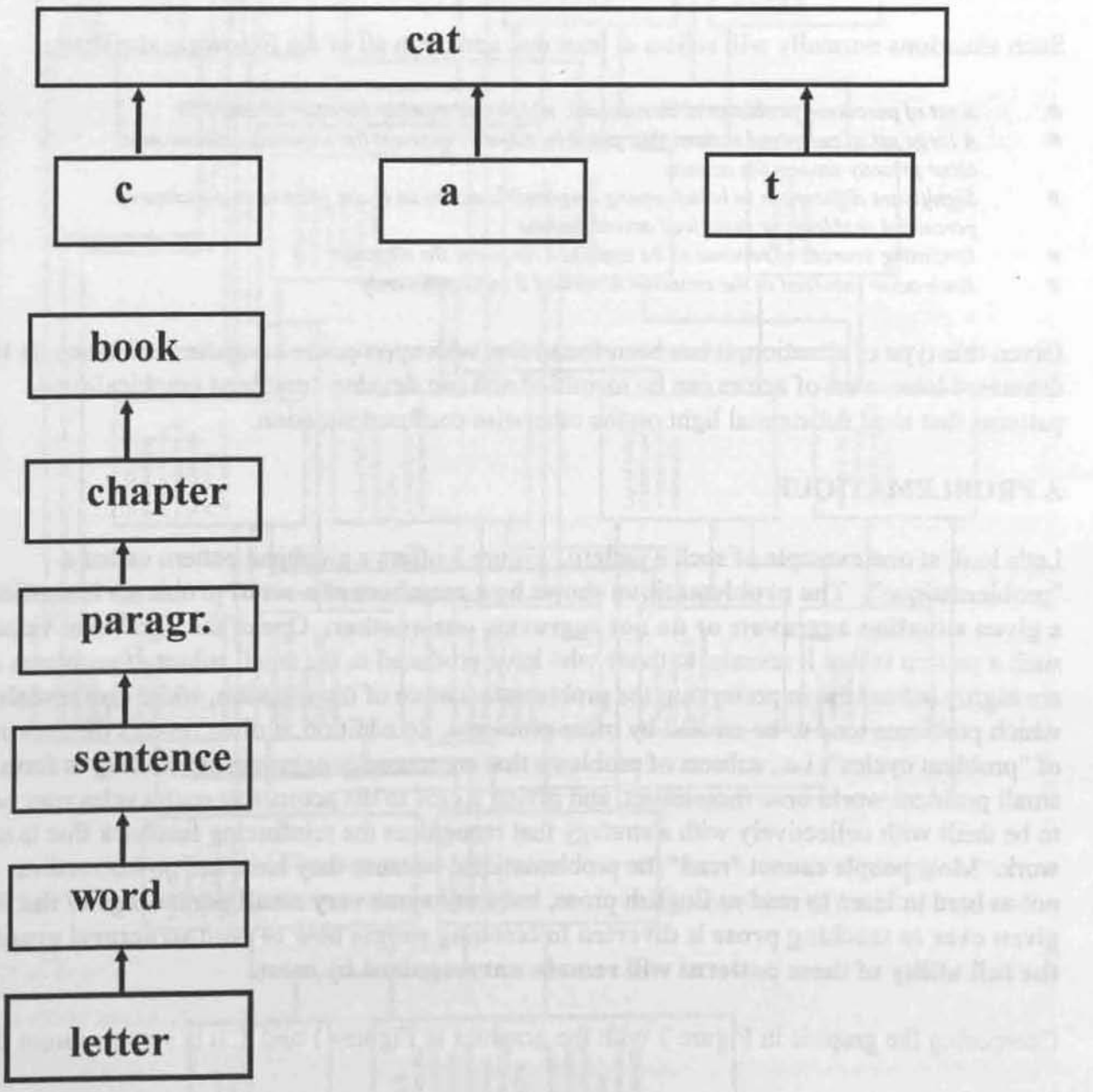
It is remarkable that anything gets written. As can be seen from the foregoing, not all literature which tells a story has a chance to measure up to Shakespeare's standards. What we need to recognize is that the interrelationships involved among aspects of the content which the author wants to produce are often very different from what the raconteur has to deal with. Much of what Shakespeare produced was discretionary, determined by his own fertile imagination. However scientific, technological, or business-oriented content is not generally well-received if the content springs primarily from the author's creative imagination. No, it is expected that what is produced will reflect accurate observations of real-world phenomena; often phenomena which an author must garner from the minds of many people, each of whom has only had a limited opportunity to observe limited parts of the situation being discussed.

Shakespeare and other authors provide proof that the imagination of a creative individual and the intellect of that person are sufficient to overcome the limits of the Procrustean Bed. But this does not mean that the English Department gets off scot-free. On the contrary, we must recognize that writing involves at least two categories: fiction and non-fiction. And while this is hardly a new idea, we must adjoin to this idea that the requirements of fiction are structurally much less stringent than the requirements of non-fiction. Then when we embellish the concept of non-fiction, we can split this type into two parts: complex and non-complex non-fiction. **Our concern in this writing is with *complex* non-fiction**. And it is in this arena that Procrustes must be thwarted. Relax, fiction writers.

FIGURE 2
THE PARALLEL (INCLUSION) STRUCTURE OF ENGLISH

EXAMPLE:

Letters: {c, a, t} **Relationship: "is included in" represented by →**



PATTERNS OF COMPLEXITY

Complex situations normally become of more than passing interest to human beings when they present some kind of threat to human well-being. Examples of such situations might include: (a) the need to design automobiles in 60% of the time in which they were designed formerly, because international competitors have demonstrated that this can be done, while improving quality; (b) a desire to change the United States defense acquisition system, to improve greatly its efficiency and effectiveness, while cutting dramatically the costs paid for equipment and parts; (c) an organization is being buried under paper work, and foresees the day when it will either have a much-better designed information system, or it will be forced out of business; and (d) a business is organized along obsolete lines, and much reconstitute itself in order to arrive at congruence between its organization and the functions the organization must perform.

Such situations normally will reflect at least one and often all of the following attributes:

- *A set of perceived problems to be resolved, which may number between 50 and 150*
- *A large set of perceived actions that could be taken to improve the situation, without any clear priority among the actions*
- *Significant differences in belief among responsible actors as to the relative importance of perceived problems or perceived action options*
- *Declining sources of revenue to be applied to improve the situation*
- *Each actor involved in the situation describes it quite differently*

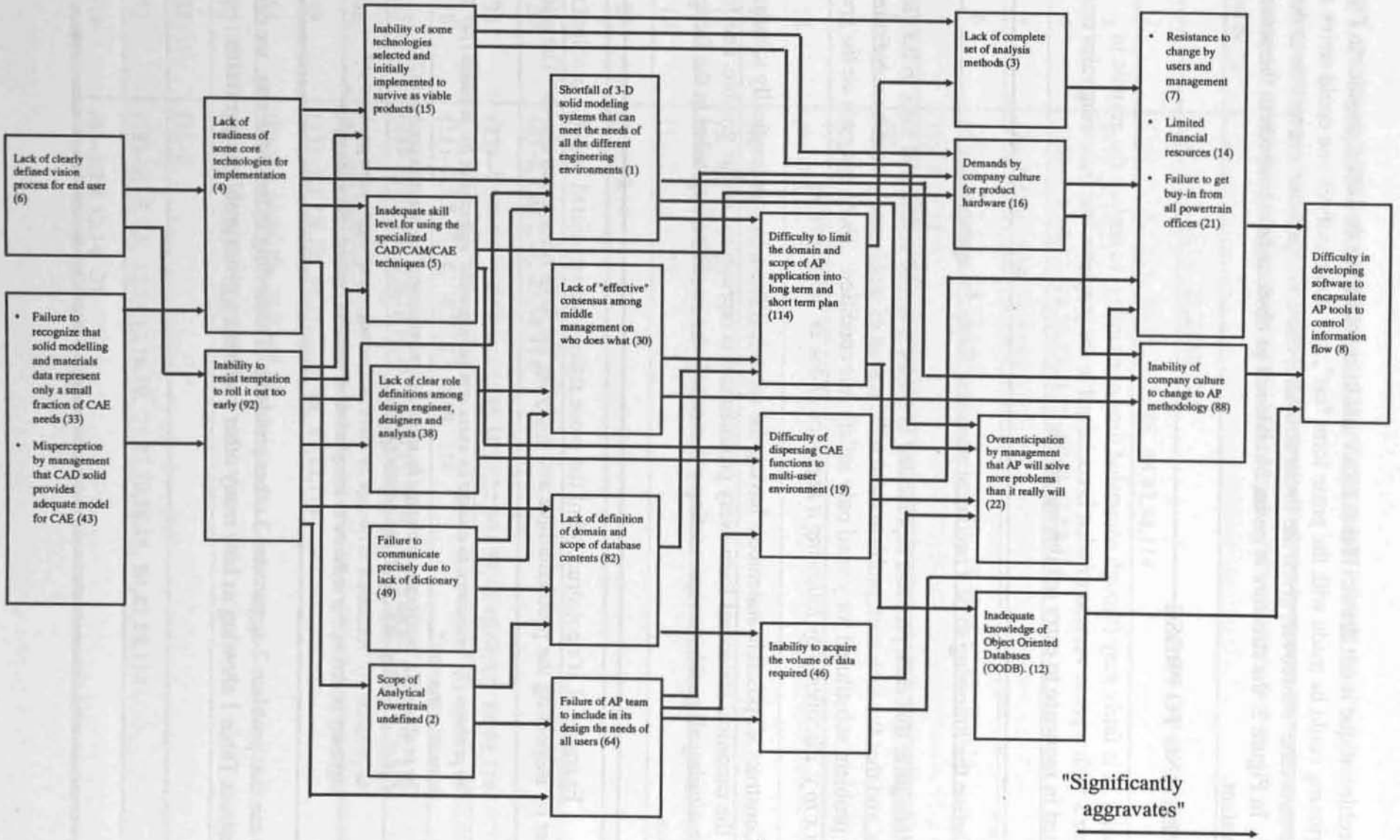
Given this type of situation, it has been found that with appropriate computer assistance, to be discussed later, a set of actors can be identified and can develop combined graphical-prose patterns that shed substantial light on the otherwise confused situation.

A PROBLEMATIQUE

Let's look at one example of such a pattern. Figure 3 offers a graphical pattern called a "problematique". **The problematique shows how members of a set of problems identified in a given situation aggravate or do not aggravate one another.** One of the significant values in such a pattern is that it reveals, to those who have produced it, the small subset of problems that are highly influential in preserving the problematic nature of the situation; while also revealing which problems tend to be created by other problems. In addition, it often reveals the presence of "problem cycles"; i.e., subsets of problems that are mutually aggravating, tending to form a small problem world unto themselves, and giving a clue to the actors that such cycles may have to be dealt with collectively with a strategy that recognizes the reinforcing feedback that is at work. Most people cannot "read" the problematique, because they have had no instruction. It is not as hard to learn to read as English prose, but **until some very small percentage of the time given over to teaching prose is diverted to teaching people how to read structural graphics, the full utility of these patterns will remain unrecognized by most.**

Comparing the graphic in Figure 3 with the graphics in Figures 1 and 2, it is very apparent that

FIG. 3 AP PROBLEMATIQUE



the problematique is not linear. Please recall that in constructing the linear graphics in Figure 1, a beginning could be made with the prose form "cat", and upon analysis one could arrive at the linear structure. Moreover, given the linear structure, one could produce a reversion to the word "cat". In Figure 3, the structure is given, but it is not so obvious how to revert to the prose equivalent.

REVERTING TO PROSE

Actually, it is fairly easy (though somewhat time-consuming) to replace the graphic in Figure 3 with a prose version of what is contained in the graphic. The following rules can be applied in sequence to carry out this operation:

---

1) Define the following to be a canonical statement form: "x aggravates y"

2) Recognize that each problem represented in Figure 3 can be substituted for x in the canonical form, and that for each such problem there will be a set of problems that can be substituted for y. Any problem substituted for y need only satisfy this condition: *There is a path on the graphic from x to y, discovered by following a sequence of one or more arrows.*

3) Construct all possible statements having the canonical form, by systematically substituting for x in the canonical statement form every problem that is represented on the graphic, and for each x substituting all problems representing y that satisfy the condition expressed in the foregoing italics.

Example. Let's construct all of the prose statements associated with the problem number 7 just by inspecting the problematique and applying the three rules given above. The statements are:

- *The problem (7) "resistance to change by users and management" aggravates the problem (14) "limited financial resources".*
- *The problem (7) "resistance to change by users and management" aggravates problem (21) "failure to get buy-in from all powertrain offices".*
- *The problem (7) "resistance to change by users and management" aggravates problem (8) "difficulty in developing software to encapsulate AP tools to control information flow".*

We see that problem 7 aggravates 3 other problems. Proceeding in the same way, we can construct Table 1 showing us how many other problems a given problem aggravates.

TABLE 1. NUMBERED PROBLEMS AGGRAVATED BY PROBLEM "x"

Problem Number "x"	Problems aggravated by Problem Number "x"
1	(9)--3,7,8,12,14, 21,22,88,114
2	(14)--3,7,8,12,14, 16,19,21,22,46, 64,82,88,114
3	(4)--7,8,14,21
4	(15)--2,3,7,8,12, 14,16,19,21,22 46,64,82,88,114
5	(8)--7,8,14,16,19 21,22,88
6	(22)--1,2,3,4,5, 7,8,12,14,15, 16,19,21,22,30, 38,46,64,82,88, 92,114
7	(3)--8,14,21
8	(0)
12	(1)--8
14	(3)--7,8,21
15	(8)--3,7,8,14,16 21,22,88
16	(5)--7,8,14,21,88
19	(5)--7,8,14,21,22
21	(3)--7,8,14
22	(0)
30	(8)--3,7,8,12,14, 21,88,114
33	(23)--1,2,3,4,5, 7,8,12,14,15, 16,19,21,22,30, 38,43,46,64,82, 88,92,114
38	(11)--3,7,8,12,14, 19,21,22,30,88, 114
43	(23)--1,2,3,4,5, 7,8,12,14,15, 16,19,21,22,30, 33,38,46,64,82, 88,92,114
46	(5)--7,8,14,21,22
49	(13)--1,3,7,8,12, 14,21,22,30,46, 82,88,114
64	(9)--7,8,14,16,19, 21,22,46,88
82	(9)--3,7,8,12,14, 21,22,46,114
88	(1)--8
92	(19)--1,3,5,7,8, 12,14,15,16,19, 21,22,30,38,46, 64,82,88,114
114	(6)--3,7,8,12,14, 21

PROSE REPRESENTATION OF THE PROBLEMATIQUE

Suppose we decided to construct a prose representation of the Problematique. From Table 1, adding all the numbers in parentheses, we get the number 227. There are 227 statements represented on the Problematique (each in the form of the canonical statement). All 227 of them can be written out, using the data given in Table 1.

We saw earlier, when looking at Problem Number 7 as an example, each relational statement occupied two lines of text. If the same amount of space is assumed for all 227 statements represented on the Problematique, our prose representation would require 454 lines of text, using font size 10 as in the foregoing example. Each line requires approximately 0.17 inches, and the page can accomodate approximately 8.5 inches of text. This number converts to about 50 lines of text. **So a printout of all of the prose relational statements would require about 9 pages of text.** The problematique, on the other hand, occupies **only one page of text**.

Unlike the prose version, the problematique is <u>not</u> linear. Moreover, while the prose version of the content of the problematique <u>is</u> linear, that linearity **totally masks the structure of the problematique.**

We require nine times as much space, and we lose the power to visualize the structure, and to interpret the significance of the structure, when going to the prose version. **We pay a high cost for using prose in two ways: we use much more space and lose most of the interpretation that is sought.** That is why we must convince Professor Procrustes to begin to teach structural modeling, as a way of achieving two valuable results:

(1) The power is gained to save space and acquire an advanced capacity for interpretation
(2) The student is freed from being taught (implicitly and erroneously) that complex situations can be adequately described solely by prose representation

EARS, EYES, AND VIDEOTAPE

Another way to approach matters relating to the structure of prose is through modes of human perception. As Americans watch the debates going on in the halls of Congress, it becomes clear that the system is operating on the basis of the concept that <u>ears</u> require linearity of presentation. To force the point again, the human ear is receptive to sequential presentation, in which word follows word, sentence follows sentence, paragraph follows paragraph, and so on. Senators and Representatives make their linear presentations in verbal prose, to which the voters' ears are highly attuned. Procrustes has had a field day preparing members of Congress to force fit the most complex subject matter into Cicero's mode of expression.

Videotapes offer complementary insights. Television transmission is highly linear, just as is prose. The camera scans a very small slice of whatever is in view, and then scans another very small slice displaced slightly from the first slice, and continues this until a raster is filled; then it repeates the process. Scan follows scan, raster follows raster, etc. The human ear can be ignored here, since it is invoked just as it is in Congress--linearly. But what of the human eye? When

the scans reach the television screen, their linearity is obscured because the flight of the activating electronic particles hitting the screen is so fast compared to the ability of the eyes to respond, that the viewer does not seen the scans as such. Instead the eyes see a pattern. To summarize, a highly linear presentation is furnished to the eyes, but the eyes tell the brain that it is the pattern that is perceived--not its individual linear, sequential components! **This outcome is precisely what would be sought in constructing a means of communicating complex information to a human being.**

Procrustes' overwhelming success with legislative bodies is not necessarily as easy to come by with the general public. Even as we speak, however, Procrustes is at work in a new domain. He is trying to make people believe that since small television monitors can portray landscape patterns, they are also quite appropriate for portraying complex discrete patterns, such as the problematique shown in Figure 3.

THE TELEVISION MONITOR--A NEW PROCRUSTEAN BED

With relatively few exceptions (those being mostly in the professions such as engineering and law, but operating without precise logical foundations), a standard size sheet of paper has had a long life as a Procrustean Bed for persons who operate with symbols.

The false assumption that Procrustes has largely succeeded in selling is this:

No matter what the required size of a graphical presentation to portray a comprehensive image of a complex situation, it must be sized to fit an 8 1/2 x 11 inch sheet of paper (or an A4 paper if you're in some countries).

And the added false assumption that he is trying to score with in the computer age is this:

No matter what the required size of a graphical presentation to portray a comprehensive image of a complex situation, it must be sized to fit on the screen of a computer monitor.

THE WALL-SIZED MURAL

Thomas Hart Benton and other famous muralists have shown us the folly in listening to the false assumptions of Procrustes. Portraying much of the history of a region in one huge wall mural, Benton has shown that one picture is worth a lot of sequential prose. Let the historians attach their prose outputs to small pieces of the mural. But don't let Procrustes get tenure in the History Department after he is impeached by the English Department!.

The kind of logic-based graphics that require careful study and examination cannot be confined to conventional sized paper or to computer screens. Instead such graphics require large wall displays granted space akin to that given to murals. Not only does this size space allow the human eye to function to its greatest advantage, but it accommodates to many viewers and to constant display and updating, as required.

THE PROBLEMATIQUE REVISITED

The Problematique was introduced via Figure 3. An example was given, and the nonlinearity of the example Problematique was noted. Also it was seen that if it were converted to linear prose, about nine pages would be required just to show the relationships that are represented graphically on the single page; and also it was noted that once the conversion to prose was made, the structure of the relationships became invisible, being buried in the prose.

NON-RELATIONSHIPS AND THE PROBLEMATIQUE

Actually the situation is more dire than the foregoing discussion revealed. While Figure 3 represents 227 relational statements, each in the canonical form, this figure also reflects additional information. This additional information can either be considered to be non-relationships, or relationships of a different type.

For example, in Figure 3, there is no arrow path directed from problem 8 to problem 6. This means that the participant group which created the Problematique did not believe that the following relational statement could be true:

Problem 8 aggravates Problem 6

Since that statement is not supported on the Problematique, one of the following two statements can be considered as true: either

(a) Problem 8 does not aggravate Problem 6

or *(b) Not enough information is available to indicate that Problem 8 aggravates Problem 6*

One could consider that statements (a) and (b) could be a non-relationship, in the sense that the Problematique shows only aggravation relationships; or one could consider that statements (a) and (b) represent a different type of relationship, in that they involve a "non-aggravation" relationship. With either interpretation, we have a condition where still more information is contained on the Problematique. If we arbitrarily call the pair (a) and (b) a non-relationship, then it turns out that there are 423 non-relationships represented by the Problematique.

If these 423 non-relationships are converted to prose, and the same assumptions are made as those prevously applied, an additional 17 pages of text is required to show the prose form of the non-relationships. This means that a total of 26 pages of text is required to present both the relationships and non-relationships represented on the Problematique! And, as before, the structure is not evident from the prose. If we arbitrarily define "Graphical Advantage" as the ratio of the number of pages required to present the prose content of the Problematique to the number of pages required to present the Problematique, we see that the Problematique in Figure 3 has a

Graphical Advantage of 26 over its prose representation; and that is before we take into account the loss of visible structure. If we arbitrarily assigned a (conservative) value of 10 to that, and added that in, the Graphical Advantage would be 36, meaning that **the graphically-presented Problematique is 36 times more advantageous than its prose equivalent as a conveyor of information.**

EXORCISM

Hopefully it is now clear that the development of a Problematique has great value in enabling an interpretation of what is wrong in a situation. But the Graphical Advantage is not the only significant advantage in development of a Problematique.

Suppose you wanted to conceptualize a national policy on some topic that is in the public eye, such as health care or welfare reform or crime. If you decided that, in order to prepare a document that offered such a policy, you would first engage a group in helping to structure such a policy.

Draw on your experience with groups and what you may well remember is that any time someone proposes an idea that could become part of a solution, someone else is inclined to explain why that idea won't work, due to some kind of anticipated problem in the system. You might want to chastise people for constantly shooting down other peoples' ideas, but keep in mind that if an idea is thought to be defective in some way, a person is really obligated to say so instead of not contributing to the dialog.

But what if all or almost all of the foreseen problems have been brought out and placed in easily-readable full view of the participants. Now the obligation to list problems has been largely, if not entirely, fulfilled. People can then proceed to concentrate on ideas for possible solutions or resolutions. In effect, in creating the Problematique, an exorcism has taken place that opens up the group activity to positive contribution. Truly this reflects a key idea set forth by Osborne when the invention of "brainstorming" was disclosed: that you get more creative performance from groups if no criticism is allowed. But it also reflects an extension of that by, in effect, purging the criticism ahead of time through recognition of the many problems that beset the system.

In dealing with major problems in organizations, it has been found that by constructing Problematiques very early in the work, it is then possible to move to a constructive mode, generating and ultimately structuring possible resolutions (design alternatives) with a minimum of interference.

The person who wishes to construct an article or book describing an existing or proposed system will do well first to reveal the negative aspects of the situation in all their glory, and then go on to discuss a constructive resolution, explaining how the problems revealed either can be overcome or can be significantly diminished by the proposed resolution.

The combined task of exorcism and constructive design are typically beyond the scope of a single individual faced with a complex situation. Therefore the person who intends to write or orate about that situation will do well to begin by having groups work on that situation in the style and with the methods comprising Interactive Management.

REFERENCES

References relevant to the foregoing are almost entirely on the subject of complexity, and on what is required to allow it to come within the purview of human interpretation. Appendix A lists relevant references derived from the work of the author. Other contributions can be found in some of the bibliographies identified in Appendix A.

APPENDIX A

WARFIELD PUBLICATIONS ON COMPLEXITY:

- **PAPERS AND MONOGRAPHS CHARACTERIZED BY THEMES**
  - Applications
  - Education
  - Graphical Representations
  - Interactive Human Processes
  - Mathematics of Modeling
  - Organizations and Human Behavior
  - Philosophy
- **BOOKS AND MONOGRAPHS**
- **BIBLIOGRAPHIES**

ORGANIZATION OF THIS APPENDIX

This Appendix organizes publications by the author that relate to complexity into three Parts. In the first Part, papers and monographs are cited in categories. Some of the entries fall into more than one category. The categories adopted for this presentation are (in alphabetical order): Applications, Education, Graphical Representations, Interactive Human Processes, Mathematics of Modeling, Organizations and Human Behavior (these two topics being grouped in order to discuss the human being in a context), and Philosophy. Within each category, publications are sequenced by date of publication.

The first publication listed appeared in the year 1956, so this document deals with a 40-year span. However the research on complexity that is portrayed here by titles, largely spanned the 27-year period from 1968 to 1995, since that period involved virtually continuous research (both theoretical and experimental) on the subject of complexity. Publications appearing before 1968 can be considered as isolated instances of what was to become a driving force in research.

Part 2 lists monographs and books on the subject, in which many of the shorter publications are incorporated in a more comprehensive way.

Part 3 lists bibliographies. These annotated bibliographies contain references not only to the work of the author, but also to the publications of many others whose writings were studied in the prolonged course of the research.

This Appendix has been prepared to try to offer an organized overview of the work, while simultaneously focusing on some of its component categories, each of which may reflect possibilities for applications.

The author carried out this work primarily at three institutions: Battelle Memorial Institute (1968-1974), the University of Virginia (1975-1983), and George Mason University (1984-1995).

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ACCELERATING PRODUCTIVITY OF INTELLECTUAL ORGANIZATIONS BY SYSTEMS METHODOLOGIES

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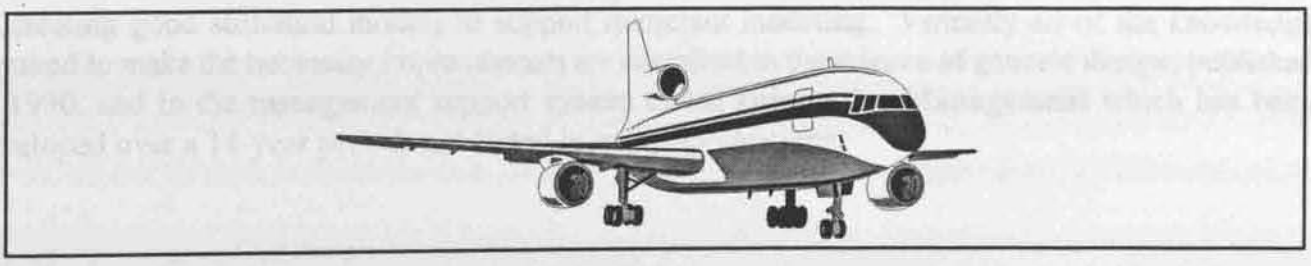

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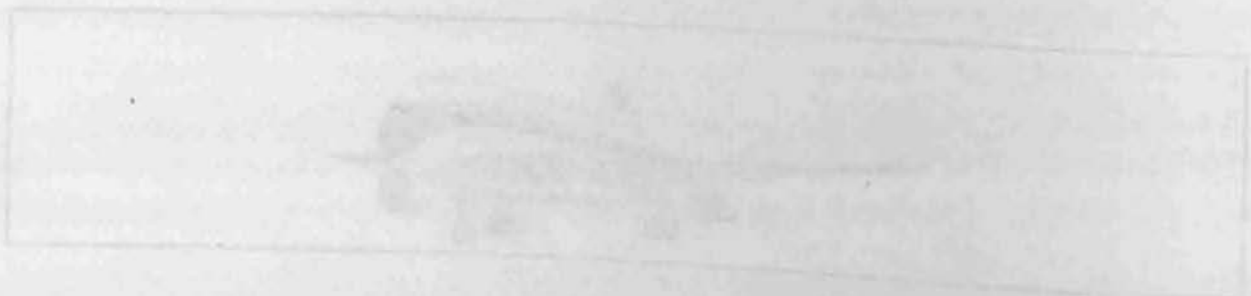

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ABSTRACT

Improvement of productivity in intellectual organizations is required in work that involves complexity. The complex systems produced to serve human needs are wasteful of human time and resources. The methods available to improve productivity appear in well-designed management support systems, which fill three main management functions: intelligence (problem finding), design of alternatives, and choice of an alternative. In well-integrated management support systems, work flows easily from one function to another in a room designed specifically to support carrying out these functions; with a workshop staff educated in conducting highly-productive Interactive Management Workshops; with computer support that sequences subprocesses, while organizing concepts produced by knowledgable participants; following a Workshop Plan tailored to achieve a successful outcome. The two main organizational goals for such systems are improving: (a) Management of Activities and (b) Product Modeling. To improve management, it is necessary to make management responsive to the 17 Laws of Complexity discovered during the past quarter-century. These Laws explain the origins of low productivity in working with complex systems, and show how to obtain substantial improvement. To improve modeling, a balance must be achieved between the development and use of **structural models** and the more commonly used **numerant models**. Structural models provide outstanding conceptualization of **context** within which **content** can be appropriately organized. Good group **processes** provide the means of creating good structural models to support numerant modeling. Virtually all of the knowledge required to make the necessary improvements are contained in the **science of generic design**, published in 1990, and in the management support system called **Interactive Management** which has been developed over a 14-year period, and tested in many applications.

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[2] The Institute for Advanced Study in the Integrative Sciences is part of The Institute of Public Policy.

ACCELERATING PRODUCTIVITY OF INTELLECTUAL ORGANIZATIONS BY SYSTEMS METHODOLOGIES

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Intellectual organizations are those organizations (large or small) that work primarily with ideas, such as universities, corporate research and development departments, research institutes, legislative bodies, public policy institutes, and trial juries. The productivity of such organizations can be accelerated significantly, and can reach new levels of accomplishment in all those areas where their work is sufficiently complex to require teams of people working together on particular products.

How to Accelerate Productivity. Productivity in intellectual organizations requires that two kinds of organizational activity be significantly improved. These are: (a) **management** and (b) **product modeling**. Improvement in modeling requires that improvements in management be made first, but improvement in management must be guided by what is known about improvement in modeling. To improve these two kinds of activity, here is what must be done:

- Learning. Organizational leaders must become familiar with (a) the newly-developed science of complexity, (b) the science of generic design[3], and (c) its implementing, intermittently-applied management system called "Interactive Management"[4].
- New Roles. New organizational roles must be defined and filled with newly-trained actors who are capable of filling these roles. These new actors operate by learning how to apply the science of complexity, using the process of Interactive Management, and controlling the quality of the process according to the requirements of the Laws of Complexity.
- Special-Purpose Facility. A special facility must be constructed, following the DEMOSOPHIA situation room design[5], in order to make the facility support increased group

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[3]This science was first published in 1990: John N. Warfield, A Science of Generic Design: Managing Complexity Through Systems Design, Salinas, CA: Intersystems. The Second Edition is identified as follows: John N. Warfield, A Science of Generic Design: Managing Complexity Through Systems Design, Ames, Iowa: The Iowa State University Press, 1994.

[4]Several informal editions have been published in spiral form by The Institute for Advanced Study in the Integrative Sciences at George Mason University. The first formal publication is scheduled for late 1994 as follows: John N. Warfield and A. Roxana Cárdenas, A Handbook of Interactive Management, Ames, Iowa: The Iowa State University Press, 1994.

[5]The room design was carried out by John N. Warfield in 1980. With minor modifications, rooms following this design are presently in use at Ford Motor Company, Dearborn, Michigan, known as the Interactive Design Room; and at the Southwest Fisheries Science Center, La Jolla, California

intellectual productivity.

- New Management System. Actors who fill the new organizational roles must collaborate with persons who are experienced in the intermittent use (as-needed) of Interactive Management, in order to install this system in the organization[6].
- Increase in Structural Modeling. Using the new system, a significant increase in the amount of structural modeling should be initiated, in order to provide an adequate basis for the always-present numerant modeling going on in the organization. The new structural models should provide the basis for context understanding, strategy development, product development and, in general, the management of complexity throughout the organization.
- Numerant Modeling. The practice of numerant modeling, involving heavy reliance on intuition, must be significantly modified to make the construction of numerant models highly correlated with what the structural models reveal.
- Higher-Education Reform in the Longer Run. In the longer run, higher education must accept the requirement to offer ways for learners to cope with complexity, using methods that are open at scale. This will require new institutional infrastructures that recognize the special scheduling, display, and facility design requirements for working with complex systems.

Examples of Acceleration. Here are two **examples** of how modeling can be improved. Early in 1994, a major corporation conducted a 4-day workshop, using the system called Interactive Management. The purpose of the workshop was to develop a strategy for designing and developing a Product Information Management System. In four days, the multi-function team identified the likely problems to be faced in moving ahead, produced a problematique showing how these problems are interrelated, a sequence chart showing deliverable dependencies, and a set of task statements showing what had to be done cooperatively to produce the deliverables. Similar projects have been known to require a significant part of a year to complete, using normal methods. A decade earlier, a group of over 160 people met to construct a plan for the future of privately-owned forestry land in the United States to the year 2,010. Again requiring four days, similar results were achieved, identifying what five different bodies (several levels of government, private citizens, and consultants) needed to do cooperatively in order to achieve the desired results. In the time between these two projects, several hundred other projects demonstrated similar productivity accomplishments.

Required Improvements in Modeling. All aspects of creative activity in an intellectual organization can be described as modeling of one type or another (consistent with the modern science of semiotics). Modeling in large organizations is almost totally driven by intuition, and is therefore lacking in careful treatment of the underlying logic of models. Virtually everything that is learned about models in higher education is inadequate to comprehend its subtleties, and inappropriate to guide effective modeling. One of the major reasons for this is that higher education teaches its clients how to model at small scale; and when the clients move into constructive social roles, they mistakenly extrapolate what has been learned about small-scale activity into large-scale arenas. This practice of ill-considered extrapolation has to be stopped and replaced with the use of processes that

[6]More than 40 practitioners are identified in Appendix 5 of The Handbook of Interactive Management, as well as their locations in North America, South America, Europe, and Asia.

are open at scale.

Improved modeling is needed for both **structural** and **numerant** models. **Structural models** (widely ignored in higher education) portray the underlying relationships involved in all kinds of systems work, whether to describe or diagnose an existing system or to conceive, design, and implement a new system. **Numerant models** (overstressed in higher education) provide for computation and assignment of numerical values to system attributes. Numerant models depend upon the underlying structural models for their quality, and past failure to develop adequate structural models explains why many numerant models yield misleading results.

The development and application of numerant models causes many major mistakes to be made, typically as a result of developing numerant models based in unarticulated and incorrect logic, too much influenced by intuition, whose reliability deteriorates as the scale of what is being considered grows larger. Intellectual organizations should stop constructing numerant models until they learn how to construct efficiently the underlying structural models, and proceed to develop them and maintain them for ready reference.

Structural models are developed based upon an understanding of the categories of relationships that are significant. The development of structural models by groups offers many advantages to organizations, going well beyond the models themselves, and extending into improved communication in the organization, and a quality of life in the organization that is dramatically improved due to increased pride in effective performance.

To understand the theory of structural modeling, it is necessary to delve heavily into those branches of mathematics associated with logic models as opposed to numerant models. These branches include: combinatorics, set theory, theory of relations, lattice theory, partition theory, ordinary and extended Boolean algebras, Boolean matrix theory, Boolean recursion equations, Boolean inequalities, digraph theory, theory of crossings in map layouts, inference theory, the theory of relationship embedding, and iterative array mapping.

Structural models provide outstanding conceptualization of context from which to approach major issues, numerant model development, and detailed design activity.

Required Improvements in Management. Intellectual organizations account for virtually all human creativity and productivity that involves complex systems. Yet their performance is adversely affected by inadequate management of the **four critical components of performance**: context, process, content, and human behavior.

Productivity in intellectual organizations can be very significantly enhanced if the various **factors** involved in these four critical components are properly managed.

All four of these critical components and the various factors that are involved in the adverse impact on organizations have been carefully studied. It has been found that in those organizations that are both reasonably successful and large, the complexity of managing these critical components is significant; requiring that **a science of complexity** be developed and applied to construct a **strategy and a management system** that can overcome the adverse effects of the factors involved in these

critical components.

The development of the science of complexity during the past two decades included the discovery of **17 Laws of Complexity**. These Laws explain low productivity and reveal the means of attaining substantial improvement in organizational productivity.

Requirements stemming from study of the Laws are of two basic types: (a) new organizational roles must be defined and filled with well-trained actors and (b) actions must be carried out through these new organizational roles to provide the necessary organizational corrections. These requirements appear in the following table.

ORGANIZATIONAL REQUIREMENTS STEMMING FROM THE LAWS OF COMPLEXITY

LAWS REQUIRING ACTION BY HIGH-LEVEL EXECUTIVE

NAME OF LAW	ACTION REQUIRED	CONSEQUENCES OF ACTION
Forced Substitution	Establish the position of Organization Process Manager	The Organization Process Manager will establish and control the choice and quality of processes carried out within the organization to produce high-quality, documented recommendations for the High-Level Executive.
Precluded Resolution		

LAWS REQUIRING ACTION BY THE ORGANIZATION PROCESS MANAGER

NAME OF LAW	ACTION REQUIRED	CONSEQUENCES OF ACTION
Organizational Linguistics	1. Establish Organizational Model for linguistic quality control both vertically and horizontally in the organization. 2. Establish positions of Group Process Managers, and assign Group Process Portfolios to them to manage	1. The major linguistic gaps that presently cause loss of correlation of beliefs and knowledge among different parts of the organization will begin to close, under the impact of the application of the Organizational Model through the coordinated efforts of the Group Process Managers. 2. The selected processes will be drawn from Interactive Management to overcome the impact of the Law of Organizational Linguistics, and will be managed for quality by the Group Process Managers.
Uncorrelated Extremes	Establish positions of Group Process Managers, and assign Group Process Portfolios to them to manage	The selected processes will be drawn from Interactive Management to overcome the impact of the Law of Uncorrelated Extremes, and will be managed for quality by the Group Process Managers.

LAWS REQUIRING ACTION BY THE GROUP PROCESS MANAGERS		
NAME OF LAW	**ACTION REQUIRED**	**CONSEQUENCES OF ACTION**
Triadic Compatibility	Adopt Interactive Management Process Portfolio, which is responsive to these six Laws	Creative employees will work within quality control guidelines, while exercising their maximum available capability
Requisite Parsimony		Creative employees will not find their abilities taxed by being asked to assimilate information at a faster rate than human capabilities support, hence their learning will be expedited and their contributions will be assimilated in communication/learning environments.
Structural Underconceptualization		Important concepts will be described in a comprehensive framework, instead of being placed in underconceived contexts
Diverse Beliefs		Widely-disparate views will be replaced with majority opinions and consensual patterns that provide essential guidance to future activity
Inherent Conflict		
Limits		Individuals and groups will find themselves working within the limits of their capabilities, not being required to exceed these limits by mindless processes imposed on them by the organization or by habitual patterns, thoughtlessly continued through time
Success and Failure	Define conditions for success and failure that are organization-specific, and incorporate them in planning for all process activity, using the five success levels in Interactive Management as a disciplining scheme	A specific strategy for success will be articulated and pursued, leading to a very high probability of success stemming from quality-controlled application of Interactive Management processes
Requisite Saliency	Adopt Interactive Management Process Portfolio, which is responsive to these two Laws	Concepts will be organized within an appropriate contextual framework, providing guidance on priorities and work sequencing
Requisite Variety		Instead of the almost-always occurring situation where this Law is ignored, leading to frequent underspecification of systems and occasional overspecification of systems, due to failure to match situational and system dimensions, the match will take place and this Law will be satisfied, producing highly-justifiable designs

LAWS REQUIRING ACTION BY THE CREATIVE SCIENTIST		
NAME OF LAW	**ACTION REQUIRED**	**CONSEQUENCES OF ACTION**
Universal Priors	The scientist must organize the knowledge coming from a given scientific area by incorporating the Universal Priors in the Foundations of the science	For any set of sciences such that this condition is satisfied, the need to integrate one or more sciences to accommodate to the comprehensive understanding of complex issues or systems will be greatly facilitated, since the integrator will not have to reorganize and upgrade every single science that is involved, but can take advantage of the component sciences directly
Triadic Necessity and Sufficiency	This Law needs to be reexamined, to construct a much simpler proof than that set forth so far	Greater confidence will be obtained about this Law, and creative work can be done to help apply it wisely and with versatility, so as to make it easier to accommodate to particular situations
Validation	The scientist needs to become part of the "scientific community" that evaluates the set of Laws of Complexity, and assists in their continuing validation or in proposing justifiable amendments	Continual improvement in the quality of the science of complexity will make this science increasingly valuable in enhancing human productivity in intellectual endeavors, thereby providing indirect improvement to the quality of life

LAWS REQUIRING ACTION BY THE IMPLEMENTING MANAGER		
NAME OF LAW	**ACTION REQUIRED**	**CONSEQUENCES OF ACTION**
Validation	Because the greatest test of scientific knowledge is in its application, and because the Implementing Manager is in a good position to assess its application, it is very important to establish communication channels with the relevant scientists to reinforce their existing science, or to spur a reexamination of deficiencies thought to have been found in applications	Continual improvement in the quality of the science of complexity will make this science increasingly valuable in enhancing human productivity in intellectual endeavors, thereby providing indirect improvement to the quality of life
Gradation	In a given learning or work situation, whatever actions are to be implemented should be done through a gradation approach, compatible with the existing situation	Human efforts will be commensurate with what can be attained through an action program that is invariably constrained by local conditions, to which the gradation is sensitive

Summary. Virtually all of the knowledge required to make the necessary organizational changes is incorporated in the science of complexity, and further illustrated in the science of generic design, first published in 1990, and in the management system called "Interactive Management", developed over a 14-year period, and tested in many applications.

The basis for improving productivity in working with ideas concerning complex systems in intellectual organizations has been developed, tested, and awaits informed management action to incorporate the necessary conditions into their organizations.

GROUPTHINK, CLANTHINK, SPREADTHINK, AND LINKTHINK: DECISION-MAKING ON COMPLEX ISSUES IN ORGANIZATIONS

by

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PREFACE

Decision-making on complex issues in organizations affects both the day-to-day living and the long-term welfare of billions of people on earth. Yet the study of such decision-making has not been widespread, and the results of such study have had relatively little impact on organizations. The daily news seems always to have something going on where bad decision-making on complex issues in organizations adversely affects many people. It seems appropriate to try to shed more and more light on how decision-making on complex issues in organizations can be described and improved.

In looking for ways to describe and improve such decision-making, it is well to remember that the number of broad approaches to such an issue is very limited. It may well be that only the scientific method offers any real promise.

The scientific method, as widely practiced may involve one of the following two practices:

- Experiments replicated in time and space
- Two experiments designed in the same way, one involving an "experimental group", the other involving a "control group"

Many might believe that neither of these common practices can be applied to the study and improvement of decision-making on complex issues in organizations.

Yet, if we think carefully about these two practices, we see that the core of each of them is "situational comparisons". If certain high-level aspects are held in common between two or more situations, it may well be possible to make situational comparisons, even though the two practices stated do not appear to be involved.

Suppose, for example, that in different situations these four factors are present:

- **Complexity of the issue** (which may vary significantly in terms of substantive content, e.g., one complex issue might involve pharmaceuticals, another automobile design, another fishery management, etc.)
- **Group of knowledgeable participants** (who bring different knowledge components and different views to the discussion)
- **A work environment that is friendly to working with complexity** (characterized by significant display capacity, absence of detractors to group work, use of technology to organize member contributions, etc.)
- **Well-defined group processes with strict quality control** (with the same processes being used in the different situations)

If these four factors are permitted to be present in each situation, even if the issues are quite different, it may be (and has been shown to be) possible to determine significant invariants that shed very substantial light on group decision-making on complex issues in organizations.

Of course it is necessary to balance the two sides of science: the theoretical and the experimental. Without both of these being correlated and continually upgraded, it is unlikely that significant improvement can occur.

That is why it is so very important in working toward improvement that organizations be very tolerant to scholars who wish to use results obtained in those organizations to help improve the scientific understanding of decision making. Executives who are more concerned about the long-term welfare of their own organizations and the society as well will not see studies that expose mistakes in their organizations as "organization-bashing", but instead will recognize the absolute necessity of incorporating such knowledge in the studies to provide quality and credibility.

By taking a tolerant viewpoint, these executives play a very positive and critical role in developing possibly very substantially-improved ways to do decision-making in large organizations.

In this essay, it may appear at first that several organizations are being criticized, or that several individuals are being exposed as bad decision-makers. It is necessary to be specific to be believed, so instances that involve particular executives must be described. Yet the very fact that these executives provided the material (in one way or another) constitutes positive acts on their part, without which this essay could not be written.

Therefore this work is dedicated to all those executives in organizations, be they governments or private industry, whose actions enable us to develop situational comparisons, without which a scientific approach to decision-making about complex issues in organizations would be impossible.

GROUPTHINK, CLANTHINK, SPREADTHINK, AND LINKTHINK: DECISION-MAKING ON COMPLEX ISSUES IN ORGANIZATIONS

A Silver Anniversary Paper
Commemorating 25 Years of Research on Complexity

John N. Warfield and Carol Teigen

ABSTRACT

Groupthink, Clanthink, Spreadthink, and Linkthink represent four aspects of group behavior. These aspects arise in connection with group efforts to resolve complex issues, usually for the purpose of advocating particular decisions or resolutions of the complex issue.

Groupthink and Clanthink both work strongly against achieving good resolutions, and work in favor of producing bad decisions. Spreadthink, on the other hand, is an immobilizing characteristic exhibited by all groups engaged in trying to resolve complex issues in the absence of any sound methodology for arriving at a resolution. Linkthink is an achievable group practice that is intended to overcome the disadvantages of the other three aspects.

Interactive Management is a well-defined system of management that denies Groupthink and Clanthink the opportunity to affect outcomes of group activity aimed at resolving complex issues. It does not and cannot prevent Spreadthink from being inherent in group work, and in fact it even demonstrates its presence in every instance, reinforcing the need for incorporating Linkthink in the group's practice. Linkthink is provided in the Interactive Management system.

Four case studies illustrate the nature and insidious effects of Groupthink and Clanthink: the Bay of Pigs, The Cuban Missile Crisis, Ford and the Automobile Industry in decades following World War II, and Nuclear Energy. A product of the Rapid Response Manufacturing Consortium illustrates the nature and consequences of Spreadthink. The John Deere pump manufacturing problem illustrates the nature of Linkthink and the potential benefits of its application.

In addition to the empirical evidence furnished by the case studies, further explanation of the four aspects is provided by Laws of Complexity discovered during the past 25 years of research on complexity.

It is concluded that decision-making in organizations involving complex issues must undergo a radical change in order to eliminate the insidious impacts of Groupthink and Clanthink, and the immobilization engendered by Spreadthink; and that this change can be effected by using Linkthink as part of the practice of Interactive Management.

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GROUP JUDGMENT SITUATIONS

Group judgment is being increasingly invoked as a resource to help support organizational decision-making involving issues acknowledged to be complex.

BAD PRACTICES

Regrettably, the practice in this field of complex organizational decision-making is not generally being informed by the best available research. Consequently, although the requirement for obtaining group judgment is becoming more widely acknowledged, the measures being taken to influence the quality of group judgment are ineffective or, even worse, lead to bad decisions.

In virtually any prominent area involving organizations and new practices, a bevy of consultants arises to provide management with guidance. These consultants are often backed up with an array of "venture literature"[7]; i.e., literature that enshrines the bad practices that the consultants advocate, and which is tailored to sell, while coming up very short in awareness of and use of the best available knowledge. Management, apparently being of very short memory, tends to shower resources on these consultants. It has been said, for example, that when "Total Quality Management" appeared on the scene in the United States, thousands of consultants appeared and were both ready and able to charge large sums in order to educate organizational management in how to practice TQM. Then, after several years of bad results in the organizations, many of these same consultants appeared to show how to correct the bad practices that had been taken on in organizations as a result of the earlier work of the same consultants. And the pressured managements took on these consultants to try to find out how to overcome the bad results their previous advice had generated.

It is generally recognized that high-level managers either do not read scientific literature or read only the most superficial accounts of such literature. As a result they are an easy "mark" for the predators whose venture literature is sometimes read by high-level managers, but is usually delegated by them to managers at lower levels.

It is also true that most of today's academic literature focuses on such narrow aspects of organizational decision-making that the venture literature looks good by comparison.

This paper will focus on four aspects of organizational decision-making. Only one of these, namely "groupthink", is fairly well known. It has been given some prominence by consultants who have taken a piece of it which they have called "The Abilene Paradox", and sold that to organizations, who may be restrained in some of their bad practices by recognizing this paradox.

By identifying all four of these aspects, comparing them with each other, and showing illustrative examples, it is hoped to diminish the bad practices that go on in organizations. As will be indicated, presentations of three of these four aspects (groupthink, clanthink, and spreadthink) are cautionary, asking high-level managers to understand and become more selective in dealing with what is involved in group judgments in organizations. The presentation of the other aspect (linkthink) is prescriptive. Although it is founded on limited evidence of good results, it is hoped that a strong enough case is made for this fourth aspect to gain the attention of conscientious managers.

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[7] Some of this venture literature comes from very prominent places. Two of the most prominent sources are the Harvard Business Review and the Sloan Management Review. Both of these journals arise from organizations that are required to generate funds in order to support their institutions. Unlike scientific journals, these journals rely on authority to make their points, and seldom show interest in embedding what they print in the long-active stream of carefully-refereed scientific development. Perhaps it should come as no surprise that two of the current best-sellers in the venture literature field are sold by publishers who reside within twenty-five miles of Harvard and M. I. T. (i.e., Memory Jogger II and Better Designs in Half the Time).

TWO COMPONENTS OF GOOD PRACTICES.

Good practices in organizational decision-making on complex issues will involve two sharply identified components. These are:

- Criteria that are used to make decisions affecting the issues
- Integrated knowledge about the issues themselves

It is a major goal in this paper to discuss the quality of these components in two ways: (a) to show how badly they have been dealt with in the past and (b) to show how they can be dealt with better in the future.

DISTINGUISHING FOUR ASPECTS OF ORGANIZATIONAL DECISION-MAKING ABOUT COMPLEX ISSUES

The four aspects of organizational decision-making about complex issues to be discussed are:

- Groupthink
- Clanthink
- Spreadthink
- Linkthink

At first it is important to say how these four aspects are distinguished from each other, to establish that they truly are four distinct aspects; and to show how they relate to the two sharply defined components discussed previously. In this section of the paper, these are the only concerns dealt with. Once the distinctions have been established, each of these aspects will be discussed in relation to cases that will be shown to illustrate them in detail.

Table 1 illustrates the four aspects of group judgment, in relationship to the two components of good practices discussed above.

TABLE 1. ASPECTS OF GROUP JUDGMENT

ASPECT	CRITERIA FOR DECISION-MAKING	KNOWLEDGE OF COMPLEX ISSUE	COMMENTS
Groupthink	Someone in the group has proposed a course of action, which is accepted without review or argument	Not evident, because of the lack of discussion	Spreadthink (see below) helps explain why Groupthink can be taken as a basis for action
Clanthink	Long-held, but incorrect beliefs that may be held by all of the group members, even though unsupported by evidence and unchallenged by thorough exploration	Not evident, because of the lack of discussion	Spreadthink (see below) helps explain why a combination of Groupthink and Clanthink can be a taken as a basis for action
Spreadthink	"Importance" is clearly not a suitable criterion. Criteria are not evident because Spreadthink does not, by itself, produce a decision.	Of great diversity because members differ significantly on relative importance of component problems of a complex issue	See Appendix A for evidence of the widespread presence of undetected Spreadthink
Linkthink	Articulated relationships among (a) component problems of a complex issue and (b) component action options of a proposed solution must be worked out, and taken into account as supplements to already-known criteria	How and to what extent component problems of a complex issue affect one another; and how and to what extent proposed action options affect each other and the interacting problems	Linkthink is implemented by using Interactive Management[8], which provides the mechanisms for the group to develop a shared view of how component problems of complex issues and component action options of proposed solutions interrelate.

[8] John N. Warfield and A. Roxana Cárdenas, A Handbook of Interactive Management, Fairfax, VA: IASIS, 1993.

GROUPTHINK AND CLANTHINK

"Groupthink" refers to the deterioration of mental efficiency, quality of reality testing, and quality of moral judgment that results from in-group pressures[1]. Subject to Groupthink, a group may seem to accept a specific decision; however, if individual group members are confronted with that point of view separately from the group, few members would accept that view as their own.

Groupthink is a valuable concept in evaluating short-term, localized, small group behavior; but human behavior does not always occur in small groups. Therefore, to extend the concept of Groupthink to larger numbers of people for longer periods of time over larger areas John N. Warfield has chosen the term "Clanthink" as a descriptor of what he calls the "big brother" of Groupthink.

This paper presents several cases demonstrating the existence of Groupthink in various decision-making groups. It also attempts to establish the point that Clanthink may be a factor as well. Two of the cases (the Bay of Pigs and the Cuban Missile Crisis) involve much that has been written by both historians and the actual participants. Case studies on Ford and nuclear energy also benefit from considerable literature. Four cases are used to present a representative sampling and, in all cases, symptoms of Groupthink and Clanthink can be detected.

One case (The RRM Consortium) illustrates Spreadthink, and one case (The John Deere case) illustrates Linkthink.

SYMPTOMS OF GROUPTHINK

Irving L. Janis described the eight main symptoms of Groupthink. These symptoms are identified by a variety of indicators derived from historical records, observers' accounts of conversations, and participants' memoirs. Janis divided the symptoms into three main types:

Type I: Overestimation of the Power and Morality of the Group

Symptoms: (1) An illusion of invulnerability, shared by most or all the members, which creates excessive optimism and encourages taking extreme risks; and (2) An unquestioned belief in the group's inherent morality, inclining the members to ignore the ethical or moral consequences of their decisions.

Type 2: Closed-Mindedness

Symptoms: (3) Collective efforts to rationalize in order to discount warnings or other information that might lead the members to reconsider their assumptions before they recommit themselves to their past decisions; and (4) Stereotyped views of enemy leaders as too evil to warrant genuine attempts to negotiate, or as too weak and stupid to counter whatever risky attempts are made to defeat their purposes.

Type 3: Pressure Toward Uniformity.

Symptoms: (5) Self-censorship of deviations from the apparent group consensus, reflecting each member's inclination to minimize to himself the importance of his doubts and counterarguments; (6) A shared illusion of unanimity concerning judgments conforming to the majority view (partly resulting from self-censorship of deviations, augmented by the false assumption that silence means consent); (7) Direct pressure on any member who expresses strong arguments against any of the group's stereotypes, illusions, or commitments, making clear that this type of dissent is contrary to what is expected of all loyal members; and (8) The emergence of self-appointed mindguards -- members who protect the group from adverse information that might shatter their shared complacency about the effectiveness and morality of their decisions. According to Janis' Groupthink hypothesis, the more amiable the members and the greater the esprit de corps among the members of a policy-making in-group, the greater the danger that independent critical thinking will be replaced by Groupthink.

SYMPTOMS OF CLANTHINK

John N. Warfield introduced the term "Clanthink" which he considers a "big brother" of Groupthink. Clanthink is characterized by involving large numbers of people for long periods of time over what might be large areas of the globe. For example, the belief in a flat earth persisted for perhaps thousands of years, involved possibly millions of people, and existed throughout the occupied countries of the era. Clanthink resulted in a belief that was counterproductive to the exploration of the planet. Clanthink may exhibit any of the symptoms of Groupthink and, in addition, may exhibit these types of symptoms:

Type 1: Defective Communication

Symptoms: (1) The undiscussibility of assumptions that underlie decisions; (2) The unexpressed and untested assumption that high-level metaphors correlate with low-level details as far as clan decision-making is concerned; and (3) The absence of functioning corrective feedback communication loops.

Type 2: Indifference (both Passive and Active)

Symptoms: (4) The disavowal of the existence of knowledge that goes counter to clan beliefs; (5) The absence of well-articulated, substantive standards for assessing performance; and (6) Existence of a continuing string of unfulfilled commitments within the clan.

Type 3: Defective Basis of Belief

Symptoms: (7) Acceptance that ideas propagated by authority for a sufficiently long period of time thereby become true; (8) Imperviance to overwhelming evidence that goes contrary to accepted clan behavior; and (9) Deference to the importance of image in lieu of substance as a standard operating criterion.

THE BAY OF PIGS CASE: ILLUSTRATING GROUPTHINK AND CLANTHINK

The Bay of Pigs scheme began when Richard M. Nixon, Vice President to President Dwight D. Eisenhower, proposed that the United States government covertly send a trained group of Cuban exiles to Cuba to fight the Castro government. In March of 1960, President Eisenhower directed the Central Intelligence Agency (CIA) to organize Cuban exiles in the United States into a unified political movement against Castro. The CIA was to provide military training to those exiles willing to return to Cuba to engage in guerilla warfare. By late 1960, the CIA expected to land a brigade of Cuban exiles, not as infiltrators, but as a full-scale invasion.

Two days after his inauguration in January, 1961, President John F. Kennedy and several members of the new administration received a detailed briefing about the proposed invasion from Allen Dulles, then head of the CIA, and General Lyman Lemnitzer, then Chairman of the Joint Chiefs of Staff. For nearly three months this core group of presidential advisors repeatedly discussed the inherited plan. In early April, 1961, all members of the group approved the CIA's invasion plan.

On April 17, 1961, the brigade of about 1400 Cuban exiles invaded Cuba at the Bay of Pigs. The brigade was aided by the U. S. Navy, Air Force, and the CIA. On the first day, none of the four ships containing reserve ammunition and supplies arrived. By the second day, 20,000 well-equipped troops of Castro's army had completely surrounded the brigade of exiles. By the third day, the remaining 1200 members of the brigade were captured and taken to prison camps.

The idea for the invasion of Cuba was initiated by the Eisenhower administration. Two days after the January, 1961, inauguration, President John F. Kennedy and several members of his new administration received a detailed briefing about the proposed invasion by Allen Dulles, head of the CIA, and General Lyman Lemnitzer, Chairman of the Joint Chiefs of Staff. For nearly three months, a core group of presidential advisors repeatedly discussed the inherited plan both informally and in the formal meetings of an advisory committee. In early April 1961, at one of the meetings with the President, all key advisors approved the CIA's invasion plan.

All the members of the the advisory committee were capable of objective, rational analysis and accustomed to speaking their minds. The members of the committee were: Dean Rusk, Secretary of State; Robert McNamara, the Secretary of Defense; McGeorge Bundy, the President's Special Assistant for National Security Affairs; Arthur Schlesinger, Jr., a Harvard historian; and Richard Goodwin, a Harvard faculty member who did not attend the policy-making meetings but was informed and did concur with the final decision. Also attending the meetings were three members of the Joint Chiefs of Staff; Allen Dulles, CIA Director; Richard Bissell, Deputy Director of the CIA; Thomas C. Mann, Assistant Secretary of State for inter-American affairs; Adolph A. Berle, Jr., Chairman of the Latin American task force; Paul Nitze, Assistant Secretary of Defense; and Robert Kennedy, the Attorney General who participated in a very limited role.

The Bay of Pigs invasion of Cuba, as described by Janis, is a classic example of a policy-making committee performing within the confines of Groupthink. A review of the events show that the failure of critical thinking can be partially accounted for by the groups' tendency to seek consensus at the expense of seeking information, critical appraisal, and debate. Table 2 shows the symptoms of Groupthink and illustrations of their presence.

TABLE 2. GROUPTHINK AND THE BAY OF PIGS INCIDENT		
Groupthink Manifestation		
Type	**Symptom**	**Illustration**
OVERESTIMATION OF THE GROUP	(1) Invulnerability	"nothing could stop us"
	(2) Inherent morality	no discussion of consequences
CLOSED-MINDEDNESS	(3) Collective rationalization	"we can pull off this invasion"
	(4) Stereotyped enemy	"'hysteric' leader...would do nothing"
PRESSURES TOWARD UNIFORMITY	(5) Self-censorship	"no strong voice of opposition"
	(6) Unanimity...silence	"kept so silent"
	(7) Direct pressure	"everyone to help him"
	(8) Use mindguards	"don't push it any further"

GROUPTHINK

Overestimation of the Group

The groups' sense of invulnerability and inherent morality is demonstrated by the words written by Robert F. Kennedy, "It seemed that, with John Kennedy leading us and with all the talent he had assembled, nothing could stop us"[2] and Schlesinger's comment, "Everyone around him [John Kennedy] thought he had the Midas touch and could not lose[3]". They seemed to view themselves as the "good guys" who could do no wrong, and who would ultimately win.

Moral issues raised by Fulbright and Schlesinger were not discussed by the group. Schlesinger, who later reproached himself for being quiet in the meetings, did however feel secure enough to present his strong objections regarding the invasion in a memorandum to the President and Secretary of State. These objections were never expressed within the meetings by Schlesinger, Kennedy, or Rusk. Senator Fulbright is another example of a moral voice not being heard. He was invited by the President to present his opposing views to what he was reading in the newspapers. In a "sensible and strong" speech he correctly predicted many of the damaging effects the invasion would have on the U.S.[4] Unfortunately, the President did not open the floor to debate, nor did any committee member press for discussion of the moral issues raised by Fulbright.

Closed-Mindedness

Everyone became somewhat biased in the direction of selectively attending to the messages that fed into the members' shared feelings of confidence and optimism, disregarding those that did not[5]. Their over optimistic viewpoint: "We can pull off this invasion, even though it is a long-shot gamble"[6] was nothing more than a rationalization to minimize the dangers of the situation. No deliberations on possible setbacks to the invasion emerged, even after the eloquent speech by Fulbright.

Another misconception of the group was the underestimation of the enemy, Castro. He was regarded as a "weak" hysteric leader whose army was ready to defect; he was considered so stupid that "although warned by air strikes, he would do nothing to neutralize the Cuban underground".[7] The group excluded most experts who should have been consulted and relied instead on the CIA data specifically supporting these characterizations of Castro.

Pressures Toward Uniformity

Doubts were entertained by many members of the group, but never expressed, partly out of a fear of being labeled "soft". Schlesinger recalled, "In the months after the Bay of Pigs I bitterly reproached myself for having kept so silent during those critical discussions in the Cabinet Room, though my feelings of guilt were tempered by the knowledge that a course of objection would have accomplished little save to gain me a name as a nuisance".[8] This self-censorship and silence of group members contributed to a shared illusion of unanimity. Sorensen wrote, "No strong voice of opposition was raised in any of the key meetings, and no realistic alternatives were presented"[9].

A phenomenon of group dynamics is the suppression of deviational viewpoints by members of the group. This pressure often takes the form of urging the dissident member to remain silent if he cannot match up his own beliefs with those of the rest of the group.[10] This is apparent when Robert Kennedy told Schlesinger, "You may be right or you may be wrong, but the President has made his mind up. Don't push it any further. Now is the time for everyone to help him all they can."[11] Not only did Robert Kennedy apply direct pressure on Schlesinger, he also functioned as a mindguard to protect the group from unfavorable information that might shatter their shared complacency.

Another member of the team, Dean Rusk, also performed as a mindguard when he withheld from the President a strongly worded memorandum which expressed dissenting views from Undersecretary of State Chester Bowles. Bowles had attended a White House meeting but was not given an opportunity to express his views against the invasion. He followed the proper bureaucratic channels by requesting Rusk's permission to present his memorandum to the President, only to be stopped by Rusk, who assured him there was no need for concern.

Rusk played a similar role when Roger Hilsman, director of intelligence and research in the State Department, asked him for permission to allow Cuban experts in his department to analyze the data the CIA presented to the committee. Rusk replied, "I'm sorry but I can't let you. This is being too tightly held."[12] As a result, the committee made an important political decision without the benefit of expert advice from an agency other than the CIA.

CLANTHINK

The Bay of Pigs invasion also applies to Clanthink in that it involved a belief that was counterproductive. Table 3 presents the results of the group's belief that no one in the U.S. would know that the clandestine invasion of Cuba was perpetrated by American government personnel.

TABLE 3. CLANTHINK AND THE BAY OF PIGS INCIDENT		
Clanthink Manifestation		
Type	**Symptom**	**Illustration**
COMMUNICATION	(1) Undiscussability	U. S. would not overtly participate
	(2) High-Level Metaphors	
	(3) Absence of Corrective Feedback	
INDIFFERENCE	(4) Disavowal of counter knowledge	"I can't believe what I'm reading"
	(5) Absence of standards	
BASIS OF BELIEF	(6) Ideas propagated by authority	
	(7) String of unfulfilled commitments	
	(8) Indifference to contrary evidence	
	(9) Image in lieu of substance	

Communication

At the beginning, President Kennedy held firm to one stipulation: "The United States armed forces would not overtly participate in an invasion of Cuba."[13] On the assumption that this requirement could be satisfied, the plan appeared to be a golden opportunity to overthrow Castro. There was no discussion of the idea that the Cuban leader was only an irritation to the U.S. but posed no serious threat.

Indifference

Weeks prior to the invasion, the press began reporting "secret" details about the U.S. military training camps in Guatemala as well as describing efforts to recruit more Cuban volunteers in Miami. President Kennedy complained, "I can't believe what I'm reading."[14] Despite the information uncovered by the press, Schlesinger recounted "somehow the idea took hold around the cabinet table that this would not much matter so long as U.S. soldiers did not take part in the actual fighting."[15] The group never discussed the obvious danger that a subversive act of military aggression may be "leaked" to the outside, especially when so many foreign politicians and Cuban exiles knew of the plan. Kennedy remained so confident that he publicly promised at a press conference on April 12, 1961 (five days before the invasion), that "There will not be, under any conditions, any intervention in Cuba by U.S. armed forces, and this Government will do everything it possibly can ... to make sure that there are no Americans involved in actions inside Cuba."[16]

Basis of Belief

The CIA representatives, Dulles and Bissell, repeatedly assured the President and the committee that all the world would believe that Cuban dissidents were the sole participants of the invasion. They presented a clever cover story whereby the U.S. would be able to deny all complicity regarding the bombings -- old World War II model B-26s without any U.S. markings would be used. Even after the evidence of the information printed in the papers revealed a major problem, the CIA continued to reassure all members of the committee that the cover story would work. This belief that

no one would know that the U.S. had any involvement in the Cuba invasion proved to be counterproductive to the success of the Advisory Committee. As a result, the Kennedy administration suffered its first major political embarrassment and Adlai Stevenson lost credibility in the United Nations.

THE CUBAN MISSILE CRISIS CASE: ILLUSTRATING GROUPTHINK AND CLANTHINK

During the months preceding what came to be known as the "Cuban Missile Crisis", Soviet leaders repeatedly claimed that the Soviet personnel and equipment in Cuba were merely intended to reinforce the Cuban air defense system. The United States intelligence specialists and the government believed this to be true. The complacency was shattered on October 16, 1962, when President Kennedy was informed that CIA photo interpreters had clearly identified a missile launching pad and an offensive missile lying on the ground.

President Kennedy promptly assembled the Executive Committee of the National Security Council (whose membership overlapped that of the group that had approved the Bay of Pigs invasion). By October 20, the Committee had decided that a naval blockade was the best initiative to be taken. On October 22, President Kennedy gave a televised speech. He revealed to the world the evidence that proved the existence of offensive missile sites in Cuba. He announced that the U. S. government had decided to quarantine Cuba. Khruschev immediately condemned the blockade. Eighteen Soviet ships persisted on their course toward the quarantine zone, pointing toward a confrontation. During the next few days, the U. S. repeated its threat to board Soviet ships and forced several Soviet submarines to surface. The U. S. Navy actually boarded a Lebanese vessel chartered by the Soviet Union. Shortly before reaching the quarantine zone on October 24 and 25, the Soviet cargo ships reversed their direction and returned to Soviet ports. The crisis was finally resolved on October 28, when Khruschev agreed to remove the missiles in exchange for assurances that Cuba would not be invaded.

According to Graham Allison, Cuba became John Kennedy's Achilles' heel for three reasons. First, the Bay of Pigs affair raised serious doubts regarding the President's judgment, the wisdom of his advisors, and the quality of their advice. Second, the Bay of Pigs taught the public some unfortunate lessons: that Cuba constituted a threat to U.S. security and the hawkish calls to overthrow Castro had some legitimacy. And, lastly, the failure of the invasion had made John Kennedy appear indecisive.

President Kennedy fought against replaying the errors of the Bay of Pigs by implementing four changes in the group process.[17] These changes were: (1) every participant was directed to examine the problems as a whole, rather than from only their expert areas or agency's viewpoint; (2) the usual rules of protocol were suspended to encourage frank discussions; (3) separate subcommittees met independently and then brought their work before the main committee for debate; and (4) President Kennedy deliberately absented himself from some meetings, especially the preliminary phases when the full range of alternatives was initially discussed.

Members of the advisory group for the Cuban Missile Crisis consisted of many of the committee members from the Bay of Pigs invasion. The committee members that overlapped with the Bay of Pigs committee consisted of: President Kennedy, Attorney General Robert Kennedy, Secretary of State Dean Rusk, Secretary of Defense Robert McNamara,

Assistant Secretary of Defense Paul Nitze, and Special Assistant for National Security Affairs McGeorge Bundy. Other key members were the Chairman of the Joint Chiefs of Staff General Maxwell Taylor, Vice President Lyndon B. Johnson, Special Counsel Theodore Sorensen, CIA Director John McCone, and Secretary of the Treasury Douglas Dillon. A few experts and officials, who attended most of the meetings by invitation of the President, were Deputy Secretary of Defense Roswell Gilpatric, Undersecretary of State George Ball, Deputy Undersecretary of State U. Alexis Johnson, Assistant Secretary of State Edwin Martin, and Soviet Expert Llewellyn Thompson.

The nonmilitary paths -- doing nothing or taking a diplomatic approach -- had powerful advocates.[18] These paths would minimize the risk of nuclear war. However, President Kennedy rejected from the beginning a diplomatic approach, either directly to Khrushchev or indirectly through the United Nations, preferring a path of forcible action. By the afternoon of the second day, serious discussion in the Executive Committee focused on two military alternatives, the air strike and the blockade.[19]

Even with the group process changes, some symptoms of Groupthink can be found in the Executive Committee. However, as seen in Table 4, members were able to overcome the symptoms of Groupthink and succeeded in maintaining a high level of critical thinking and problem-solving.

GROUPTHINK

Overestimation of the Group

The cohesion of this Executive Committee did not come from the same source as the committee for the Bay of Pigs invasion. That first group was cohesive because of the success they experienced during the campaign for John Kennedy's presidency. McNamara spoke about the cohesiveness of the missile crisis group as one that resulted from a common exposure to danger which "forges bonds and understanding between men stronger than those formed by decades of close association."[20]

Contrary to the illusions of safety, comfortable rationalizations, and shared sense of invulnerability found in the Bay of Pigs deliberations, the Executive Committee did not develop a consensus involving shared illusions of invulnerability. Most members thought that even the best possible alternative was loaded with the enormous danger of touching off a nuclear holocaust.[21] This is evident in Sorensen's comment, "Not one of us at any time believed that any of the choices before us could not bring anything but either prolonged danger or fighting."[22]

By speaking frequently about the grave risks and reminding the group of the intolerable consequences of miscalculations, John Kennedy pressed his advisors to consider the moral implications of their proposals. Therefore, members of the Executive Committee explicitly voiced their concerns about the morality of the policy alternatives they were considering. They upheld an attitude of vigilance toward both military and moral risks. For instance, on the second day of the crisis, George Ball vigorously objected to the air-strike option, arguing that a surprise attack would violate the best traditions of the U.S. and would harm the moral standing of the nation, whether or not the attack proved to be militarily successful.[23] Robert Kennedy continued the argument, calling attention to the enormous toll of innocent human lives that would result. Urging a decent regard for humanity, the Attorney General pointed out that a surprise air attack would undermine the United States' position at home and abroad by sacrificing America's humanitarian heritage and ideals. He emphasized this moral stance by stating that he was against acting as the Japanese had in 1941 by resorting to a "Pearl Harbor in reverse".[24]

The debate on these moral issues continued as Dean Acheson challenged Robert Kennedy's position by arguing that, on the basis of the Monroe Doctrine and prior official warnings, the U.S. government would be fully justified in using any means to eliminate the threat to national security posed by the Cuban missiles.[25] Douglas Dillon announced that initially he felt an air attack was justified because the

TABLE 4. GROUPTHINK AND THE CUBAN MISSILE CRISIS		
Groupthink Manifestation		
Type	**Symptom**	**Illustration**
OVERESTIMATION OF THE GROUP	(1) Invulnerability	
	(2) Inherent Morality	
CLOSED-MINDEDNESS	(3) Collective Rationalization	
	(4) Stereotyped Enemy	"Russians would make no response" "Our adversaries would use theirs"
PRESSURES TOWARD UNIFORMITY	(5) Self-Censorship	
	(6) Unanimity...silence	
	(7) Direct pressure	"pull the group together quickly" "not serving the President well" "knew little brother was watching" "shaping our deliberations"
	(8) Use mindguards	

Russians had deceived us and would paralyze the U.S. ability to react[26], but he no longer perceived this position as morally justified. He continued, "what changed my mind was Bobby Kennedy's argument that we ought to be true to ourselves as Americans, that surprise attack was not in our tradition. Frankly, these considerations had not occurred to me until Bobby raised them so eloquently."[27]

Robert Kennedy recalled, "We spent more time on this moral question during the first five days than on any single matter ... We struggled and fought with one another and with our consciences, for it was a question that deeply troubled us all."[28]

Closed-Mindedness

The committee found after a day of probing that the military viewed the term "air strike" to mean "massive attack"[29]. The Air Force informed the group that there could be no assurances that all missiles would be destroyed by an air strike. However, during the second week, civilian experts examined the surgical air strike option, discovered that it could be chosen with high confidence, and thus added it to the list of options.[30] Why the committee did not probe the option further is not known.

Most members viewed their opposite numbers in the Kremlin as no less rational than themselves. This was not easy when strong Soviet provocation evoked resentment and the desire to retaliate. Nevertheless, there were transient tendencies to invoke stereotypical images of the enemy. For instance, the Chiefs of Staff attempted to assure John Kennedy that the Russians would make no response to an air strike. The exception was Air Force Chief of Staff Curtis LeMay who presented the opposite argument that the U.S. should use nuclear weapons in the strike since "our adversaries would use theirs against us in an attack"[31]

Unlike the Bay of Pigs deliberations, which excluded most of the experts who should have been consulted, the policy-makers' deliberations during the missile crisis relied heavily on expert judgments from Kremlinologists in many

different agencies, with priority given to those who had a good record of predicting Soviet actions in earlier crises.[32]

Pressures Toward Uniformity

Most recollections of the meetings depict unpleasant arguments and stressful agitation which demonstrates the lack of self-censorship by the members. Robert Kennedy commented "And so we argued, and so we disagreed -- all dedicated, intelligent men, disagreeing and fighting about the future of their country, and of mankind."[33]

There was no illusion of unanimity since no participant felt compelled to remain silent regarding their judgments in any view, either the majority or minority. One such example is the switch of Douglas Dillon from favoring an air strike to favoring a blockade after hearing Robert Kennedy's moral argument. Another who displayed a reversal was President Kennedy when, after hearing arguments from McNamara and others, he changed his mind from favoring a surgical air strike to favoring the blockade.

Participants agree that an outstanding characteristic of the group's deliberations was the frequent shifting of position that occurred while trying to develop an acceptable strategy. Comments were made by Sorensen, Schlesinger, and Robert Kennedy. Sorensen stated, "Each of us changed his mind more than once that week on the best course of action to take"[34]. Schlesinger recalled, "Thinking aloud, hearing arguments, entertaining new considerations, they almost all find themselves moving from one position to another"[35]. Robert Kennedy explained the circumstances as "None was consistent in his opinion from the very beginning to the very end ... For some there were only small changes, and perhaps varieties of a single idea. For others there were continuous changes of opinion each day".[36]

However, the tendency to pressure members into consensus did exist. According to Sorensen, "The President was impatient and discouraged. He was counting on the Attorney General and me to pull the group together quickly -- otherwise more dissensions and delay would plague whatever decision he took. He wanted to act soon.[37] When the consensus was not forthcoming in the next meeting, Sorensen departed from his usual conduct at these meetings and tried to push the members toward a unified response by telling them that "we are not serving the President well."[38] McNamara also felt the pressure from Robert Kennedy, "We all knew little brother was watching; and keeping a little list of where everyone stood"[39].

In addition to the direct pressure the use of mindguards also materialized. Robert Kennedy and Theodore Sorensen were the engineers of consensus.[40] These two men were to pursue relentlessly every bone of contention in order to prevent errors arising from too superficial an analysis of the issue. Because of the changes in the process made by John Kennedy, their was no formal chairman of the committee; however, participants recalled that Robert Kennedy soon emerged as the discussion leader.[41] As the discussion leader, Robert Kennedy in effect acted as a mindguard as Sorensen acknowledges that in "shaping our deliberations when the President was absent, the best performer ... was the Attorney General"[42].

CLANTHINK

The Executive Committee retained one belief that proved to be counterproductive and caught them off-guard. All past U.S. administrations as well as the Kennedy administration believed that nuclear weapons in Cuba would be intolerable and, since the world knew that, the Kennedy administration refused to consider that the Kremlin would dare to install offensive weapons. Table 5 presents the results.

TABLE 5. CLANTHINK AND THE CUBAN MISSILE CRISIS		
Clanthink Manifestation		
Type	**Symptom**	**Illustration**
COMMUNICATION	(1) Undiscussability	"no present evidence"
	(2) High-Level Metaphors	
	(3) Absence of Corrective Feedback	
INDIFFERENCE	(4) Disavowal of counter knowledge	CIA reports: "Soviets never take risks"
	(5) Absence of standards	
BASIS OF BELIEF	(6) Ideas propagated by authority	
	(7) String of unfulfilled commitments	
	(8) Indifference to contrary evidence	
	(9) Image in lieu of substance	

Communication

The Kennedy administration continued to propagate the belief that nuclear weapons in Cuba would be unacceptable and the Kremlin would not install them. However, in statements on the floor of the House and Senate, in campaign speeches across the country, and in interviews and articles carried by national news media, Cuba -- particularly the Soviet program of increased arms aid -- served as a stick for stirring the domestic political pot.[43] The administration took an offensive stance and attacked these allegations calling them irresponsible and unfounded. Bundy asserted in an interview "I know that there is no present evidence, and I think that there is no present likelihood that the Cubans and the Cuban government and the Soviet government would, in combination, attempt to install a major offensive capability."[44] The administration remained steadfast in their assumption that the Kremlin would not install missiles in Cuba; the contrary assumption was not discussed as a viable possibility within the group.

Indifference

During the months preceding the crisis, the CIA had received reports asserting that Russia was shipping offensive atomic weapons in addition to the publicly acknowledged defensive conventional weapons. U.S. intelligence specialists and the U.S. government continued to believe the Russian leaders who claimed the personnel and equipment were intended to reinforce the Cuban air defense system. On August 22, the CIA Director, John McCone, met with the President, McNamara and Rusk to voice suspicions that the Soviets were introducing offensive missiles to Cuba. Both McNamara and Rusk disagreed using the available evidence which indicated only a defensive build-up.[45] Both men held fast to the prevailing view that the Kremlin would never take the risk of installing offensive weapons in Cuba. This shared opinion prevented the Kennedy administration from taking the early warning signs seriously.

THE FORD MOTOR COMPANY CASE: ILLUSTRATING GROUPTHINK AND CLANTHINK

Today the Ford Motor Company enjoys the position of producing five of the ten best-selling vehicles in the U. S., and its reputation for quality is constantly growing. But this situation represents a gradual recovery from a situation far worse than Ford's situation today.

The Ford Motor Company was founded in 1903. By 1914, Henry Ford had successfully created processes of mass production which, in turn, instigated mass consumption. Because of mass production, the automobile industry began to flourish.

After World War II, the automobile industry was in a position of relative financial strength. Because of the American public's demand for cars, the postwar automoguls began implementing cost-cutting procedures and focusing on style and power as the dominant buying motives, as opposed to quality and reliability. Detroit did not view imports as a threat in the 1950s when the success of the Volkswagen Beetle grew, nor in the 1960s when Japan's share of the U. S. market grew from 4% in 1962 to over 9% in 1967. Not until the early 1980s, when Japan's share of the U. S. market had risen to more than 21% did the Big Three automakers begin to evaluate critically their own practices and core assumptions. For the first time, quality and reliability came to the fore. Unfortunately, Detroit was slow to adjust and, by 1989, the Japanese share of the U. S. auto market approached 30%.

Worldwide, the U. S. auto industry's share of cars on the road in 1930 was 75%. In 1960 it had fallen to 58%. In 1986 it was only 35%.

By the end of 1893, the idea of horseless carriages had become generally known to the readers of newspapers and scientific publications, even though few people had actually seen one.[46] The Ford Motor Company, founded in 1903, pioneered the mass production of automobiles with the assembly line set up to make the celebrated Model T.[47] Early ads emphasized cheapness as well as durability -- that the car was strong and well made.[48] By the standards of the day this claim was quite true.[49] Ford believed in quantity production; it was his idea to produce "what the largest possible public would buy at the lowest possible price and getting the best men to work for him by paying the best wages".[50]

Henry Ford II became the executive officer of Ford Motor Company on September 21, 1945. "Can you believe it," Ford remarked later, "in one department they figured their costs by weighing the pile of invoices on a scale".[51] He quickly decided that the methods employed by his grandfather would not be successful in returning Ford to the position of industry leader. Henry II wanted to be number one in the industry. He hired a brilliant administrator, Earnest R. Breech as executive vice president and brought in a cohesive group of ten young Air Force officers, later known as the "Whiz Kids."[52] Two of the better known Whiz Kids were Charles "Tex" Thornton and Robert S. McNamara. These were numbers men whose strength lay in analyzing data. They had little interest in, or knowledge of, the automobile industry, but instead relied on polling, market research, and statistical analysis.[53] This number fixation led the Whiz Kids to build a monumental disaster: the Edsel.

"Whatever their accomplishments before or since, Henry Ford II and Lee Iacocca, who was Ford's president from 1970 to 1978, presided over major strategic snafus, bad safety decisions and a serious decline in the quality of Ford cars..."[54] Ford management failed to interpret the signs of change in the U.S. marketplace. The group tendency was to seek consensus and/or financial gain at the expense of seeking information, critical appraisal, and debate. Table 6 shows the

symptoms of Groupthink experienced at Ford.

TABLE 6. GROUPTHINK, FORD AND THE AUTOMOBILE INDUSTRY		
Groupthink Manifestation		
Type	**Symptom**	**Illustration**
OVERESTIMATION OF THE GROUP	(1) Invulnerability	Sellers' market
	(2) Inherent morality	Obvious virtues: efficiency, thrift, honesty
CLOSED-MINDEDNESS	(3) Collective rationalization	"Appetite bigger than leaders expected", "No reason to change strategy"
	(4) Stereotyped enemy	Shipments of defective cars to dealers: "not real Americans"
PRESSURES TOWARD UNIFORMITY	(5) Self-censorship	
	(6) Unanimity...silence	No challenge to do better
	(7) Direct pressure	"Live in sin"
	(8) Use mindguards	

GROUPTHINK

Overestimation of the Group

Henry II assumed control of the Ford Motor Company when it had fallen out of first place in the industry, and, due to the loss of war contracts, was losing nearly $10 million per month. The decision to use the pre-war models rather than spend the time and money to create new ones bolstered the company's financial position -- 800,000 units of the 1949 model were sold which was the biggest year since 1929; 1950 profit (after taxes) reached $265 million; and in 1953 Ford moved past Chrysler into second place.[55] Henry II, referring to the immediate postwar production, told an interviewer in 1978, "We didn't have the money we needed to bring out really good products, but ... the damned market had had no vehicles at all for several years so you had a seller's market for a long period of time. You could sell almost anything you could make, regardless of whether it was any good or not. People just wanted to buy transportation and admittedly we didn't make a terribly good product".[56] This initial success fostered a sense of invulnerability and optimism within Ford.

In combination with the financial success, the postwar American public viewed the corporation and the business system in which it lives as friendly to certain virtues that were not only good in themselves but were thought good by most Americans. According to John Knox Jessup's article "A Political Role for the Corporation," in the August, 1952, *Fortune* "among its more obvious virtues are efficiency, thrift, and honesty -- virtues that the voters do not always find in their government, but which the business world harbors and perpetuates because they are the laws of its being." This view not only enhanced the sense of invulnerability of the group at Ford but empowered them with a sense of inherent morality. They were the "good guys"; they were "virtuous". Management knew what was best and could do no wrong.

Closed-Mindedness

Throughout the fifties the company prospered. Management knew that the 1949 model revealed approximately 8,000

minor defects[57] but rationalized that because the consumer still purchased the cars there was no problem. This was reinforced in the mid-1950s by comments such as the one in *U.S. News & World Report* which declared, "The appetite of the American people for new cars is turning out to be bigger than even the optimistic leaders of the automobile industry had expected."[58] Henry II and the Whiz Kids accepted this type of good press; it was encouraging and enhanced their sense of optimism.

Without updating old data regarding the preferences of the marketplace, the Whiz Kids forged ahead on the creation of the monumental failure, the Edsel. During the manufacturing of the car, problems developed. Worried about quality, Richard E. Krafve, assistant general manager, went to Robert McNamara, who had taken over responsibilities for cars and trucks, to request the right to install his own quality inspections on every Ford and Mercury assembly line that was producing Edsels. But the division chiefs of Ford and Mercury defended their territories forcing McNamara to institute a tally system whereby defects were analyzed numerically: a missing part cost twenty points, a chip in the paintwork, 0.1.[59] It was agreed that if a sampling of any half-dozen cars resulted in a tally of more than thirty-five points *on average* per car, then every Edsel in that production batch would be made good at that particular factory's expense before allowing delivery.

The assembly plants reacted to McNamara's tally system. To keep up deliveries, they would identify and correct sufficient defects to ensure a thirty-five point average, but then they stopped bothering, so that, by the law of averages, some Edsels were shipping out with only five or ten points against them, while others went to dealers with defects totaling seventy or more -- and, quite often, with repair instructions taped to the steering wheel for the dealer to cope with himself.[60] Even with the data proving the defects of poor workmanship, the management group continued to view the dealer and customer as weak and insignificant since they continued to place orders for more cars. This false characterization of the dealer prevented the group from seeing the true issue -- poor quality.

Ford continued to ignore the defects and prepared a media blitz including a publicity drive by a journalist. Seventy-five demonstration Edsels would be involved. It was imperative that these vehicles should not be afflicted by the quality problems that were becoming apparent by the Spring of 1957. But when a special mechanical unit was set up to test and prepare these seventy-five demonstration vehicles, it took two months to get them all in shape -- and only sixty-eight cars emerged from the netting process.[61] The other seven had to be cannibalized to supply spare parts; the average repair bill for each vehicle came to $10,000, more than twice the sticker price on a top-of-the-line Edsel. And yet, the company continued to discount the warnings presented in the data. In addition to stereotyping the dealer and customer as weak, Ford also refused to take foreign imports seriously. In 1955, Henry II told officials at British Ford, who manufactured smaller cars: "I don't think you have a chance for any tremendous growth in the U.S."[62] While U.S. car sales were declining in 1956, sales of foreign cars jumped 68%.

By 1957 the Detroit impression of import buyers was: "people attracted to foreign crackerboxes were not real Americans, but a coterie of sophisticated eggheads, and urban snobs who drink French wine, read *The New Republic*, and possibly voted for Adlai Stevenson. This minute band of cultural renegades offered no reason to change strategy".[63] The Ford management deluded themselves that imports were not a threat to their sales and import buyers were only crackpots and skinflints.

Pressures Toward Uniformity

When the 1949 model revealed thousands of minor defects the division reported to the Product Planning Committee, "In the main, competitive disadvantages reported by dealers in the present Ford car will be eliminated before the introduction of the 1950 model".[64] Crusoe, Division Manager, also promised that this would be a much improved car, and that a wholly new one would be ready by 1952. However, one defect, the body shell, could not be fully corrected before that time because a whole new design would be necessary to stop its rain and dust leaks. Crusoe told regional sales managers in a letter, "We are going to have to live in sin on this shell until we get the 1952 job out".[65] Doubts were entertained by some Ford dealers but never expressed. Therefore, an illusion of unanimity grew throughout Ford primarily because no one challenged the decisions for fear of unemployment.

The Crusoe letter represented direct pressure applied to Ford workers as well as dealers. The self-censorship and silence of all participants fostered the illusion of unanimity. Henry II retained the ultimate veto power and members who disagreed had only two choices ... leave the company voluntarily or be fired, as learned by Iacocca.

CLANTHINK

After the war the industry began the task of reconverting to peacetime production. The private automobile had now passed all other forms of transportation as a passenger carrier.[66] More important, public tastes were changing; during the 1950s the automobile was regarded as a necessity of life for the American public. Increased affluence and new values made many car buyers -- especially women, who had come to have more influence in car sales -- increasingly style conscious and interested in more comfort and conveniences.[67] Men insisted on the latest mechanical innovations and additional speed. The car became a necessity for all Americans and automation was introduced to the car industry to meet the demand. The automobile companies were in a position of relative financial strength after the war and the demand for cars placed them in a position of power. The automotive industry began cost-cutting methods and forgot about quality. By the time Henry II had fired Iacocca as Chairman in 1979, the quality was so bad, a middle-level executive said, "It was embarrassing to go to cocktail parties and tell people where you worked."[68] Table 7 shows that the automobile industry suffered from Clanthink and wrongfully believed that the American public valued style more than quality in their cars. In fact they insisted, until the 1980s, that the U.S. automobile industry could not profitably manufacture small cars and, beside, the American people wanted large, stylish cars, not quality.

TABLE 7. CLANTHINK, FORD AND THE AUTOMOBILE INDUSTRY

Clanthink Manifestation		
Type	**Symptom**	**Illustration**
COMMUNICA-TION	(1) Undiscussability	
	(2) High-Level Metaphors	They want beauty, style, power Quality is Job One
	(3) Absence of Corrective Feedback	
INDIFFERENCE	(4) Disavowal of counter knowledge	Recalls
	(5) Absence of standards	
BASIS OF BELIEF	(6) Ideas propagated by authority	"Can't make small car" "Customer decides the car we make"
	(7) String of unfulfilled commitments	
	(8) Indifference to contrary evidence	Import sales
	(9) Image in lieu of substance	

Communication

There was no discussion regarding the belief that Americans wanted large, stylish cars. Henry II told the British "They (Americans) want beauty and style and power, and they pay for it."[69] And the industry did not question the validity of that belief.

Not until the late 1970s did the domestic automobile industry decide that poor quality was a major problem.[70] Much of the early effort was window dressing: television ads trumpeting Ford's contention that "Quality is Job One" or General Motors "Quality of Work Life" program. Henry II provided the rhetoric, "We've got to do a better job; we've had too damn many recalls,"[71] but the industry continued with business as usual. These high-level metaphors did not improve

the quality. The rhetoric sounded good, but it did not improve the quality.

Indifference

In the early 1960s Ford introduced the Falcon and General Motors introduced the Chevrolet Corvair. Both cars sold well, however, they did not address the real issue of subcompact cars like the successful Volkswagen Beetle. What Detroit would not believe was that European cars like the Volkswagen were selling well in the U.S. not just because they were cheap, but because they were better made.[72] They were engineered to hold the road and there were fewer rattles.

Recalls provided a challenge to the industry's belief that American cars were good products and quality was not the issue. In 1967 Ford recalled 1/3 of all the cars it built; the Pinto had a gas tank with a propensity to explode, linking it to two dozen deaths, 60 multimillion-dollar civil suits, and 1.4 million recalls.[73] Previously the company had been forced to call back 2.7 million four- and six-cylinder engines found to be wearing too fast in cold weather because of a cost-cutting move to eliminate two oil holes in the engine block.[74] In 1977, Ford led the industry in recalls. "By midsummer 1978, no less than 18.163 million Ford vehicles were the subject of recalls or official probes for safety, mechanical, or emissions defects."[75] Some of the shabbiest automobiles in the history of the industry appeared in 1978.[76] In 1979 alone, the National Highway Traffic Safety Administration recalled 6.5 million domestically manufactured vehicles. The result has been a public perception of domestic car quality as inferior to that of foreign makes. Saab featured an ad pointing out that "bored people build bad cars."[77] It was Boss Kettering, General Motors chief of research, who summarized the latent sentiments of the industry when he grumbled: "It isn't that we build such bad cars. It's that they are such lousy customers."[78] In the rush to meet the demands of the marketplace, volume had become the primary goal while quality and quality control disappeared. Even with undisputable data regarding the recalls, the industry continued blindly to manufacture the same poor quality vehicles. The standard for assessing performance remained the dollar.

During the turnaround at Chrysler, Lee Iacocca displayed a total denial of the existence of knowledge contrary to the industry's belief. Iacocca's slogan was, "If you find a better car, buy it."[79] Of course there were better cars -- most of them Japanese-built.

Basis of Belief

In 1955, the industry reassured themselves that the subcompact car market segment was insignificant. Unless a car model could be produced in bulk lots of 200,000, the economics of modern mass production would not make it profitable.[80] Industry's attitude toward small imports was summarized in one statement: "America has all the low-cost transportation it needs. We call them used cars."[81] The industry continued to accept the idea that they were unable to build quality, subcompact cars like those being manufactured in Germany and Japan. In 1968, Henry II further validated that belief by stating, "We just finally decided that we couldn't manufacture a subcompact car in this country. We considered all the problems of tooling and manufacturing it and the interchangeability of parts and putting it on the highway, and I just didn't think the people would buy it."[82]

In the early days, Detroit did not take the imports seriously. The Volkswagen looked so funny. However, this tiny machine, which was gaining the same status as the sturdy Model T of thirty years earlier, was transforming the national consciousness about automobiles.[83] The Big Three's research staff regularly did surveys into public perceptions of the European cars that started trickling into America in the 1950s, and they concluded that Detroit had nothing to worry about.[84] Early in 1960 consumers asked for styling, luxury, and accessories.[85] "To the average American," ran one such report by the Ford Division in 1952, "our present car and its size represent an outward symbol of prestige and well-being".[86] Detroit never tired of saying "it is the customer who decides the kind of car they will make."[87] It seemed obvious that as America became more prosperous, she would express her prosperity in terms of a bigger and more powerful car.[88]

Concern over the increasing sales of small foreign cars in North America built up for years. A 1968 *Washington Post* headline over an automotive story described the situation neatly: "Small Cars Give Detroit Big Headache."[89] But still the automoguls remained indifferent and continued to believe that nobody with a decent job and education could possibly choose a European car for its own sake. Beetle-buyers were people who could not afford a real car -- a

challenge to the used-car market, perhaps, but not a phenomenon that domestic manufacturers need concern themselves with.[90]

However, the statistics for 1974 showed that imports had captured some 1.4 million sales in a total market of about 8.7 million. By 1979, the number had grown to over 2.3 million in a U.S. market that had peaked in 1978 and was declining to a smaller volume.[91] Predictably, in late February, 1981, Ford announced that its losses for 1980 totaled $1.5 billion, the largest ever for an American Corporation.[92] The fact that Chrysler was also a big loser was hardly any solace.

THE NUCLEAR ENERGY CASE: ILLUSTRATING GROUPTHINK AND CLANTHINK

On December 2, 1942, the world's first nuclear reactor was operated in the United States. Government secrecy and control of nuclear energy was dominant during World War II, after President Franklin Roosevelt authorized research to develop atomic weapons. On April 25, 1945, President Harry Truman was briefed by Secretary of War Stimson and Military Director of the Manhattan Project, General Leslie A. Groves. None expressed any doubt that the atomic bomb would be dropped on Japan when it was ready. The culmination of that meeting occurred on August 6 and 14, 1945, when atomic bombs were dropped on Hiroshima and Nagasaki, respectively.

The U. S. exploded a hydrogen bomb on November 1, 1952, and detonated a thermonuclear warhead on March 22, 1954. The building of commercial reactors proliferated during the 1950s and 1960s. In 1970, 13 commercial reactors were operating, and by the end of 1988, there were 108 in operation. Recently the government revealed that 33.5 metric tons of plutonium, with a half-life of tens of thousands of years, is unsafely stored in six states.

Serious accidents, such as Three Mile Island in the U. S. and Chernobyl in the U. S. S. R., have demonstrated the hazards of nuclear radiation and the astronomical costs of cleanup. Nonetheless licensing has recently become easier, in spite of the fact that no permanent solution to the nuclear waste disposal problem has been discovered.

The neutron was discovered in February, 1932. On December 2, 1942 -- the official birth date of the Atomic Age -- United States scientists operated the world's first nuclear reactor in a converted squash court under the stands of the University of Chicago's football stadium.[93] World War II escalated the search for power and the results were witnessed on August 6, 1945, at Hiroshima and again three days later at Nagasaki, forcing Japan to surrender unconditionally on August 14, 1945.

The atomic explosions at Hiroshima and Nagasaki etched grim pictures of atomic warfare into the minds of the American public. By 1947 Einstein recognized the significance of the continued atomic research and commented, "It should not be forgotten that the atomic bombs were made in this country as a preventive measure. It was to head off its use by the Germans if they discovered it. We are in effect making the low standards of the enemy in the last war our own for the present."[94] Then in August, 1949, the Soviets tested their first atomic bomb. And now the Cold War with the Soviet Union embraced the race toward additional power, the "Super" or hydrogen bomb. The testing of the first hydrogen fission bomb on November 1, 1952, showed the world a spectacle greater than any atomic blast and the testing of a thermonuclear warhead on March 22, 1954, absolutely stunned those witnessing the event. Fear and anxiety enveloped the public as reports on the destruction generated by the blast and the horrendous damage produced by

radiation began to surface.

GROUPTHINK

Government secrecy and control of nuclear power began when President Roosevelt authorized the search for atomic weapons; he died before the potent effects were unveiled. On April 25, 1945, Secretary of War Stimson and Military Director of the Manhattan Project General Leslie A. Groves briefed President Truman regarding the atom bomb project. None of these men expressed any doubt that the bombs would be used against Japan when ready.

The President's advisors Stimson, Head of the War Department George C. Marshall, Chief of Defense Research Vannevar Bush, President of Harvard James B. Conant, and General Groves were of like mind regarding the bombing of Japan. An Interim Committee was established and, among other duties, instructed to anticipate and prepare for the unveiling of the atomic bomb to the public. In addition to Stimson, Bush, and Conant, the members of the Interim Committee were consultant George L. Harrison, Secretary of State James F. Byrnes, Ralph Bard of the Navy Department and William Clayton of the State Department.

The members of this group conducted their meetings with the understanding that the prime directive, given by President Truman, was to the end the war as quickly as possible. From the beginning, the failure to maintain critical thinking can be partially explained by the situation of war, itself. The group failed to seek information, critical appraisal, and debate on any idea contrary to dropping the bomb on Japan cities. Table 8 shows examples.

TABLE 8. GROUPTHINK AND NUCLEAR ENERGY

Groupthink Manifestation		
Type	**Symptom**	**Illustration**
OVERESTIMATION OF THE GROUP	(1) Invulnerability	"win the war"
	(2) Inherent morality	"save lives"
CLOSED-MINDEDNESS	(3) Collective rationalization	Cities okay as military targets
	(4) Stereotyped enemy	Kamikaze pilots
PRESSURES TOWARD UNIFORMITY	(5) Self-censorship	
	(6) Unanimity...silence	Secrecy
	(7) Direct pressure	Military professionals
	(8) Use mindguards	Withhold report/information

Overestimation of the Group

The Pope uttered a warning against the destructive use of atomic energy in a speech to the Pontifical Academy of Science on February 21, 1943.[95] At this time the public still knew nothing of the atom bomb. And with the war building in Europe, his moral message fell on deaf ears. By the middle of 1945, Germany had surrendered and the U.S. appeared near victory in the Pacific. The success of the Pacific campaign provided the Interim Committee with a sense

of invulnerability -- they were in position to win the war. In conjunction with this was their moral obligation to win the war quickly and save as many American lives as possible. These conditions created a sense of excessive optimism and an intrinsic morality within the group. They could do nothing wrong by winning the war. Both the practical and moral consequences of the atomic bomb were less important than ending the war quickly.

Closed-Mindedness

The Interim Committee viewed the enemy as savage and inhuman. Kamikaze tactics employed by Japanese fliers only enhanced that image. In addition, by the end of the war the bombing of cities had become an acceptable military tactic. This tactic was rationalized as an effective way to end the war because it destroyed weapons plants. Even the American public knew of the new strategy from media reports such as those appearing in *The New York Times*, "The B-29s destroyed the major portion of the industrial productive capacity of fifty-nine Japanese cities."[96] Such reports contained no reference of civilian deaths, only military targets destroyed. Great lengths were taken to camouflage the number of civilian deaths and the Interim Committee accepted the rationalization that civilian cities provided excellent targets, even for the atomic bomb. No member questioned the President's decision to use the bombs as soon as possible. Everyone accepted that the bombing of Japan would occur.

Pressures Toward Uniformity

During the war, the prevailing attitude was that the war must be won by winning it, and that is the business of military professionals. Military professionals, especially when at war, demand a high level of secrecy and, because of this secrecy, the pressures toward uniformity are achieved simply by participants being selectively told what they need to know. It is not surprising that the work on the atomic bomb warranted a classification of top-secret. The secrecy had begun with a proper concern not to arouse Hitler's interest but had become a state of mind with a life and meaning of its own by May, 1945. Germany had surrendered and the war was nearly won; still the bomb was secret. Why? It was secret now because it was secret throughout the war.[97] This need to classify material tends to suppress any deviational views.

On May 31, 1945, the bombing of Japan was discussed during a joint meeting of the Interim Committee and its Scientific Advisory Panel. The distinguished members of this panel were Arthur Compton, Enrico Fermi, Ernest Lawrence, and Robert Oppenheimer, all nuclear physicists. Since these men were somewhat of an out-group, they felt free to voice an option to the decision of dropping the bomb on cities. Lawrence suggested, "give the Japanese some striking but harmless demonstration of the bomb's power before using it in a manner that would cause great loss of life."[98] Most members objected to the idea for reasons such as the bomb may be a dud, the Japanese may shoot down the delivery plane, or bring American prisoners to the test site. They all agreed that if the demonstration failed to bring surrender, the chance of administering the maximum surprise shock would be lost.[99] They were convinced that their enemy was so fanatical, that simply a demonstration would not stop the war; and their directive was to "end the war".

About this time, the Franck report, representing the viewpoint of some Chicago scientists, was brought to the attention of Harrison, a member of the Interim Committee. The report urged that instead of making an attack on Japan without warning, it would be better to begin with a demonstration "before the eyes of representatives of all the United Nations, on the desert or a barren island."[100] Harrison functioned as a self-appointed mindguard and withheld the report from the Science Advisory Panel fearing it would only prolong the discussions and become more difficult to reach a consensus. As a result, the conclusion of Compton, Fermi, Lawrence, and Oppenheimer: "We can propose no technical demonstration likely to bring an end to the war; we see no acceptable alternative to direct military use"[101] was achieved without access to all the information submitted to the Committee such as the Franck report which did, in fact, present the practical beginnings of an alternative. However, this conclusion justified the Interim Committee's decision to drop the bomb on the targets chosen by the military.

The cohesion of the Interim Committee was threatened by the issue of whether or not to warn the Japanese about the bomb. The only member of the Committee strongly in support of providing a warning was Ralph Bard. Initially he concurred with the recommendations of the committee that the bomb should be used without warning. By June 27, 1945, Bard had changed his mind. He felt Japan should have two or three days "warning" and that feeling was based on his view of the "position of the United States as a great humanitarian nation and the fair play attitude of our people generally ..."[102] He proposed American emissaries make private contact with Japanese representatives and "give them

some information regarding the proposed use of atomic power."[103] He presented his position face-to-face with the President in a farewell interview in early July (he was leaving the government for other reasons), and Truman assured him that the whole matter of a warning had been very carefully considered,[104] thus suppressing the unfavorable information from further discussion.

Meanwhile at Los Alamos, a special subject brought up by the scientists was the game of hide-and-seek played by the Army with the problem of radioactivity. Some physicists entreated Groves to allow pamphlets to be dropped at the same time as the bomb, pointing out the unfamiliar dangers of radioactivity arising from the explosion of this new weapon. The military authorities refused the request for fear that such warnings might be interpreted as a confession that they had been employing a type of weapon like poison gas.[105] The military's natural resistance to any direct advance disclosure of a new secret weapon silenced the issue.

CLANTHINK

The government expended enormous energy to minimize the public's fears and knowledge of the effects of radiation. The belief that technology would find a solution to the radiation wastes produced from nuclear weapons and reactors before it became a problem was counterproductive to finding a viable solution. Table 9 exhibits the examples.

TABLE 9. CLANTHINK AND NUCLEAR ENERGY

Clanthink Manifestation		
Type	**Symptom**	**Illustration**
COMMUNICA-TION	(1) Undiscussability	
	(2) High-Level Metaphors	Radiation "very pleasant"
	(3) Absence of Corrective Feedback	
INDIFFERENCE	(4) Disavowal of counter knowledge	All are reported well
	(5) Absence of standards	
BASIS OF BELIEF	(6) Ideas propagated by authority	Radiation is safe
	(7) String of unfulfilled commitments	
	(8) Indifference to contrary evidence	Three-Mile Island
	(9) Image in lieu of substance	

Communication

After the war the government proceeded to try to divert attention from the radioactive effects of atomic bombardment. It was explained that there was now no dangerous radioactivity to be found in the ruins of Hiroshima, and the number of the victims who had been exposed, at the moment of the explosion, to a fatal dose of radiation or one likely to cause chronic illness, was kept secret. Groves stated openly at a Congressional hearing that he had heard death from radiation was "very pleasant"[106].

When President Truman announced the U.S. would continue research on all atomic weapons including the hydrogen bomb, the public was shocked. The H-bomb aroused the same fear and indignation as the first atom bomb. Churchmen,

scholars, politicians and editors throughout the world warned of the danger and urgently called for a renewed effort to reach an understanding between West and East. Nobel prize winner Compton declared: "This is not a question for experts, either militarists or scientists. All they can do is to explain what the results will be if we do or do not try to develop such destructive weapons. The American people must themselves say whether they want to defend themselves with such weapons."[107] Szilard, a nuclear physicist, expressed in a broadcast that the radioactive effects of the Super bomb could be so much intensified that even the explosion of five hundred tons of heavy hydrogen would suffice to extinguish all life on earth. Einstein said: "If successful, radioactive poisoning of the atmosphere and hence annihilation of any life on earth has been brought within the range of technical possibilities."[108] The civilian response, from reputable and knowledgeable men in the field of nuclear science, should have provoked the government to think about correcting or amending its position. However, these pleas and demands for reassessment of the decision to compete for the hydrogen bomb were not considered. The race continued.

In the early years the nuclear industry-federal government complex considered the disposition of spent fuel and other wastes from commercial reactors and the weapons program to be a problem of much less eminence than that of increasing the production of electricity and nuclear warheads.[109] The belief, at that time, was that the waste problem would be easily resolved once the accelerating advance of nuclear technology delivered the inevitable solution. The lack of attention to the waste end of the nuclear fuel cycle by the Atomic Energy Commission (AEC) through the 1950s was described by the General Accounting Office (GAO) as being a product of "expediency" and of confidence in the certainty of a technological "fix" surfacing before the problem became critical.[110] As a result, nuclear waste management decisions were based on short-term expediency rather than long-term management; the belief that a technological fix would materialize before nuclear waste and radiation became a problem was counterproductive.

Indifference

On November 1, 1952, the U.S. tested the Hydrogen bomb. As soon as the fireball of the first Super, a flaming dome three and a half miles in diameter, had disappeared and the vast, mushroom-shaped cloud rose into the sky, the observers realized a fact which they at first could hardly believe -- the island of Elugelab had disappeared.[111] The test shot had surpassed all expectations.

At dawn on March 1, 1954, the test shot of a thermonuclear device was carried out. *Time*, March 22, 1954, reported on the spectacle in an article entitled, "The Atom: Five Hundred Hiroshimas." "U.S. scientists exploded a thermonuclear device atop a tower. Calculations of the explosion's energy and effect are incomplete, but they were so great that the AEC was forced to reclassify the previous tower shot (Nov. 1, 1952) as a misfire. This test makes all its predecessors, including the 1952 shot, look like a string of one-inch salutes. The force of the explosion probably exceeded ten megatons (500 Hiroshimas). It sent a radioactive cloud billowing to a height that may have exceeded 20 miles." Twenty-eight U.S. observers and 236 natives of local islands had been evacuated to what had been considered a completely safe refuge, but the unpredicted "fallout" showered them with radioactive particles. Their exposure to radiation was ten times greater than scientists deem safe, but the AEC was reassuring. "There were no burns," said a commission announcement. "All are reported well. After completion of the atomic tests, they will be returned to their homes."[112] The public was becoming educated on the topic of radiation.

It was not until two weeks later that the world learned that a Japanese steam trawler, the Lucky Dragon, had been overtaken by a "snowstorm" in open sea and the storm had been a rain of radioactive ashes from the U.S. test site. On the morning of March 1, the Lucky Dragon rode at anchor 71 miles east of Bikini, and well outside the announced danger limits of the U.S. atomic proving grounds. A fine ash began to fall on the Lucky Dragon and her crew. It descended for several hours, and when the seamen bathed, they found that it was hard to scrub off. Very soon the men experienced loss of appetite, depression and other first symptoms of radiation.[113] By the time medical authorities were aware of the incident, the 16,400 pounds of radioactive fish from the Lucky Dragon had been distributed to markets throughout Japan. The bottom dropped out of the fish market, Geiger counters were sold out, all incoming boats were checked for radiation, and U.S.-Japanese relations became seriously strained. The U.S. response came from U.S. Ambassador John Allison who offered profound official apologies and promised restitution if "the facts so warrant."[114]

The other reactions taken by the U.S. government only enhanced the continuance of the testing. For instance, in Washington, Representative Sterling Cole, head of the Joint Congressional Atomic Energy Committee, began an investigation of the March 1 explosion and announced that the U.S. now has a deliverable thermonuclear weapon; the

AEC enlarged the danger zone around the atomic-test site in the Marshalls to twenty times its original area; and the Food & Drug Administration ordered a Geiger check on all shiploads of tuna and shark coming into West Coast ports from the test area.

The government remained indifferent to the reports of radiation poisoning. In the late 1950s, A.H. Sturtevant, a renowned geneticist, remarked in a public address that probably 1,800 of the children born in 1954, the year of the bomb test, were already infected by the high radiation. In the same year the American zoologist declared: "by now everyone in the world harbors in his body small amounts of radioactivity from past H-bomb tests: 'hot' strontium in bones and teeth, 'hot' iodine in thyroid glands."[115] As more information appeared regarding the explosions of the H-bomb, AEC Chairman Strauss lost no time in mounting a counteroffensive. He announced that his "own" scientists considered it an exaggeration to fear that the spread of increased radioactivity would endanger life wherever it was to be found.[116]

Basis for Belief

Particularly after nuclear reactors began being built, the nuclear industry and government continued to reassure the public that radiation posed no problem. For example, the October 23, 1972,(p.49) issue of *Time* displayed an advertisement promoting nuclear energy.

The ad had a picture of the middle school class of '75 standing in front of their school building with the following:

> "Going to school exposes these kids to more radiation than they got from the nuclear power plant.
>
> To confirm what the people in the area of Ontario, NY, already know 'that nuclear power plants are safe' radiation detection devices were installed around town. They measured the natural background radiation the residents live with day-in and day-out.
>
> Not surprisingly, it turns out that both this school and the local firehouse expose people to more radiation in a year than even the closest neighbor gets from the area's nuclear power plant.
>
> Of course, these community buildings are not unusual or unsafe. Radioactivity is just naturally everywhere -- in the air, the water, the ground, even in common building materials such as brick, concrete, and tiles. The whole world is radioactive, and always has been.
>
> Facts like these are important, because over the next decade America's need for electric power will increase, and clean, safe nuclear power is one of the best ways to meet that need."[117]

The propaganda of safe radiation continued even after the March, 1979, disaster at the Three Mile Island reactor in Middletown, Pennsylvania. In 1981, the favorable attitude toward nuclear power in Washington returned and soon manifested itself in pressure on the Nuclear Regulatory Commission from both Congress and the Reagan administration to speed up the reactor licensing process.[118] Provisions allowing interim licensing without public hearings were attached to the NRC's 1982-1983 budget authorization by the Senate Environment Committee and by the House Energy and Commerce Committee. Also, legislation was approved to allow the NRC to change the operating license of an existing reactor without a public hearing if it determined the change would present no "significant" hazard to the public.[119] And, in 1991, President Bush's new energy bill streamlined the licensing of commercial nuclear power plants, allowing "one-stop" permits for construction and operation. The government continued to believe that a technological fix would materialize.

In 1993, it was disclosed that "the government conducted 204 underground nuclear tests during the past half-century without any public mention in the hope that they would pass unnoticed by the Soviet Union"[120]. In making this disclosure, the Secretary of Energy "told reporters that she was disclosing sensitive nuclear data in response to requests from nuclear activists, environmentalists, health experts, scientists and historians, some of whom have long depicted her department as an unresponsive bureaucracy wedded to a bomb-building culture...[Secretary] O'Leary described the earlier policy not to announce many nuclear tests as an artifact of superpower conflict. 'We were in a struggle for survival as a nation, and national security was at the heart of everything that happened in the Department of

Energy...We were shrouded and clouded in an atmosphere of secrecy. And I would even take a step further--I would call it repression', she said."[121]

SPREADTHINK AND LINKTHINK

Both Spreadthink and Linkthink have been the subject of significant empirical studies. In fact, both were discovered through the process of interpreting a large number of empirical results obtained from working with a wide variety of groups who were dealing with a wide variety of complex situations.

The variation in the groups and the variation in the topics would normally be thought of as qualities that invalidate empirical results, which normally benefit from holding factors constant. Actually, two factors were held constant in these studies: the methodologies used, and the requirement that the issues dealt with shall be complex. The results obtained concerning Spreadthink and Linkthink could not have been obtained if the methodologies had not been held constant and if the issues being dealt with were not complex.

SPREADTHINK

Spreadthink refers to the demonstrated fact that when a group of individuals is working on a complex issue in a facilitated group activity, the views of the individual members of the group on the relative importance of problems and/or proposed action options will be literally "spread all over the map".

The predictable incidence of Spreadthink leads to certain conclusions.

1. If nothing is done to resolve the difficulties caused by Spreadthink, there will be no consensus among individual members of the group on any course of action, unless that consensus is reached through Groupthink.

2. Not only is there no consensus among individual members of the group upon a course of action, but there is almost always no majority view on which problems facing the group or which courses of action are the most important.

3. Importance is not a suitable criterion for reaching a majority point of view or a consensus, in spite of the fact that groups and individuals will often invoke it as a criterion.

4. Facilitators who try to bring groups to a majority view or a consensus without the aid of some methodology that resolves the difficulties caused by Spreadthink may well be driving the group to Groupthink or Clanthink, and thus helping to arrive at a decision that lacks individual support and, usually, lacks substance.

Examples of the incidence of Spreadthink will be given in the next section, and Appendix A will show data about Spreadthink coming from numerous applications. These data indicate clearly that in all groups working with complex issues there is inherent difference of opinion about the relative importance of component problems, thus illustrating the virtually universal presence of Spreadthink in regard to groups working with complex issues.

Nevertheless, there is possibly an artificial way to avoid Spreadthink. That way is to choose group members who are already known to have reached consensus. However in all the instances for which empirical data were taken, the members were chosen to reflect a variety of knowledge, in order to try to get a comprehensive view of the complex issue. Some might say that if you recruit group members who are inherently coming from different backgrounds, it is not surprising that Spreadthink is found.

In order to illuminate this situation a bit further, it is noted that the methodology used to arrive at the empirical results is the well-known methodology called Nominal Group Technique (NGT)[122]. With NGT, Step 1 is the silent generation of ideas in response to a triggering question. Step 2 is a round-robin gathering of the ideas carried out by a facilitator, who arranges that all the ideas appear on the wall in front of the entire group.

Step 3 is the systematic clarification of the ideas appearing on the wall. This third step (which is often omitted from other methodologies for gathering ideas from groups) has been clearly established as critical in regard to assuring that most of the group members understand most of the ideas that are on the wall. There is always a significant amount of discussion in this clarification section of NGT, revealing that at the beginning there is another form of "spread"--members do not understand the same thing when they read the same statement.

It is only after this clarification has been completed that Step 4 in NGT is carried out. In this step, each member is asked individually and without consulting other members or revealing votes to other members, to select the five "most important" ideas, and to rank these ideas in relative order of importance. It is the data from these voting records that confirm the presence of Spreadthink.

LINKTHINK

Linkthink is responsive to the difficulties introduced by Spreadthink. Linkthink occurs when members of the group have completed their work in generating and voting on ideas as mentioned above. With Linkthink, members are asked to determine how those ideas that received at least one vote during the NGT process are related. For example, if the ideas are problems, members will be asked about problems in pairs, to determine, e.g., whether a certain problem aggravates (makes worse) another problem. This activity is carried out using a methodology called Interpretive Structural Modeling (ISM).[123] This methodology provides computer assistance in sequencing the questions which members of the group discuss, and on which they eventually vote.

A typical product of an ISM session is called a "Problematique"[124]. This is a graphical structure showing how problems are interrelated through the relationship "aggravates". Typically, such a structure may have between 5 and 10 stages. When drawn with the first-stage problems appearing at the extreme left, and the last-stage problems appearing at the extreme right, aggravation will be seen to flow from problems at the left to those to which they are connected on the right.

Every relationship on the Problematique has this property: it appears there as a result of (at least) a majority vote by the group. Unlike the results of the NGT voting, in which there is seldom a majority on anything, with the Problematique there is a majority on everything. It is reasonable, therefore, to say that the Problematique represents a consensus view of the group. In observing the development of dozens of Problematiques over the years, nothing has occurred that would invalidate that description.

What has occurred, however, is a study done by I. B. Kapelouzos[125]. This study showed that there is essentially no correlation between the results of the work done to produce the Problematique and the results of the individual importance voting done in NGT.

Several possible explanations for such a significant difference might occur to the reader.

1. Maybe there is no connection between the importance of problems and their ability to aggravate other problems in the set of problems relating to the complex issue.

[This explanation is very far-fetched. On the contrary, it seems very likely that those problems which have the greatest capacity to make other problems worse are among the most important in terms of making decisions about actions to take.]

2. Maybe the members of the group had never systematically considered the relationship among the members of the problem set until they were asked to do so using the ISM methodology.

[This explanation is very reasonable. First of all, the group members were chosen to reflect varied backgrounds related to the complex issue. It may well be that some of the problems that were generated during the NGT had occurred to them for the first time, so that they had never had an opportunity to reflect on how those problems might be aggravating other problems. Furthermore, it is very likely that until the facilitated ISM process was made available to the group, the members had never even thought about how problems interrelate and, even if they had, may have lacked any systematic methodology for assessing the interaction.]

3. The members of the group learned enough in the discussions that go on prior to the voting in the ISM process that they were able to understand how problems interact, and produce a consensus diagram showing those interactions.

[This is the explanation advanced by Kapelouzos. It seems very reasonable, in the light of the observed learning that goes on in the ISM session, as indicated by group member comments.]

In the advanced form of Linkthink, members are asked first to work out how the problems interrelate, and then they are asked later to work out how proposed action options may help resolve problems. In this respect, they may produce a "resolution structure" showing how certain action options help reinforce other action options, and how they help resolve some of the most heavily influential problems that aggravate other problems.

In the cases to follow, examples of Spreadthink and Linkthink will be given.

THE RRM CONSORTIUM CASE: ILLUSTRATING SPREADTHINK

Complexity in organizations is likely to be attacked by bringing groups of people together to take advantage of their collective knowledge and experience. If these groups operate with well-defined processes, executives might hope that they would arrive at well-defined recommendations. Numerous test cases have shown that such groups come to the activity with widely varying views of how to cope with complex issues. When the spread of views is clearly demonstrated, it becomes clear that processes are needed which narrow the perspectives, by a process where members of the group educate each other by sharing individual expertise all-around with the group.

Consensus can then be reached, along with documented rationale, which provides executives with the best of all worlds for proceeding.

To illustrate the foregoing, results coming from several Interactive Management workshops are presented. The groups involved, in two instances, were Ford engineers; and in the third instance a consortium was involved: The Rapid Response Manufacturing Consortium, comprised of representatives of Ford, Texas Instruments, and General Motors. The presence of Spreadthink is clearly illustrated in all cases, in order to pin down the idea that groups must engage in processes that narrow the diverse opinions in order to form a basis for wise executive decisions.

A three-day Interactive Management (IM) Workshop was held in Dearborn, Michigan, during May 19-21, 1993, involving members of the Rapid Response Manufacturing (RRM) Consortium (representatives of Ford Motor Company, General Motors, and Texas Instruments). Later a report was prepared showing what transpired, and interpreting the products of the Workshop.

IM Workshops are designed to facilitate "structural thinking". Structural thinking, in its most elaborately researched form, is responsive to the requirement that any contextual implication of linguistic components shall be elaborated in detail, in order to uncover defective suppositions (consciously held and stipulable) and/or presuppositions (unconsciously held and not articulated); and to the requirements that displayed products of structural thinking lend themselves to referential transparency; that the structural thinking be marked by thinking in articulated sets and

articulated relationships, patterns, and systems; and that the processes applied in structural thinking shall be open at scale (i.e., not limited in application to some predetermined scope or dimensionality.) **These and other evaluation criteria relate to the Laws of Complexity, discovered during a twenty-five year period of research on complexity.**

Structural thinking, **by definition**, integrates the following attributes:

- It generates sets by generating and clarifying members of the sets
- It focuses upon selected, particular relationships as the basis for organizing information concerning the generated sets
- It explores the relationships among the members of the generated sets in great detail
- It produces logically consistent relationships among the members of the generated sets
- It specifies the structural features of the relationships in generic terms that enable effective interpretations to be developed
- It allows comparisons of relative complexity to be made among relationships
- It foregoes exclusive use of prose as the means of representing structural features of the relationships, instead producing designed types of visual patterns for interpretation
- It uses computer assistance in developing, organizing, and representing the relationships
- It is indifferent to the scale of the topic being considered, because the methods used in structural thinking are open at scale
- It is a self-documenting process
- It incorporates what is known about formal logic

STRUCTURAL THINKING STRESSES RELATIONAL THINKING

The term "structure" as a base for the phrase "structural thinking" refers to the relational patterns that are involved among members of a set or system. Structural thinking stresses relational thinking as its primary distinguishing attribute. While the term "structural thinking" might be interpreted by some readers as thinking that leads to familiar forms of engineering graphics, this is not the case. The patterns produced by structural thinking, as defined, necessarily possess the property of being unambiguously translatable into prose. A high percentage of familiar engineering graphics lack this property because they involve intuitive aspects that are not communicated to the viewer by the symbols on the structure. The patterns produced by structural thinking, as defined, combine the intuitive and the rational in a single format, and every symbol on such patterns has a well-defined meaning which contributes to the translatability of the pattern into prose. [The only widely-known graphic that shares these features is sheet music. The latter is well-known to communicate across national boundaries and across the centuries.] Structural thinking is the basis for Linkthink.

WORKSHOP ACTIVITY AND PRODUCTS

In the RRM Workshop, the activity involved the production of the following:

A. Problem Set Production of a Problem Set consisting of those problems that the Participants anticipated would be encountered in developing a variant design process. This Problem Set included 81 member problems. The methodology used to develop this set was the widely-used Nominal Group Technique (NGT). Among other things, this facilitated group process requires that participants vote individually on problem importance in the manner to be described next.

B. Votes on Problem Importance Each Participant identified, from the Problem Set having 81 members, those 5 problems that were perceived as most important. Since there were 13 participants in this RRM workshop, this voting produced 13 subsets of the Problem Set, one for each participant. The voting thereby identified an Important Problem Set, consisting of all those that received votes from any Participant. The number of members in this Set (which is a subset of the Problem Set) was 42. Furthermore, following the well-established NGT procedure, each Participant ranked the five problems as being (1) the most important, (2) the second most important, etc., down to (5) the fifth most important.

C. Problematique In response to many queries to the group, each representing a particular instantiation of a Generic Question identified in the Workshop Plan, it was possible for the group of participants to develop a Problematique. This is a structure that reveals how each problem in the more highly ranked 29 members of the Important Problem Set relates to each other member of the set of 29 problems.

D. Numerical Interpretation of the Problematique When drawn as an "influence structure", it is possible to construct a numerical interpretation of the Problematique. This interpretation allows computation of the following numerical interpretants:

- *Activity Score*--which assigns a numerical value to each problem based on the amount of interaction it displays with other problems, without regard to whether a problem aggravates other problems or is aggravated (i.e., made worse) by other problems
- *Influence Score*--which assigns a signed numerical value to each problem based on the extent to which it aggravates other problems or is aggravated by other problems. A positive score is indicative of the ability of a problem to aggravate other problems; while a negative score is indicative of the vulnerability of a problem to being aggravated by other problems

INTERPRETATION

The Problematique is a structure that shows how a significant subset of problems is interrelated; more specifically, how each problem aggravates or is aggravated by other problems. The Problematique is drawn as a graphic structure, wherein the problems appear in boxes, while the arrows that connect the boxes show the flow of aggravation. Figure 1 shows the Problematique, except that all of the problem statements have been suppressed, and the problems are represented by problem numbers appearing in the boxes. Also shown in each box is an "influence score" and an "activity score" for each element. These scores are computed based entirely on the structure of the Problematique. A high positive influence score means that a given problem aggravates many other problems, while a high negative influence score means that a given problem is aggravated by many other problems. A high activity score means that the problem is heavily involved in aggravation, and may aggravate many problems while being aggravated by many problems.

If we leave on a graphic picture all the problem boxes in the position in which they appear on the Problematique, and eliminate from the picture all the problem statements as well as the arrows connecting them, a pattern appears where the individual importance votes can be tabulated, so that it is possible to see how non-consensus data from the voting results appear on a structure developed by consensus.

Figure 2 shows such a pattern. The number of importance votes that participants produced for problems appearing on the Problematique (but before they had produced the Problematique) is shown in the various boxes. This pattern clearly illustrates Spreadthink. Note that no problem received a majority vote in the NGT voting. The highest score is 4, but 7 votes would be required for a majority.

There are seven problems represented vertically at the extreme left in Figure 2, each of which aggravates all the problems to which they connect. There are seven more appearing in the second stage, which aggravate problems appearing to the right.

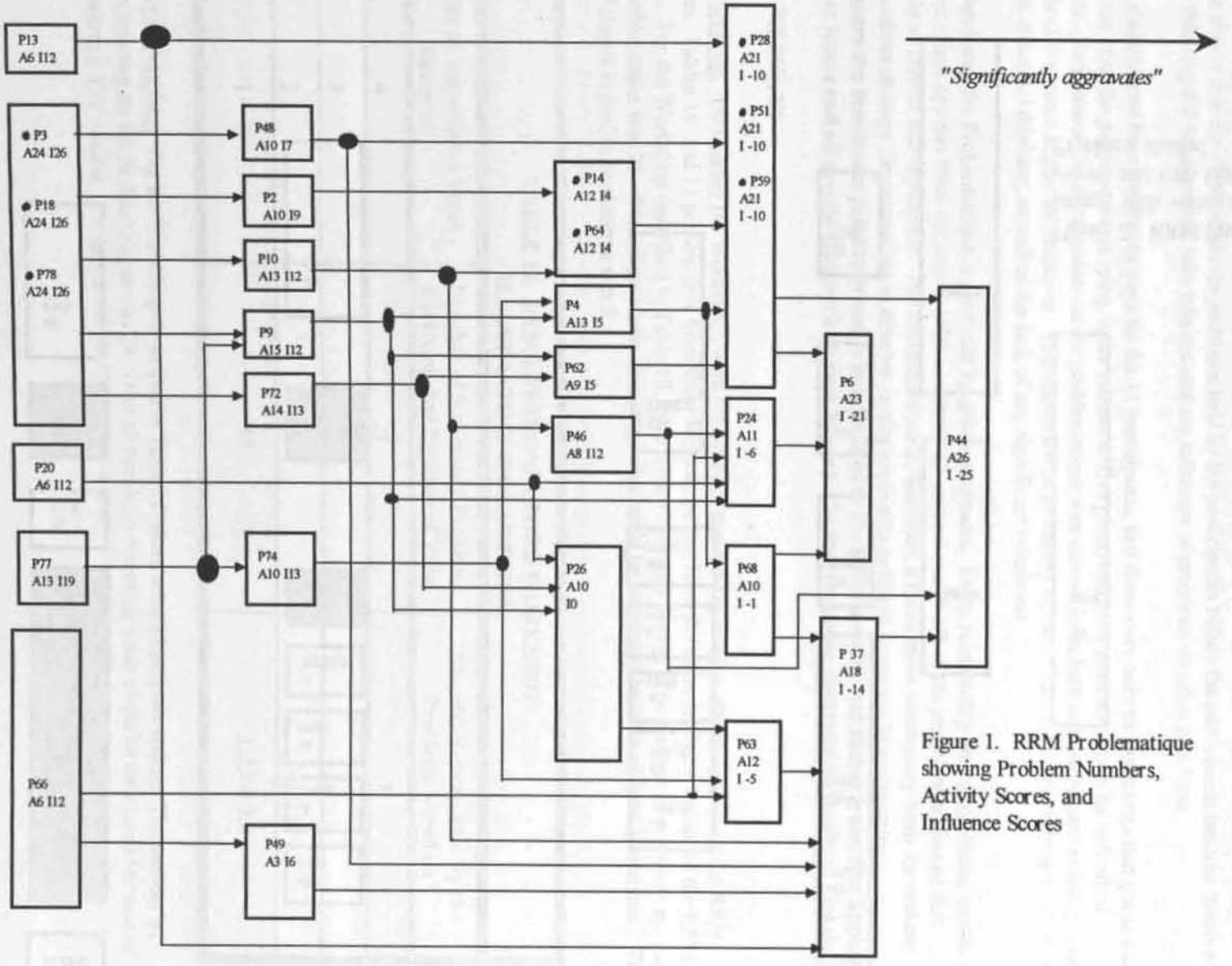

Figure 1. RRM Problematique showing Problem Numbers, Activity Scores, and Influence Scores

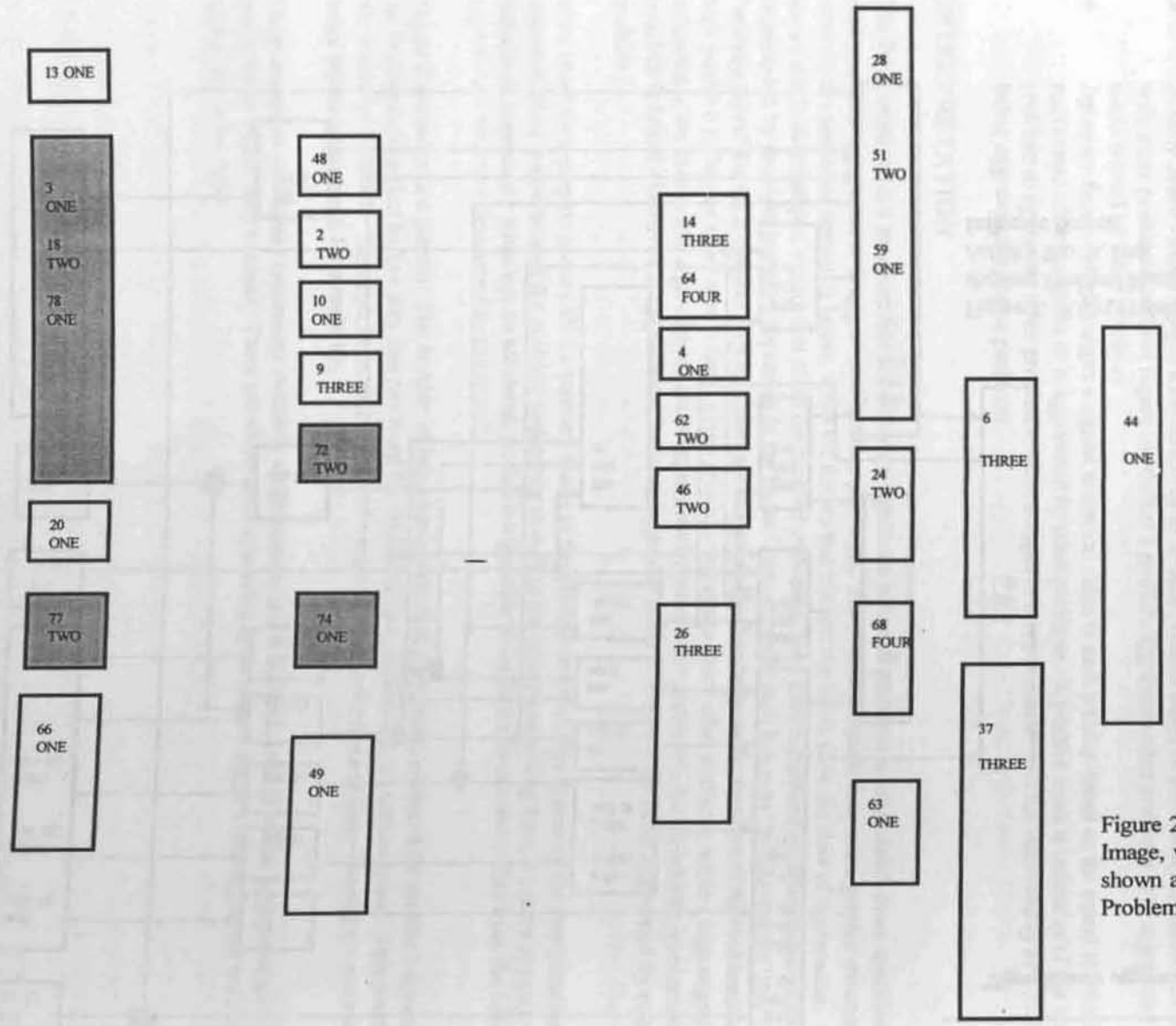

Figure 2. RRM Problematique Image, with voting records shown and with highest-Influence Problems shaded

The shaded boxes represent those problems that analysis reveals had the highest influence scores, as computed from the structure of the Problematique.

One may observe that of the 53 total importance votes that went to problems appearing on the Problematique, a total of only 9 (17%) went to those with the highest influence scores. A total of 21 (40%) went to problems appearing in the right half of the Problematique (i.e., to those problems that are symptomatic of more basic problems appearing to the left). This shows that the views about the problems held by the participants before the participants became involved in structural thinking did not generally take into account the influence of problems on other problems.

One may also observe from the voting done by the 13 participants, that there were only two problems that got as many as four votes from the participants, as lying in the subsets of five perceived to be most important by individual participants. Furthermore, every problem on the problematique was viewed by at least one participant as lying in one of the subsets of five most important problems. This shows the large variety of views held by the participants before they engaged in structural thinking, as well as the lack of any significant consensus.

On the other hand, the Problematique is produced by group consensus. Every relationship among problems shown on the Problematique appears there because at least a majority (7 or more out of 13) of the participants viewed that relationship as correct and significant. The Problematique is, therefore, a much more satisfactory basis for making judgments about strategy for proceeding to develop results applicable to Rapid Response Manufacturing. **(Furthermore the conclusion just illustrated is not confined to the RRM activity, but rather is one that applies to all complex issues and all groups that work on such issues.)** The Problematique illustrates the results of Linkthink.

OTHER RESULTS

A Ford Workshop. Two earlier IM Workshops were held at Ford that did not involve other members of the RRM Consortium. Tables 10 and 11 present data from these Workshops that have the same attributes noted for the RRM Workshop. For the Workshop described in Table 10, there were 10 persons voting. The number of problems appearing on the Problematique was 26. (Not all problems receiving votes could be structured because of time limitations.) The number of stages in the Problematique was 8.

TABLE 10. RESULTS FROM A FORD WORKSHOP ILLUSTRATING SPREADTHINK

Number of Importance Votes Received	Number of Structured Problems Receiving that Number of Votes	Stage(s) Represented by the Problems Voted on
4	1	7
3	2	2,3
2	5	1,3,5,7,8
1	18	1,2,3,4,5,6

Another Ford Workshop. For the Workshop described in Table 11, there were 15 persons voting. The number of problems appearing on the Problematique was 28. (Not all problems receiving votes could be structured because of time limitations.) The number of stages in the Problematique was 6.

TABLE 11. RESULTS FROM A FORD WORKSHOP ILLUSTRATING SPREADTHINK		
Number of Importance Votes Received	**Number of Structured Problems Receiving that Number of Votes**	**Stage(s) Represented by the Problems Voted on**
6	2	2,3
5	0	
4	1	3
3	2	2,4
2	11	1,2,3,4,5,6
1	12	2,3,4,5,6

Common Workshop Features. No problem in either of these Ford Workshops received a majority of the votes on importance. Problems lying in stage 1 (most likely to aggravate other problems) received very few votes in either instance. In both instances voting was spread across the entire Problematique. These Workshops also illustrate Spreadthink.

Appendix A presents results from over 40 other Workshops, in which Spreadthink is uniformly present.

THE JOHN DEERE CASE: ILLUSTRATING LINKTHINK

A large midwestern manufacturing organization had repeated difficulties in getting a high yield from a manufacturing process. After numerous attempts to correct the problem, the company elected to use a methodology that stresses structural thinking in order to try to enhance the manufacturing operation substantially. By proceeding in this way, it was demonstrated that the product output from one pass through the production process could be increased from less than 50% to 85%. This produced significant cost savings.

DESIGN FOR QUALITY CONTROL OF AN INDUSTRIAL PRODUCT

This case describes work carried out by Mr. Steve Landenberger, with consulting assistance from Dr. Robert Waller, on behalf of the John Deere Company. A department in the factory was engaged in assembling and testing hydraulic pumps. The pump test machine was rejecting 51% of the pumps arriving at the test machine. A task force was created to determine what was causing the high reject rates. Management set a goal to achieve 85% acceptance without retest. The task force objective was to develop a plan to achieve the goal of 85% acceptance. Once the plan was approved by management, the task force was responsible for implementation. The task force was able to achieve these goals by creative use of multiple methods, including the prominent use of Linkthink.

BACKGROUND

Extensive and informed use of statistical quality control has been acclaimed as one of the major factors in the ascendence of Japan as a manufacturer of quality products. Well-managed American manufacturers likewise apply statistical quality control. However this approach is best suited to determining that something is wrong in

manufacturing, and the magnitude of the problem, and is of lesser significance in determining precisely how to correct the problem.

Mr. Steve Landenberger decided to use a hybrid methodology in which, once statistical quality control practices had identified the severity of the problem, follow-up methods would be used for arriving at a proposal to correct the problem.

Stages The work was carried out in six stages: (1) use the NGT process to develop an element list of items thought to be contributory to pump rejects, (2) use the ISM process to construct a problematique, showing a hypothesized relationship among the problem elements, (3) use the Kepner-Tregoe™ decision analysis technique to decide which elements should be studied and attacked first, (4) gather data to support the proposed implementation sequence, (5) consolidate all the prior information to formulate the required plan, including estimates of impact on reduction of pump rejects, estimated cost, and estimated time to implement and (6) use the consolidated information to develop the recommendations to management.

Stage 1 Generate the element list. The task force, consisting of a product engineer, a manufacturing engineer, a quality control engineer, and a production supervisor were presented with the triggering question: "What elements are causing rejects on the pump test machines?"

The group produced a list of 25 problems shown in Table 12.

Stage 2 Construct the Problematique. The group used the ISM process to structure the 25 elements, using the generic question:

"Does problem A
contribute to the severity of
problem B?

Here A and B refer to any two members of the set of 25 elements Figure 3 shows the structure developed by this process. The structure is of the hybrid type, incorporating two cycles, one with 2 members, and one with 5 members. Members of a cycle negatively influence each other. The condensed structure is a hierarchy of length 8.

Stage 3 Decide which elements should be studied first. If the Problematique were used as the sole basis for deciding which elements should be attacked first, element 21 would be the first choice, element 20 would be the second choice, and so on, because the element 21 that has no incoming lines negatively influences many other elements, and the element 20 negatively influences many other elements, and so on.

However the extent to which any one element will influence other elements will depend not only on its position in the structure, but also on its intensity and the intensity of the relationship. Moreover, even if an element is very influential, it may involve great cost and a long time to correct. Thus the choice of a sequence should be based on criteria that go beyond simply what is shown in the Problematique, but which overtly take account of the interactions shown in the Problematique.

The team chose three decision criteria to apply in determining the sequence to be used to attack the problem elements. These were: impact on rejects, cost to implement, and time to implement. These three criteria were assigned weights of 10, 10, and 5 respectively. Application of these criteria produced a subset consisting of problems 13, 16, 17, 22, and 25. These problems are shaded in Figure 3. Note that four of these chosen problems lie in Stage 1 at the extreme left of the Problematique, while the other is in a cycle.

TABLE 12. LIST OF PROBLEMS THOUGHT TO CONTRIBUTE TO PUMP REJECTION
1. Stroke control valve not stable
2. Sticky pistons
3. Standby pressure setting
4. Piston bore wear
5. Machine controlled outpressure
6. Standby input power of the pump
7. Standby input power of the test machine
8. Contamination
9. Endplay adjustment
10. Pump shaft groove
11. Inlet oil temperature variation
12. Machine inlet pressure variation
13. Test specifications (tolerances)
14. Misalignment of bores on SCV housing
15. Seal drain flow in the pump
16. Valve leaks and/or line leaks in the machine
17. Program not sensitive to break-in
18. RPM variation
19. Auxiliary pressure control, servo control
20. Faulty electrical sensing equipment
21. No feedback from malfunction test stand components
22. Poorly seated stroke control valve
23. Seal drain flow in the test machine
24. Low pump efficiency
25. Out-of-calibration machine

Stage 4 Gather data. Data were gathered to support the proposed plans for implementation of the prioritized elements.

Stage 5 Consolidate the information to formulate the plan. All of the preceding work was applied to produce five proposals, one for each problem chosen in Step 3. Each proposal showed the estimated impact on pump reject reduction, estimated cost, and estimated time to implement.

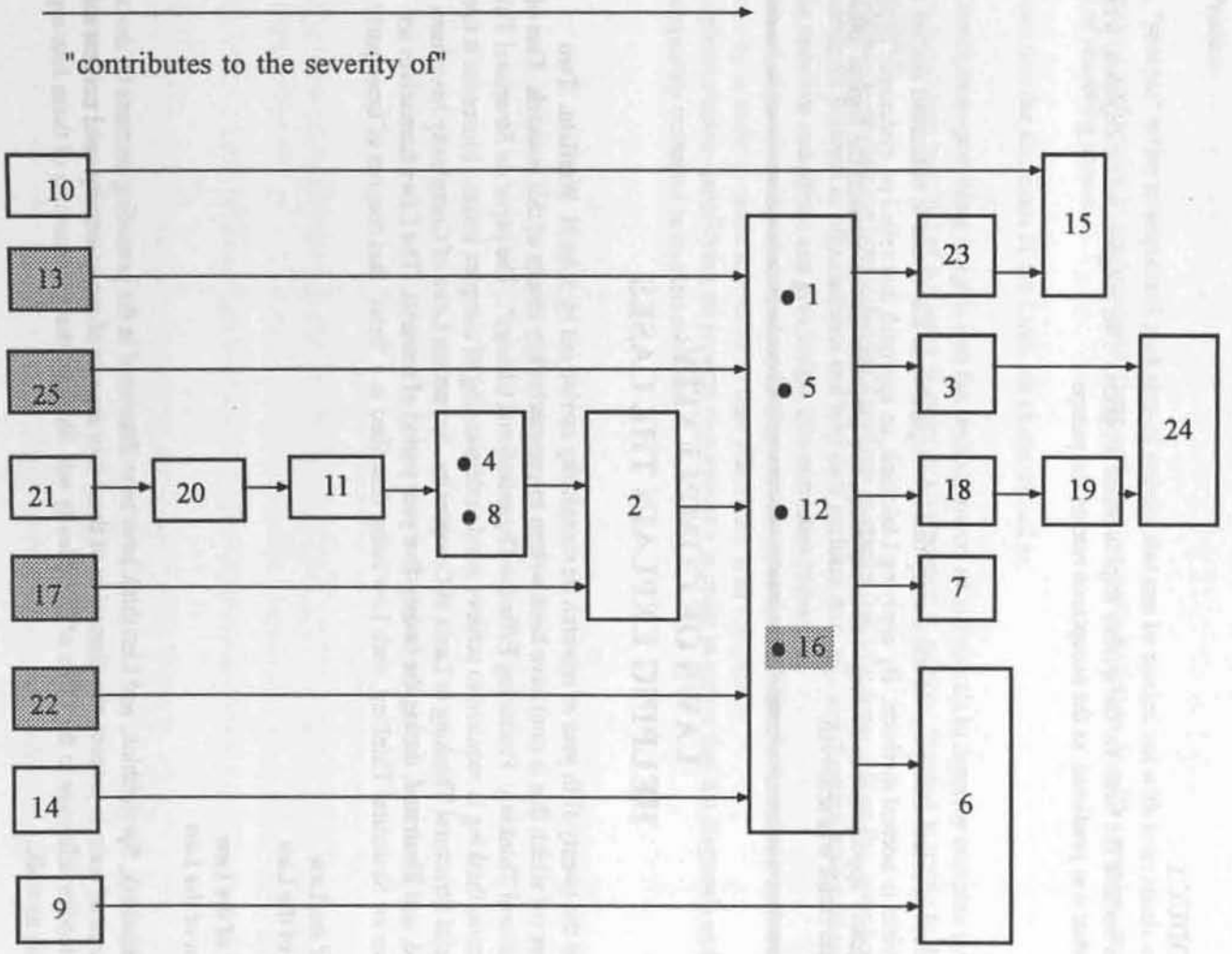

Figure 3. Problematique for John Deere pump manufacturing problem. Problem statements are represented by numbers. Shaded numbers correspond to the critical problem set, which formed the basis for resolving the pump problem. Details appear elsewhere (Warfield, 1994).

Stage 6 Develop recommendations to management. It was recommended that management approve **the parallel approach** to deal with the five high-priority problems. The analysis shows that if these five were pursued along the lines recommended, the acceptance rate could be raised from 49% to 87%. Management approved the recommendations.

Stage 7 Implement the recommendations Implement the recommendations that management approved and assess the outcomes.

USE OF THE PRODUCT

The recommendations became the basis for the quality improvement program. This program was completed, with results very close to what was predicted, as the acceptance rate on the pumps rose to 85%.

CONCLUSIONS.

The pump quality control problem incorporated complexity that is comparable to that found in numerous studies of problems that do not yield to normal methods. By applying Linkthink, an approach that relied on systematic application of design tools specifically appropriate to dealing with complexity, in a sequence that recognized the logical foundations of the issue, a favorable result was achieved.

LAWS OF COMPLEXITY: HELPING EXPLAIN THE CASES

The year 1993 marked the twenty-fifth year of research on complexity carried out by John N. Warfield. Two commemorative papers (of which this is one) have been written to summarize key results of this research. One of these papers is titled: "Structural Thinking: Producing Effective Organizational Change". The paper on Structural Thinking emphasizes that structural thinking is required to achieve good understanding of complex issues. Moreover it ties the conditions for successful Structural Thinking to Laws of Complexity. Seventeen Laws of Complexity have been discovered, articulated, and illustrated, during the twenty-five year period of research. The Laws themselves are aggregated in the paper on Structural Thinking, each Law being described in a "brief" that consists of these parts:

- The Name of the Law
- The Origins of the Law
- References
- A Statement of the Law
- Interpretation of the Law

While Groupthink, Clanthink, Spreadthink, and Linkthink have been illustrated in the preceding sections by describing cases where one or more of them is present, the discussion of these four aspects of group activity need not rest solely on empirical studies. Selective reference to the Laws of Complexity will illustrate that explanations of these four aspects have a theoretical basis as well.

The briefs given in the companion paper on Structural Thinking will not be repeated here. Instead an outline of the basis in the Laws for understanding the four aspects of group thinking will be given. The serious reader will want to study the companion paper for a more in-depth appreciation of this outline.

A CONTEXT FOR THE SEVENTEEN LAWS

Figure 4 provides a context for orienting the seventeen Laws of Complexity discovered so far. This Figure shows that each Law can be placed in one or more cells of a two-dimensional matrix. One dimension of this matrix provides the

"Focus" for the Laws. The other dimension provides a "Function" for the Laws.

It can be seen that the Laws are focused with respect to

- The Individual
- The Group
- The Organization
- Process

In this set, "process" refers to sequential packages of activity that can be carried out with individuals acting in groups, and with groups performing in organizations, these activities generally having to do with complex issues that require some kind of resolving action.

It can be seen that the functions of the Laws are characterized as:

- Description--providing insights into the limited powers of individuals to describe complex systems, and into the conditions required of a science in order to give support to persons engaged in trying to describe a complex situation
- Diagnosis--explaining how individuals perform in groups and why they perform this way; how top-level managers perform in organizations and why they perform this way; and showing how a science that satisfies the requisite conditions can give insight into corrective measures
- Prescription--showing what needs to be done to overcome the individual's limitations and to correct group activity in order to make it possible to deal effectively with complexity
- Implementation--amplifying on process requirements in order to assure that the diagnosis and interpretation are adequately managed in implementation

FOCUS→→→→→→ FUNCTION↓↓↓↓↓↓↓	INDIVIDUAL	GROUP	ORGANIZATION	PROCESS
DESCRIPTION	■ Limits ■ Triadic Compatibility	■ Limits ■ Uncorrelated Extremes	■ Limits ■ Organizational Linguistics	■ Limits ■ Triadic Necessity and Sufficiency ■ Universal Priors
DIAGNOSIS		■ Inherent Conflict ■ Structural Under-Conceptualization ■ Diverse Beliefs	■ Forced Substitution ■ Precluded Resolution	■ Success & Failure ■ Universal Priors
PRESCRIPTION	■ Requisite Parsimony ■ Requisite Saliency	■ Requisite Variety		
IMPLEMENTATION				■ Gradation ■ Validation

FIGURE 4. LAWS OF COMPLEXITY, STRUCTURED VERTICALLY BY FUNCTION AND HORIZONTALLY BY FOCUS

EXPLAINING SPREADTHINK

Spreadthink differs from the other three aspects of group activity being discussed in this paper. The distinguishing feature of Spreadthink is that it is always present in all group activity involving complex issues, if the group members are representative of the varied points of view pertaining to the complex issue. Moreover, its effects are always the same: to present to any oversight body that is hoping to receive recommendations for action on a complex issue a widely divergent set of viewpoints without any consensus on any of the components.

Spreadthink is a phenomenon that represents a short-hand version of two Laws of Generic Design:

- The Law of Inherent Conflict--which asserts that no matter what the complex issue and no matter what the group involved, there will always be significant conflict in interpreting what is important in resolving that issue
- The Law of Diverse Beliefs--which asserts that at the outset of an investigation of a complex issue, members of the group will have quite diverse beliefs about the issue

While Spreadthink is always present, what accounts for this phenomenon? These Laws help account for Spreadthink:

- The Law of Limits--which relates to the inability of any one individual to carry out the investigation and integration required to achieve, individually, without scientific assistance, a valid overview and in-depth understanding of a complex issue
- The Law of Organizational Linguistics--which relates to the inadequacy of organizational language to supply the conceptual terminology in which to couch a proper viewpoint of a complex issue
- The Law of Structural Underconceptualization--which explains why individuals and groups cannot properly structure complex issues when they are working in the normal group setting and environment
- The Law of Spurious Saliency--which asserts that people do not organize ideas well on the basis of relative saliency, this being borne out by the data showing how individuals vote on relative importance of ideas

(The concept of "spurious saliency" was set forth by Kenneth Boulding[126] as one of the three primary reasons for poor intellectual productivity.)

This set of six Laws of Complexity that help account for Spreadthink can be called the ***"Spreadthink Package"*** for purposes of later reference.

EXPLAINING GROUPTHINK

Two Laws of Complexity describe the situation facing a high-level executive who is under pressure to resolve a complex issue. These are:

- The Law of Forced Substitution--which asserts that in the absence of any carefully-formulated plan for resolving a complex issue, the executive will be forced to substitute for the actions that should have been taken those actions that appeal to the executive--forced, because an executive that does not take action in the face of prolonged organization-threatening complexity will not be retained by the oversight group, which has been conditioned to expect action (though without knowing what has to occurin order for the action taken to be successful)
- The Law of Precluded Resolution--which asserts that the effect of Forced Substitution will be to preclude resolution of the complex issue

Behind the Law of Precluded Resolution stands perhaps the most fundamental Law of Complexity:

- The Law of Requisite Variety--which asserts that to resolve a complex situation, one must systematically match the dimensionality of the proposed resolution with the dimensionality of the complex situation

and, since groups do not normally produce an appropriate description of the complex situation, in which the dimensions have been developed and clarified, the groups cannot satisfy this Law and, in fact, are precluded from coming close to satisfying it because of the immobilizing impact of un-neutralized Spreadthink.

The failure of groups to produce an appropriate description is incorporated in another Law:

- The Law of Structural Underconceptualization--which asserts that, in the absence of a methodology that is carefully tailored to assist groups in structuring a complex system or system concept, the system structure will be underconceptualized; that is to say that whatever organization of the system is produced by the group, it will be inadequate to describe it properly. The description will lack sufficient variety both in terms of the substantive aspects of the description and in terms of the structural variety.

The failure to produce an appropriate description reflects, at root, the inability of the human being to work mentally with a sizeable group of ideas and their interactions. This inability is described in another Law:

- The Law of Triadic Compatibility--which asserts that the individual can work mentally with three ideas and their interactions, but that the individual cannot work mentally with more than three.

Since complex issues or systems typically involve many more than three ideas, attempts to organize the structure of the issue or system in the absence of any methodology that takes account of and circumvents the impact of this Law are doomed to fail.

If several individuals produce structures, they will be quite different due to Spreadthink.

This package of five Laws of Complexity that help explain Groupthink emphasizes the idea that forces are at work that demand some form of action. Also it emphasizes the idea that, in the normal group situation, in the absence of carefully chosen methodology that enables these Laws to be circumvented, the product of group work will be defective, and any action taken on the basis of that product will be poorly conceived. Whether the actor acts on the basis of the group product or on the basis of the actor's own product is essentially irrelevant. The action taken will be poorly conceived, and it is unlikely to produce any resolution of the complex issue or situation.

For convenience in later discussion, this group of five Laws of Complexity can be called the ***"Groupthink Package"***.

Conditions are, then, very favorable for the onset of Groupthink for these reasons: (a) the executive is under pressure to get a decision on a course of action; (b) the members of the group are unable to come anywhere near to a consensus because of Spreadthink, (c) the members of the group are conditioned by experience not to "rock the boat" because they, too, want action, and they understand that the executive is at risk, and (d) they lack any understood way of overcoming the impact of Spreadthink and Groupthink.

EXPLAINING CLANTHINK

Clanthink has some features in common with Groupthink. However it differs most sharply from Groupthink as follows. With Groupthink, there is **no consensus within the group**, even though it appears that there is. With Clanthink, there is **consensus within the group** that involves some fundamental criteria and beliefs that are applied in reaching a proposed resolution; but this consensus is faulty, even though it may have been carried forward for decades or generations.

The Groupthink Package is at work in Clanthink, and for exactly the reasons mentioned in explaining Groupthink. Two more Laws of Complexity, appended to the Groupthink Package, help explain Clanthink.

Because Clanthink involves beliefs (assumptions, presuppositions, suppositions) that are incorrect, but widely held, a key Law of Complexity that relates to Clanthink is:

- The Law of Validation--which asserts that knowledge deserving of being broadly accepted must meet the criterion of scientific knowledge set forth by CharlesSanders Peirce: there must be a community of scholars at work constantly to test the validity of the belief.

The testing described here can go on for decades or centuries. What is important is that the social aspects of science, regarded as a joint venture of scholars in which each listens to and assesses critically the received doctrine, is a most critical aspect of scientific knowledge. If, instead of this ongoing validation, one substitutes "authority" as the basis for

belief, there is in place the basis for Clanthink, and it can only be dislodged by reverting to appropriate validation.

It is generally understood that final validation is an inappropriate concept. Validation is achieved by repeated efforts to test a concept, in a variety of ways, without discovering any way to invalidate the ideas. Inability to invalidate, when it occurs on a large scale, over a prolonged period of time, is the best that can be achieved to validate an idea, so to speak, through the "back door".

But as has been shown[127], scientific knowledge is impossible unless the science incorporates the "universal priors" as part of its foundation. This idea is seen in another Law:

- The Law of Universal Priors--which asserts that any science must account for four "universal priors", these being: the human being, the language, reasoning through relationships, and means of archival representation

Unless these four universal priors have been incorporated at the foundation of the belief that animates Clanthink, it is almost certain that the belief is defective; and it can only be corrected by returning to the foundations and incorporating these four universal priors in a way that forces other ideas to be dependent on and compatible with the way these priors are embedded in the foundations of the science. Since this is almost never done and, if done, is done accidentally rather than systematically, virtually all beliefs that are encompassed in Clanthink are suspect.

For purposes of later reference, the set of five Laws that make up the Groupthink Package, together with the two additional Laws identified in this section can be called the ***"Clanthink Package"***. It is notable that while there is substantial overlap between the Groupthink Package and the Clanthink Package, the two packages differ in terms of the way in which basic knowledge enters the group purview. In Groupthink, basic knowledge is not at issue, and the decision is reached without consensus. In Clanthink, basic knowledge is shared, and the decision is reached in the light of that shared knowledge, which is typically defective.

Before leaving the subject of Clanthink, it seems worth noting that the presence of validated consensus offers a powerful basis for decision making and for resolution of complex issues. The goal of achieving such a consensus is an important part of the prescription for avoiding the dysfunctional aspects of Groupthink and Clanthink in their typical forms.

SUMMARIZING THE RELATIONSHIPS

Table 13 summarizes the described relationships between Laws of Complexity and three aspects of group activity: Groupthink, Clanthink, and Spreadthink. An X in the Table means that there is a relationship between the Law shown at the left and the aspect shown at the top, and this relationship is one wherein the Law helps explain the aspect.

TABLE 13. SUMMARIZING DESCRIBED RELATIONSHIPS OF LAWS OF COMPLEXITY TO THREE ASPECTS OF GROUP ACTIVITY

LAW	ASPECT		
	GROUPTHINK	CLANTHINK	SPREADTHINK
DIVERSE BELIEFS			X
FORCED SUBSTITUTION	X	X	
GRADATION			
INHERENT CONFLICT			X
LIMITS			X

ORGANIZATIONAL LINGUISTICS			X
PRECLUDED RESOLUTION	X	X	
REQUISITE PARSIMONY			
REQUISITE SALIENCY			X
REQUISITE VARIETY	X	X	
STRUCTURAL UNDERCONCEPTU-ALIZATION.	X	X	X
SUCCESS & FAILURE			
TRIADIC COMPATIBILITY	X	X	
TRIADIC NECESSITY AND SUFFICIENCY			
UNCORRELATED EXTREMES			
UNIVERSAL PRIORS		X	
VALIDATION		X	

EXPLAINING LINKTHINK

In contrast to the explanation applied to Groupthink, Clanthink, and Spreadthink, in which the Laws were applied to help explain these observed phenomena; the explanation applied to Linkthink is intended to show that Linkthink is an outcome of a deliberate process design, in which the intention was to account for all of the undesirable aspects suggested by the Laws by providing a new process design that overcomes or avoids what otherwise would naturally occur.

This posture can be compared to the following. Suppose one said that there is a law that the human being cannot rise a mile above the earth, due to the effects of gravity. This was certainly a true statement, so far as we know, for most of the millennia of the human being on earth. It is still true today, as long as it is perceived in a context where inventions aimed at overcoming the limitations expressed in the law are prohibited. To overcome the limitations, the context must be changed through invention.

Some of the ways to change the context are to admit airplanes, gas-filled balloons, and rockets.

To overcome the undesirable impacts indicated by the Laws, a concept called Sigma-Five is introduced[128]. This concept refers to the integration of five factors: the participant group, a facilitating staff, a set of consensus methodologies, appropriate computer software, and a physical facility (room) that is equipped to provide the necessary visual support and comfort for prolonged intellectual work.

When this Sigma-Five concept is invoked, the context is dramatically changed, and virtually all of the dysfunctional aspects of group activity represented in the Laws of Complexity can be circumvented or overcome, as indicated in Table 14.

TABLE 14. RELATIONSHIP OF LAWS OF COMPLEXITY TO LINKTHINK	
LAW	**RELATIONSHIP**
DIVERSE BELIEFS	Linkthink involves the in-depth consideration of numerous questions, each of which is only a small part of the larger issue. The group answers to these questions produce a consensus structure which, when interpreted, produces consistent ideas that generally involve modification of the original diverse beliefs in the direction of consensus.
FORCED SUBSTITUTION	The application of IM to generate Linkthink produces coherent results that high-level decision-makers can interpret, and which make it unnecessary for those making the high-level decisions to construct decisions out of thin air that are unsupported by subordinates. Forced substitution occurs because management must substitute personal beliefs in the absence of coherent, systematic recommendations. When such recommendations become available through Linkthink, forced substitution is no longer required.
GRADATION	Because the application of IM produces results in great detail, it is usually possible to aggregate these detailed results in smaller packages, giving a gradation of interpretations, ranging from the most detailed to the most general; while preserving the linkages between the general and the highly detailed. This is very compatible with the idea of the hierarchical organization, in which different objectives are dealt with at different levels.
INHERENT CONFLICT	The inherent conflict is partly due to the inadequacy of the describing language and partly due to inadequate learning on the part of the participants. During the application of IM, the group automatically creates a new linguistic domain in the process of responding to the questions posed, helping to resolve the linguistic uncertainty. Also because the dialog is question-focused, there is a kind of Socratic learning that goes on which raises the level of understanding of all participants and, in the process eliminates much or all of the inherent conflict that was originally present.
LIMITS	The processes of IM are designed so that none of the known limits that impact on individuals and groups are breached by the processes. By operating within the bounds set by the limits, high-quality results are obtained.
ORGANIZATION-AL LINGUISTICS	Particularly when creative results are desired, there must be creative developments in the language as well as in the product conceptualization. These can best be obtained by focused dialog of the type engendered by IM. Moreover, it is possible by applying Linkthink to connect the high-level metaphors and categories used in organizations to the lower-level details, thus provided an often-missing consistency in the organizational linguistics.
PRECLUDED RESOLUTION	Since forced substitution is the usual cause of precluded resolution, when forced substitution is replaced with the products of Linkthink, the primary cause for precluded resolution is eliminated, allowing positive actions to proceed.
REQUISITE PARSIMONY	The processes of IM involve deliberate pacing that keeps the rate of flow of information slow enough to meet the information processing needs of the participants; thereby avoiding fast-paced activity that engenders uninformed decisions of the type characteristic of Groupthink and Clanthink.

REQUISITE SALIENCY	A specific process in the set of processes used with IM provides for the detailed study and discussion of relative saliency of components of a complex issue. In this way, the uninformed and undiscussed assessment of saliency that often characterizes bad decisions is replaced with a systematic development of relative saliency.
REQUISITE VARIETY	Selection of participants with a wide variety of backgrounds helps provide the requisite variety needed in the ideas and relationships. By using IM also to develop the dimensions of the situation as well as the dimensions of a prospective solution, dimensional matching is possible, satisfying this Law.
STRUCTURAL UNDERCONCEPT UALIZATION	IM provides the necessary detailed logic assistance to allow for the development of structures of the most general type, which is never available in ordinary group dialog and in most, if not all, of the decision-support systems presently advocated.
SUCCESS & FAILURE	The specific components of success become part of the Workshop Plan for IM activity, and the level of success that is likely is spelled out. This helps assure that vital components of success are not left out, and that the components required are all present.
TRIADIC COMPATIBILITY	By asking participants to compare component ideas in pairs, using two elements and one relationship, triadic capability is exploited, and participants are not required to engage in intellectual activity that exceeds the bounds of what is believed to be possible.
TRIADIC NECESSITY & SUFFICIENCY	This law tells us that we can deal with complexity by dealing at the level of triadic comparisons, thereby justifying the adherence to the Law of Triadic Compatibility.
UNCORRELATED EXTREMES	Each application of IM provides detailed illustration of this Law, thereby helping to convince participants and managers alike that the products of the Linkthink activity are appropriate for planning and decision-making.
UNIVERSAL PRIORS	All of the activity involving LInkthink through IM is based in the Science of Generic Design. The latter is specifically rooted in the universal priors.
VALIDATION	Validation relies on careful archiving and diligent adherence to experimental conditions. Since IM is self-documenting, and since the processes used are very well defined, contribution to validation is always possible when using Linkthink.

CONCLUSIONS: ORGANIZATIONAL DECISION-MAKING SHOULD UNDERGO RADICAL CHANGE

Organizational decision making, as currently practiced, should undergo radical change. Many organizations that may have been heavily oriented toward hierarchy are presently trying to invoke group judgment as a resource to help support organizational decision-making involving issues acknowledged to be complex. Yet both experience and scientific study show that there is much more to be considered when group activity is invoked to deal with complexity than most organizations seem prepared to recognize.

Spreadthink has been found to occur with every group convened to study a complex issue. Spreadthink means that people in the group have widely differing views of what is important. Spreadthink means that there is not even a majority view that any single problem is most important. Spreadthink assures that any overseeing executive will discover that group members do not agree on what is most important and cannot, therefore, propose a consensus program to the executive. Morever, there is no reason to believe that the executive can arrive at a proper course to follow, even when the group has produced "food for thought" for the executive. The executive is in the same position as the group member, being faced with a complex issue, and being part of the Spreadthink condition.

Some groups, recognizing that Spreadthink is present, fall vicitim to Groupthink. If a single point of view is to be recommended, the group will recommend it. However what appears to be a consensus point of view is neither a studied point of view nor a consensus point of view, but rather is a concession to the forces identified as part of Groupthink. The decision-making in regard to the Bay of Pigs incident illustrates beautifully the effects of Groupthink and the kind of aftermath that can ensue by allowing Groupthink to dominate action.

Even when groups are alerted to the problems of Groupthink, they fall victim to Clanthink: collective belief in incorrect information that has been sustained long enough to be taken as fact, even though there has never been any serious effort to determine its validity. Clanthink allows incorrect information to be taken as criteria for choosing a course of action. If the criteria are wrong, the course of action is likely to be wrong as well.

Every group is subject to Spreadthink and Clanthink, and some groups will be subject to Groupthink. All three of these phenomena can be observed in practice but can also be explained by certain Laws of Complexity, arrived at during a twenty-five year period of study of complexity.

Prolonged study and experimentation has shown that the effects of Groupthink, Clanthink, and Spreadthink can be circumvented and overcome by Linkthink. Linkthink introduces the practice of structural thinking into group deliberations, by means of a carefully designed system of management called Interactive Management (IM). This system is in its twelfth year of testing and application, and has been found effective in many locations involving many groups and many complex issues.

Given the combination of understanding of why group effort is immobilizing, falsely indicative, based in unsound beliefs, and given the experience that IM can circumvent and overcome these negative factors, it becomes clear that organizational decision-making involving complex issues cannot be sustained in its current status, and that it must begin to adopt the practices of IM in order to arrive at sound, understood, supportable decisions involving complex issues.

APPENDICES

A. DATA ON SPREADTHINK

Data on 43 Interactive Management sessions involving the use of the Nominal Group Technique have been published previously[129]. Table 15 is adapted from the previous publication, and is intended only to show how many ideas were "selected", i.e., chosen by individual members of groups as being in the top five according to relative importance.

TABLE 15. DATA ON NOMINAL GROUP TECHNIQUE APPLICATIONS

Case Number	Number of Ideas Generated	Number of Ideas Individually Selected	Selected Ideas as a Percent of Ideas Generated	Departure Ratio [Number of Selected Ideas Divided by 5]
1	56	28	50	5.6
2	67	35	52	7
3	68	36	53	7.2
4	42	20	48	4
5	48	31	65	6.2
6	79	36	46	7.2
7	54	26	48	5.2
8	59	46	78	9.2
9	64	40	63	8
10	101	43	43	8.6
11	50	28	56	5.6
12	84	55	65	11
13	92	67	73	13.4
14	58	29	50	5.8
15	36	24	67	4.8
16	47	31	66	6.2
17	49	29	59	5.8
18	43	21	49	4.2
19	96	44	46	8.8
20	64	48	75	9.6
21	71	48	68	9.6
22	52	35	67	7
23	57	30	53	6

24	37	19	51	3.8
25	56	35	63	7
26	74	45	61	9
27	80	44	55	8.8
28	45	22	49	4.4
29	127	34	27	6.8
30	51	26	51	5.2
31	58	40	69	8
32	93	34	37	6.8
33	82	35	43	7
34	44	26	59	5.2
35	36	23	64	4.6
36	78	32	41	6.4
37	67	37	55	7.4
38	67	29	43	5.8
39	58	26	45	5.2
40	57	24	42	4.8
41	66	28	42	5.6
42	58	30	52	6
43	90	32	36	6.4
AV-ERAGE	64	35	55	7

How does this Table support the concept of Spreadthink? First of all, look at the average values representing 43 sessions. With an average number of 64 ideas being generated, individual participants selected 35 of these ideas (55%) as being in the most important 5 ideas in the set of 64. If the members were in perfect accord on the most important ideas, each would have selected the same 5 (only 8%). We can use the last column in the Table to measure departure from unanimity. If all mem- bers had selected the same 5 ideas as the most important, the number in the last column would be 1. One can see that the average value for the last column is 7, showing that seven times as many ideas were selected by the individual members as would be found if the group were totally agreed on what were the most important ideas. There is a very large spread in points of view among members of the group, based solely on the average values.

If each individual row is inspected, it can be seen that the values shown in the last column range from a minimum of 3.8 to a maximum of 13.4. The value of 3.8 (Case 24) comes closest of all to showing unanimity of opinion, but even in that case the individual members chose 19 (over half) of the relatively small set of 37 members as lying in the top 5. For the value of 13.4 (Case 13) members had 92 ideas to choose from, and selected 67 of these (73%) as lying in the top 5!

Study of these data show that points of view are "spread all over the map", which is the basic idea of Spreadthink.

Notably, it is not terribly difficult for data of this type to be gathered and assessed independently. The Nominal Group Technique is used in many places for many purposes. One need only keep in mind that the above data represent work on complex issues, and that the steps up to and including the individual voting in the NGT need to be carefully followed to assure that methodological departures do not corrupt the data.

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