A COMPRESSED HISTORY OF

THE DEVELOPMENT OF:

- Interpretive Structural Modeling

- The Science of Complexity

- The Science of Generic Design

- Interactive Management

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CONTENTS

EXECUTIVE SUMMARY

Growth of Complexity. In the second half of the 20th century, American life has witnessed the growth of complexity in many systems. Political processes, long in place; corporate decision-making, following historical lines; and a system of higher education insensitive to the demands and unique characteristics of complexity, have all been unresponsive to the innate requirements to deal with complexity on its own terms.

Initiating a Research and Development Effort: A Threefold Aim. In the late 1960s, a research and development effort was begun at a time of extreme turmoil in American life, with the threefold aim of (a) studying complexity scientifically, (b) creating, testing, and upgrading a management support system: an integrated behavioral/technical process and a supporting process environment that could become a basis for working effectively with complexity in organizations and (c) ultimately moving this technology into the mainstream of American life in both government and corporate settings.

Significant Results. A program of research, development, and testing was carried out during the period 1968-1995, founded in the threefold aim. Three significant results of this program are: (a) the successful development of **the sought management support system** (a process), called Interactive Management, heavily documented in books, papers, application reports and videotapes of Interactive Management Workshops; (b) the development and publication of **a science of generic design**, which provides the conceptual foundation for the process; and (c) the **discovery of 17 Laws of Complexity**, which underpin both the science and the management process.

Extensive Testing. During the 27 years of its development, the management support system has been progressively tested in numerous settings, always in realistic settings on problems of urgency to the organization and individuals involved. The test or professional working sites have included, in approximate temporal order, Tata Consultancy Services, Hyderabad, India; the University of Queensland in Australia; several Japanese corporations; **the University of São Paulo in Brazil**; the U. S. Forest Service, Washington, D. C.; **the Southwest Fisheries Science Center, La Jolla, California; City University in London, United Kingdom**; the National Marine Fisheries Service, Washington, D. C., **the Defense Systems Management College, Fort Belvoir, Virginia**; the University of Hokkaido in Japan; Americans for Indian Opportunity in the United States; **the Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM), Mexico; CWA, Ltd., in Berwyn, Pennsylvania; the National Railroad Passenger Corporation ("AMTRAK"); Northern Telecom and the Bell Northern Research Company of Canada; the Ford Motor Company of Dearborn, Michigan**; the University of Humberside, Hull, United Kingdom; the Rapid Response Manufacturing Consortium operating under a project managed from the National Center for Manufacturing Sciences, Ann Arbor, Michigan; the **Center for Interactive Management, New Delhi, India**, and the U. S. Food and Drug Administration, Rockville, Maryland.

Transfer of the Technology. The Interactive Management technology has been successfully transferred to those organizations highlighted in the preceding list.

Outcomes. Among the outcomes of its application are: (a) the redesign of the defense acquisition system of the United States, followed by major changes to that system in the past few years (and incorporated into legislation by Congress as the "Federal Acquisition Streamlining Act of 1994"; (b) development within Ford Motor Company of new prototypical front-end approaches to new system design; (c) significant cultural change highly contributory to NAFTA occurring in Mexico, in AMTRAK, and in the Ford Motor Company; and (d) dramatic increases in system design productivity in many of the organizations involved.

Some of the Lessons Learned. Many lessons have been learned during this development. Many reflect **the importance of careful consideration of scale in determining how to manage complexity**. Other lessons reflect **the impact of role confusion in large organizations**, which creates major gaps in what ought to be integrated management practices. Still others relate to **the interpretation and value of IM products**.

Import for Higher Education. A major conclusion stemming from this work is that, **in the long run, higher education must become sensitive to the importance of scale, and modify its infrastructure to accommodate to the study of complexity**. Such a significant change apparently will not occur unless academic leaders become aware of the invasive nature of complexity in human life, and resolve to pay attention to it in their own institutions.

CONTRIBUTION	AREA OF CONTRIBUTION						
	ANALYSIS	APPLICA-TIONS	BEHA-VIOR	COURAGE	HISTORY OF THOUGHT	LAN-GUAGE	SYN-THESIS
First articulation of transitivity	Abelard	Abelard				Abelard	Abelard
Formal logic	2,3,4,6,14,16	6,16				Peirce	Peirce
Concept of variety in systems	Ashby	Ashby					Ashby
Detriments to intellectual productivity, incidence of public awareness	Boulding		Boulding		Boulding		
Philosophy of knowledge reconstruction	8,10,16	Foucault	Foucault		Foucault		Foucault
Concept of metalanguage	Hilbert	Hilbert				Hilbert	
Concept of situation room	Lasswell	Lasswell	Lasswell				
Philosophical overviews	2,6,8,15,16	3,11,13,14	5,13,15,16,17,18,19	9,12,16,17	5,7,14,16,19	2,6,11,14,16	3,7,10,16
Analysis of belief, semiotics	Peirce		Peirce	Peirce	Peirce	Peirce	
Summarizing in (verse and/or prose)	5,16,17,19	Whitehead	5,16,17	16,17	5,15,16	Peirce	Peirce
Problematic situation as base of study	Dewey						
Criticality of language	2,14,16					2,4,6,11,12,14,16,19	3,10,13,14,15,16
Practical humanism	5,18	Vickers	13,18				

COLLEAGUES OF INHERITANCE:

1 Pierre (Peter) Abelard
2 Aristotle
3 W. Ross Ashby
4 George Boole
5 Kenneth Boulding
6 Augustus DeMorgan
7 John Dewey
8 Michel Foucault
9 Galileo Galelei
10 J. Willard Gibbs
11 David Hilbert
12 Antoine Lavoisier
13 Harold Lasswell
14 Gottfried Leibniz
15 F. S. C. Northrop
16 Charles Sanders Peirce
17 Alexander Pope
18 Geoffrey Vickers
19 Alfred North Whitehead

NAME OF CONTRIBUTOR	NATURE OF CONTRIBUTION
Henry Alberts	Pioneering applications to the redesign of the U. S. Defense Acquisition System, and to the legislation that effected the redesign
R. F. Bales	Developing the concept of role distinctions and the observational classification of behavior in group settings
I. M. Bochenski	Publishing a scholarly overview of the history of formal logic
Benjamin Broome	Teaching Interactive Management (IM), training IM staff, conducting IM Workshops in many settings, and pursuing scholarly study of group work
Roxana Cárdenas	Co-authoring a textbook on IM, pioneering the application of IM in Mexico, teaching IM to faculty and staff in Mexico, and collaborating in offering short courses on the science of generic design and the application of IM
Alexander Christakis	Collaborating in the development of IM, pioneering its application in a variety of arenas, co-authoring work on dimensionality, and contributing to the proper use of language
Raymond Fitz	Leading the first computer-assisted application of Interpretive Structural Modeling (ISM), and pioneering its application to renovation of the African Sahel
Frank Harary	Publishing a scholarly work on structural modeling
B. L. T. Hedberg and his co-authors	Publishing a scholarly work on organizational change
F. Ross Janes	Pioneering the introduction, teaching, and application of IM in the United Kingdom
I. W. Janis	Publishing a scholarly work on dysfunctional group behavior
I. Kapelouzos	Publishing a scholarly work assessing the before-and-after aspects of the application of IM
J. L. LeMoigne	Clarifying the history of engineering education in France and the U. S. A., including the fateful choice of Auguste Comte as a model instead of Da Vinci
David Mackett	Pioneering the application of IM to problems of fishery-related industries and research
Robert McDonald	Pioneering the application of IM to forestry and to education
George A. Miller	Clarifying intellectual limitations caused by limited memory capability
Scott M. Staley	Pioneering the application and successful installation of IM in Ford Motor Company
B. W. Tuckman	Clarifying the major sequential aspects of ordinary group work
Robert J. Waller	Pioneering the application of IM, leading the first (non-computer-assisted) workshop on urban projects, and applying it to a variety of applications; and publishing enhancements to the theory
Rosamond Warfield	Helping in many areas, to free up John Warfield to carry on this work in the absence of adequate institutional support
James T. C. Wright	Pioneering the application of IM in Brazil to a variety of significant national and urban issues

Names of **direct collaborators** are highlighted. Other names are those of "colleagues-at-a-distance", i.e., who are believed to be living at the time of this writing.

MAJOR OPERATIONAL CONTRIBUTIONS, TIME PERIODS, AND RESULTS		
CONTRIBUTION	**TIME PERIOD INVOLVED**	**RESULTS**
Showing how to organize complex relationships through linked matrices	1970-1972	Two papers were published by Warfield and Warfield & Hill in 1972 showing how to organize complex relationships using a system of linked matrices. The system, called "Unified Program Planning", described in the open engineering literature, resurfaced 15 years later at Ford Motor Company, and was described in the Harvard Business Review, where it was called "Quality Function Deployment" or "The House of Quality" in a paper by Hauser and Clausing. It was stated in the paper that this was a Japanese development which they had discovered at the Mitsubishi Shipyards. It was in 1972 that Battelle (Warfield's employer) had signed an agreement to have Mitsubishi Corp. represent their contract research marketing in Japan. At that time Battelle provided Mitsubishi with recent research results coming from Warfield's work. Ford invested significantly in the development of QFD software for internal use. The same people who promoted it with Ford promoted it to many other U. S. industries. Surveys consistently have shown that this method is disliked by a majority of firms who have tried it. When I advised Ford and MIT (Clausing) that I had developed this system in 1970-72, and that I had recognized its deficiencies then, and had set about to correct them in the years from 1972-the present, Ford became interested, and contracted to bring Interactive Management to Ford. The Harvard Business Review, however, failed to publish any clarification concerning the Hauser/Clausing paper and, since the time when Warfield notified them of the discrepancy, several changes of editor have occurred. Since Clausing was notified of the discrepancy, he has examined the Warfield work and had a graduate student do an M. S. thesis on it at M. I. T., but he has never acknowledged in an appropriate forum the discrepancy, in spite of his many private comments about the high quality of the work.

Developing, Testing, and Upgrading Logic-Based Computer Software for Structuring Knowledge	1974-onward	Interpretive Structural Modeling (ISM) is a computer-based, facilitated process, that uses foundations of logical inference to help human facilitators facilitate groups to structure knowledge; i.e., to engage in organizing relationships among a complex set of elements. Warfield published the fundamental algorithms while at Battelle Columbus in 1974. The first ISM software was developed at Battelle in 1973-74, and first tested in an application at the Kettering Foundation in 1974, in a project on urban transportation in the Dayton, OH area. In the years from 1974-1987, many versions of ISM software were written in many locales, e.g., University of Dayton, IBM do Brasil (in Rio de Janeiro), IBM Headquarters (Armonk, NY), University of Virginia (Charlottesville), George Mason University (Fairfax, VA), University of Northern Iowa (Cedar Falls), City University (London, U. K.), Bell Northern Research (Ottawa, Canada for the MacIntosh™ line of Apple Computer), CWA (Berwyn, PA), Tata Consultancy Services (Bombay, India), and ITESM (Monterrey, Mexico, as NeXtStep software). Hundreds of applications are documented involving dozens of organizations coping with many complex subjects. The first DOS-based PC ISM Software was completed at George Mason University in 1987, and since then has been widely distributed. In 1994, the first Windows™ based ISM Software has been completed at George Mason University under Warfield's direction, and it has been successfully used in Interactive Management (IM) Workshops at Ford and at the Defense Systems Management College. It is currently being evaluated by the National Railroad Passenger Corporation and by the Jeffrey Group for use as a successor to the GMU DOS-based software they have used previously. It has been shown clearly by Kapelouzos that the ISM process yields major learning benefits to groups, producing in-depth knowledge about interactions among many factors involved in a complex situation, and replacing highly-dispersed points of view with near-consensus beliefs about how those factors interrelate. These results are consistently replicated, and have become the basis for some of the Laws of Complexity.
Developing, Testing, and Upgrading Logic-Based Computer Software for Structuring Knowledge (Continued)		The work on ISM was aggregated and placed in the context of the Systems Engineering Series in the Wiley Interscience publication of Warfield's 1976 book (commissioned by Battelle) called Societal Systems: Planning, Policy, and Complexity. In this book, Warfield recast the mathematics of Boolean Algebra, Sets, Binary Relations, Binary Matrices, Binary Matrix Models, Digraphs, Digraph Maps, and Digraph Models into compact forms most suitable for presenting the relevant theory of ISM. Following the mathematical chapters (Chapters 8-10), he was able to present the ISM theory and algorithms. (The Wiley book has since been translated into Chinese (1993), since ISM is being used in China in various governmental planning activities.) Further literature was published by Warfield in 1982, to recast the theory in a form that avoided matrices altogether, since some readers seemed to feel that they could work with all of the theory except matrix theory. Software developers have relied on the presentations in the 1976 book, along with related material incorporated in the "List of Selected Copyrighted Publications of John N. Warfield" given elsewhere in this document, to learn the ISM algorithms. Additional help has been provided by Professor Azuma Ohuchi, of the Department of Electrical Engineering at the University of Hokkaido, who has published ways of speeding up the software realization of the ISM algorithms, which were incorporated in the GMU DOS-based ISM software referred to above. (That software has been supplied to more than a dozen users, including Ford Motor Company and the Defense Systems Management College, since its development.)

Developing and testing a process (Interactive Management) for Managing Complexity Through System Design	1972-onward	The system of management of complexity, proposed for intermittent use to enable organizations to cope with the most complex issues confronting them, was given the name "Interactive Management" by Warfield at the University of Virginia in 1981, when he started the first Center for Interactive Management at that institution. Incorporated in this concept were the following developments produced by Warfield: Interpretive Structural Modeling (ISM), the Options Field/Options Profile Method, and the situation room given the name DEMOSOPHIA (which Warfield designed specifically to enhance the conduct of Interactive Management Workshops). Also incorporated were these developments produced by others: Ideawriting, Nominal Group Technique (NGT), DELPHI, and a form of Tradeoff Analysis developed for and used by the U. S. Forest Service. The collection of seven "consensus methodologies" was viewed as a sufficient set to be responsive to virtually all of the detractors identifed as making group work difficult or impossible, and to all of the enhancers required to assist participants in working effectively in a group setting.
Developing and testing a process (Interactive Management) for Managing Complexity Through System Design (Continued)	1972-onward	The Center for Interactive Management was moved in 1984 to George Mason University where it became part of the Institute of Information Technology directed by Warfield, and where an improved version of the DEMOSOPHIA facility was constructed. The Director of the new Center became Dr. Alexander Christakis, who had been Associate Director at the University of Virginia. During the period 1984-1988, this new Center found many sponsors and conducted many IM Workshops. It also hosted many visitors from abroad and elsewhere. Among the various sponsors was the Defense Systems Management College, which gradually began to develop its strong interest in Interactive Management (see below). Throughout the period, continued testing in on-line issues involving organizations was carried out, to evaluate the efficacy of the methods and the software, resulting in continuous improvement in many aspects of the system.
Developing and publishing a science of generic design	1972-onward	It was recognized by Warfield in 1972 that an ultimate goal of the project begun at Battelle would be a science of complex system design. It was also clear at that time that such a science would not have much value unless it were used to support the development of a technology for making major improvements in the ability of informed people to work together on issues involving complex systems. Contributions to this science slowly grew over the period from 1972 to 1990, including the experience gained in working with many groups through the Center for Interactive Management. All of this work was instrumental in making possible the publication in 1990 of the book by Warfield titled A Science of Generic Design: Managing Complexity Through Systems Design which was published in two volumes by Intersystems Publications of Salinas, CA.
Educating others in the generic design science and in the Interactive Management technology	1974-onward	Throughout the period of development discussed in the foregoing, educational activities were carried out by Warfield in both formal and informal settings. A table in this document identifies "practitioners", all of whom either studied directly with Warfield or with persons who studied the relevant materials with Warfield. Included in the relevant materials were the copyrighted publications by Warfield which appear elsewhere in this document.
Transferring the Interactive Management technology to various organizations	1978-onward	The IM technology was transferred to nine North American organizations (described herein), and to several international organizations also identified in this document. Warfield was personally involved in several of these transfers, but others were effected by persons who previously had learned IM from Warfield or from his publications.

ORGANIZATION	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94
1. Fisheries and Fish Packing Companies in California (35)	■	■	■	■	■	■	■	■	■	■	■	■
2. U. S. Defense Industries (60)					■	■	■	■	■	■	■	■
3. NAFTA-Related Mexican Organizations (12)							■	■	■	■	■	■
4. Christakis, Whitehouse and Associates (56)									■	■	■	■
5. Pharmaceutical Industry (e.g. Schering-Plough) (35)									■	■	■	■
6. National Railroad Passenger Corp. (AMTRAK) (8)									■	■	■	■
7. Northern Telecom (Bell Northern Research) (25)									■	■	■	■
8. Ford Motor Company (19)									■	■	■	■
9. Rapid Response Manufacturing Consortium (Ford, General Motors, Texas Instruments, and United Technologies Pratt & Whitney Division) (4)									■	■	■	■

NORTH AMERICAN ORGANIZATIONS INVOLVED IN INTERACTIVE MANAGEMENT ACTIVITY WITH DURATION IN YEARS OF ACTIVITY INDICATED BY BARS

(Estimated number of Interactive Management Workshops related to organization is shown in parentheses in first column).

NORTH AMERICAN ORGANIZATIONS INVOLVED IN INTERACTIVE MANAGEMENT ACTIVITY AND PERSONS DIRECTLY AND INDIRECTLY INVOLVED IN TRANSFERRING THE TECHNOLOGY

(Estimated number of I-M Workshops related to organization is shown in parentheses in first column). (CONTINUED, NEXT PAGE)

ORGANIZATION	INDIVIDUALS INVOLVED IN TRANSFERRING THE TECHNOLOGY
1. Fisheries and Fish Packing Companies in California (35)	National Marine Fisheries Service, Southwest Fisheries Science Center, Isadore Barrett, Director; David J. Mackett, Program Planning and Evaluation Officer. This organization installed Interactive Management beginning in 1983, and also installed a situation room following Warfield's room design, where it conducts Interactive Management Workshops. Both Barrett and Mackett have received federal awards for their work in this area, Barrett getting a $10,000 bonus and Mackett receiving the NOAA Administrator of the Year Award.
2. U. S. Defense Industries (60)	Professors Henry J. Albert and Stan Crognale of the Defense Systems Management College, along with several hundred Department of Defense Program Managers, and several industry representatives who, collectively, redesigned the Defense Acquisition System, which has produced major changes in that system. The results of their work, extending over several years, have been made available to the Under Secretary for Acquisition, and both the House and Senate Armed Services Committees, all of whom have used and continue to use these results in their own activities. One significant part of this work has to do with stabilizing the U. S. Industrial Base following the end of the Cold War, and creating collaborative activity among the U. S. Industrial Base and selected Canadian and Russian activities.
3. NAFTA-Related Mexican Organizations (12)	Professor Roxana Cárdenas of ITESM (Monterrey Campus) and the following Monterrey Campus colleagues: Andres Sotomayor, Carlos Villanueva, Carmen Moreno, Hector Moreira, Hector Rincon, Mary del Carmen Temblador, Alvaro Rico, Francisco Colorado, Sandra Garzon, and Sofia French; and the following branch campus people: (Leon Campus) Alberto Lenz, Carlos Flores, Eduardo Sojo, Reynaldo Treviño, Rosa Elena Moreno; (Chihuahua Branch Campus) Ann Carvajal, Leonel Guerra; (Ciudad Juarez Campus) Cristinia Salas-Porras; (Guadalajara Branch Campus (Alfredo Molina); (Mazatlan Branch Campus) Alejandro Cristerna. These individuals assist corporations that are involved in the NAFTA agreement, e.g, Quimica del Rey, and state planning agencies who are working with industries to develop competitive capabilities and to engage in trade with the NAFTA partners.
4. Christakis, Whitehouse and Associates (56)	Alexander Christakis and Robert J. Whitehouse, who have developed an Interactive Management consulting business following several years of Christakis' collaboration with Warfield in conducting Interactive Management Workshops at the University of Virginia and at George Mason University. Christakis has taken the lead in transferring this technology to U. S. pharmaceutical firms in the Philadelphia area. These firms, in turn, have provided the stimulus for the U. S. Food and Drug Administration to apply Interactive Management in complex matters involving potential cooperation between the pharmaceutical industries and the U. S. Food and Drug Administration on matters affecting new drug approval efficiency and timeliness.
5. Pharmaceutical Industry (e.g. Schering-Plough) (35)	Alexander Christakis and Robert J. Whitehouse have provided Interactive Management services to Schering-Plough and other organizations involved in pharmaceutical development.

6. National Railroad Passenger Corp. (AMTRAK) (8)	Mr. Kenneth J. McIlvoy, Senior Director, Systems Development, has taken the lead in the Interactive Management applications, after taking course work from Professor Benjamin Broome at George Mason University. Broome learned Interactive Management by his association with the Center for Interactive Management at George Mason University, and through specific tutoring from John Warfield. At AMTRAK, Interactive Management has supplanted various abortive Total Quality Management attempts, using methods that lacked adequate scientific foundation.
7. Northern Telecom (Bell Northern Research) (25)	At Bell Northern Research, Interactive Management methods were first applied by Dr. Cliff Saunders, and after his departure to start a management consulting firm, subsequently by Sylvia Laale and Prudence Craib, who do organization development work for the Lab Director. This work relates to NAFTA-related telecommunications trade involving the U. S. and Mexico, and incorporates activities being carried out in various U. S. components of Northern Telecom, including the Nashville office. The work relates mainly to improving software system design, and to the use of management support systems involving Interactive Management.
8. Ford Motor Company (19)	Interactive Management was brought to Ford through a collaboration between Dr. Scott M. Staley of the Ford Research Laboratory and Dr. John N. Warfield. Part of the intention was to replace Quality Function Deployment, introduced to Ford several years earlier by MIT and the American Supplier Institute. Over a 4-year period of sponsored work with Ford, the Interactive Management technology was transferred to Ford primarily through the work of John Warfield, with assistance from Professor Benjamin Broome of GMU and Professor Roxana Cárdenas of ITESM, Monterrey. (At ITESM, Roxana's Systems Engineering Department teaches Interactive Management and generic design to members of the Quality Center, which is partly sponsored by Ford, and which provides staff and training services related to quality control for several Ford plants in Mexico.) Ford's work involving Interactive Management has mainly been applied to large design-manufacture software systems development in areas such as: powertrain, climate control (air-conditioner hose design), product information management, and variant design.
9. Rapid Response Manufacturing Consortium (Ford, General Motors, Texas Instruments, United Technologies Pratt & Whitney Division) (4)	Work with the Consortium revolved primarily around variant design methods, and has included comparisons of member design practices with the general design process developed specifically for the RRM Consortium by John Warfield and Scott Staley. Sponsors within Ford have included Robert G. DeLosh (Powertrain Systems Engineering) and Peter Sferro (Alpha Manufacturing). The Project Monitor from the National Center for Manufacturing Sciences is Mr. William Waddell.

NORTH AMERICAN ORGANIZATIONS INVOLVED IN INTERACTIVE MANAGEMENT ACTIVITY AND PERSONS DIRECTLY AND INDIRECTLY INVOLVED IN TRANSFERRING THE TECHNOLOGY
(Estimated number of Interactive Management Workshops related to organization is shown in parentheses in first column).

ORGANIZATION	'76-'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94
Tata Consultancy Services, Hyderabad, India		■	■	■	■	■	■	■	■	■	■	
University of Queensland, Australia	■											
Fujitsu Corporation, Japan	■						?????					
Hitachi Corporation, Japan	■								?????			
Sony Corporation, Japan	■								?????			
University of São Paulo, Dept. of Administration, Brazil	■	■	■	■	■	■	■	■	■	■	■	
City University, London, England	■	■	■	■	■	■	■	■	■	■	■	
University of Hokkaido, Japan					■	■	■	■	■	■	■	■
Americans for Indian Opportunity, Bernallilo, New Mexico						■	■	■	■	■	■	
Instituto Tecnológico y de Estudios Superiores de Monterrey (Main Campus and many Branch Campuses), Mexico							■	■	■	■	■	
University of Humberside, Hull, England											■	
Centre for Interactive Management, New Delhi, India											■	

ORGANIZATIONS INVOLVED IN INTERACTIVE MANAGEMENT ACTIVITY WITH DURATION IN YEARS OF ACTIVITY INDICATED BY BARS

PRACTITIONERS OF INTERACTIVE MANAGEMENT (IM)

PRACTITIONER	PRACTITIONER'S ORGANIZATION	PRACTITIONER'S ROLE AND LOCATION
Surender K. Batra	Centre for Interactive Management	Centre Director, New Delhi, India
Benjamin Broome	George Mason University	Professor/Facilitator, Fairfax, VA, USA
Alexander N. Christakis Ali Geranmaye Robert Whitehouse	Christakis, Whitehouse, and Associates (CWA)	IM Consultants, Berwyn, PA, USA
Henry Alberts Stan Crognale Amy Rabuchin John Snoderly	Defense Systems Management College	Planner and Organizer of IM Workshops, Fort Belvoir, VA, USA
R. Keith Ellis	University of Humberside	Planner and Facilitator of IM Workshops, Hull, United Kingdom
Ken Hammer	City University	Planner and Facilitator of IM Workshops, London, United Kingdom
A. Roxana Cárdenas Francisco Colorado Sofia Frech Sandra Garzon Hector Moreira Carmen A. Moreno Alvaro Rico Hector Rincon Andres Sotomayor Mary del Carmen Temblador Carlos Villanueva	Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM), Main Campus (Monterrey)	Planner and Facilitator of IM Workshops in educational institutions, industry and government; teach generic design science and IM in higher education, Monterrey, México
Ana Carvajal Leonel Guerra	ITESM, Chihuahua Campus	Planner and Facilitator of IM Workshops, Chihuahua, México
Cristinia Salas-Porras	ITESM, Juarez Campus	Planner and Facilitator of IM Workshops Juarez, México
Alfredo Molina	ITESM, Guadalajara Campus	Planner and Facilitator of IM Workshops Guadalajara, México
Carlos Flores Alberto Lenz Rosa Elena Moreno Eduardo Sojo Reynaldo Treviño	ITESM, Leon Campus	Planner and Facilitator of IM Workshops Leon, México
Alejandro Cristerna	ITESM, Mazatlan Campus	Planner and Facilitator of IM Workshops Mazatlan, México
Ross Janes	City University	Center Director, Plans and Conducts IM Workshops, London, U. K.
Carol Jeffrey	The Jeffrey Group	Plans and Conducts IM Workshops, Woodbridge, VA, USA

PRACTITIONERS OF INTERACTIVE MANAGEMENT (IM)
(continued)

PRACTITIONER	PRACTITIONER'S ORGANIZATION	PRACTITIONER'S ROLE AND LOCATION
David Keever	Science Applications International, Inc.	Plans and Conducts IM Workshops, McLean, VA, USA
David Mackett	National Marine Fisheries Service Southwest Fisheries Science Center	Plans and Conducts IM Workshops La Jolla, CA, USA
Robert McDonald	Flordia Division of Forestry	Plans and Conducts IM Workshops Tallahassee, FLA, USA
Kenneth McIlvoy	National Railroad Passenger Corp. (AMTRAK)	Plans and Conducts IM Workshops Washington, D. C., USA
Scott M. Staley	Ford Motor Company, Ford Research Laboratory	Plans and Conducts IM Workshops, Dearborn, MI, USA
James T. C. Wright	University of São Paulo, Department of Administration	Plans and Conducts IM Workshops, São Paulo, Brazil

LIST OF SELECTED COPYRIGHTED PUBLICATIONS
OF JOHN N. WARFIELD

A. PUBLICATIONS RELATED TO
INTERPRETIVE STRUCTURAL MODELING

1973   Warfield, J. N., **"Constructing Operational Value Systems for Proposed Two-Unit Coalitions"**, Proceedings 1973 IEEE Conference on Decision and Control, 204-213.

1973   Warfield, J. N., **"On Arranging Elements of a Hierarchy in Graphic Form"**, IEEE Transactions on Systems, Man, and Cybernetics, March, 121-132.

1973   Warfield, J. N., **"Binary Matrices in Systems Modeling"**, IEEE Transactions on Systems, Man, and Cybernetics, September, 441-449.

1974   Warfield, J. N., **"Developing Subsystem Matrices in Structural Modeling"**, IEEE Transactions on Systems, Man, and Cybernetics, January, 74-80.

1974   Warfield, J. N., **"Developing Interconnection Matrices in Structural Modeling"**, IEEE Transactions on Systems, Man, and Cybernetics, January, 81-87.

1974   Warfield, J. N., **"Toward Interpretation of Complex Structural Models"**, IEEE Transactions on Systems, Man, and Cybernetics, September, 405-417.

1974   Warfield, J. N., **"An Interim Look at Uses of Interpretive Structural Modeling"**, Research Futures, Third Quarter.

1974   El Mokadem, Ahmed, J. N. Warfield, D. Pollick, and K. Kawamura, **"Modularization of Large Econometric Models: An Application of Structural Modeling"**, Proceedings of the 1974 IEEE Conference on Decision and Control, November, 683-692.

1975   Warfield, J. N., **"Transitive Interconnection of Transitive Structures"**, Proceedings of the 6th Pittsburgh Conference on Modeling and Simulation, Pittsburgh: Instrument Society of America, April.

1976   Warfield, J. N., **"Implication Structures for System Interconnection Matrices"**, IEEE Transactions on Systems, Man, and Cybernetics, January, 18-24.

1976, 1989, 1993 Warfield, J. N., **Societal Systems: Planning, Policy, and Complexity**, New York: Wiley Interscience, [reprinted in paperback--Salinas, CA: Intersystems, 1989] [Chinese translation published in 1993, directed by Professor Zhang Bihui, Chairman of the Wuhan Science and Technology Commission, and Director of The Administrative Office of Wuhan East Lake High

Technology Development Zone; publisher is the Hubei Science and Technology Press, Wuhan, Hubei Province, China]

1976   Warfield, J. N., "**Extending Interpretive Structural Modeling**", Proceedings of the Pittsburgh Conference on Modeling and Simulation, Pittsburgh: Instrument Society of America, 1163-1167.

1976   Fertig, J.A., and J. N. Warfield, "**Relations and Decision Making**", Proceedings of the Pittsburgh Conference on Modeling and Simulation, Pittsburgh: Instrument Society of America, 1177-1181.

1980   Warfield, J. N., "**Complementary Relations and Map Reading**", IEEE Transactions on Systems, Man, and Cybernetics, June, 285-291.

1980   Warfield, J. N., "**Priority Structures**", IEEE Transactions on Systems, Man, and Cybernetics, October, 642-645.

1982   Warfield, J. N., "**Interpretive Structural Modeling**", Chapter 5 in Group Planning and Problem-Solving Methods in Engineering (S. A. Olsen, Ed.), New York: Wiley, 155-201.

1987   Warfield, J. N., "**Interpretive Structural Modeling**", in Systems and Control Encyclopedia, Oxford: Pergamon Press.

1980, 1990   Warfield, J. N., **Annotated Bibliography: Interpretive Structural Modeling and Related Work**, Fairfax, VA: IASIS, 131 pages (first edition was made available by the Department of Electrical Engineering at the University of Virginia in 1980).

B. PUBLICATIONS RELATED TO INTERACTIVE MANAGEMENT

1957   Warfield, J. N., "**How to Improve Systems Engineering**", Aeronautical Engineering Review, 16(7), July, 50-51.

1971   Warfield, J. N. and J. D. Hill, "**The DELTA Chart: A Method for R&D Project Portrayal**", IEEE Transactions on Engineering Management EM-18(4), November, 132-139.

1972   Warfield, J. N. and J. D. Hill, et al, **A Unified Systems Engineering Concept**, Columbus: Battelle Memorial Institute, Monograph Number One, June.

1972   Warfield, J. N., "**Participative Methodology for Public System Planning**", Proceedings of an International Symposium on Systems Engineering and Analysis, West Lafayette: Purdue University, October, 23-40 . [reprinted in Computers and Electrical Engineering 1(1), 1973, 187-210, by invitation of the Editor]

1972   Hill, J. D. and J. N. Warfield, "**Unified Program Planning**", IEEE Transactions on Systems, Man, and Cybernetics, SMC2(5), November, 610-621.

1973   Warfield, J. N., **"Intent Structures"**, <u>IEEE Transactions on Systems, Man, and Cybernetics</u>, March, 133-140.

1975   Warfield, J. N., **Improving Behavior in Policymaking**, Approaches to Problem Solving, No. 1, Columbus: Academy for Contemporary Problems, August.

1975   Warfield, J. N., **Totos: Improving Group Problem-Solving**, Approaches to Problem Solving, No. 2, Columbus: Academy for Contemporary Problems, August.

1975   Warfield, J. N., H. Geschka, and R. Hamilton, **Methods of Idea Management, Approaches to Problem Solving**, No. 4, Columbus: Academy for Contemporary Problems, August.

1982   Warfield, J. N., **"Organizations and Systems Learning"**, <u>General Systems</u>, 27, 5-74.

1983   Warfield, J. N., **"Principles of Interactive Management"**, <u>Proc. International Conference on Cybernetics and Society</u>, New York: IEEE, January, 746-750.

1984   Warfield, J. N., **"Progress in Interactive Management"**, <u>Proc. 6th International Congress of the World Organization of General Systems and Cybernetics,</u> Paris: AFCET, XXIX-XXXV.

1990   Warfield, J. N., **"Widely-Ignored Subtleties That Are Critical to Decision-Making"**, in <u>Multiple Criteria Decision Making -- Proceedings of the Ninth Multicriteria Decision-Making Conference: Theory and Applications in Business, Industry, and Government,</u> (Edited by Ambrose Goicoechea, Lucien Duckstein, and Stanley Zionts), [conference held at George Mason University, August, 1990], pp. 449-457.

1994 Warfield, J. N., and A. Roxana Cárdenas, **A Handbook of Interactive Management**, Ames, IA: The Iowa State University Press.

1990, 1994 Warfield, J. N., **A Science of Generic Design: Managing Complexity Through Systems Design**, 1st Ed., Salinas, CA: Intersystems; 2nd Ed., Ames, IA: The Iowa State University Press.

C. PUBLICATIONS RELATED TO THE SCIENCE OF GENERIC DESIGN

1983   Warfield, J. N., **"Selecting Participation Methodologies for Systems Design"**, <u>Proc. International Conference on Cybernetics and Society</u>, New York: IEEE, January, 762-764.

1985   Warfield, J. N., **"On the Choice of Frames for Systems Studies"**, <u>Proc. Society for General Systems Research</u>, Seaside, CA: Intersystems, (1), 294-299.

1985   Warfield, J. N., **"Developing a Design Culture in Higher Education"**, <u>Proc. Society for General Systems Research</u>, Seaside, CA: Intersystems, (2), 725-729.

1986   Warfield, J. N., **"Education in Generic Design"**, <u>Proc. Society for General Systems Research,</u> Salinas, CA: Intersystems, I, H22-H33.

1986   Warfield, J. N., **"The Domain of Science Model: Evolution and Design"**, <u>Proc. Society for General Systems Research</u>, Salinas, CA: Intersystems, I, H46-H59.

1986   Warfield, J. N., **"Dimensionality"**, <u>Proc. 1986 International Conference on Systems, Man, and Cybernetics, 2</u>, New York: IEEE, 1118-1121.

1987   Warfield, J. N., and A. N. Christakis, **"Dimensionality"**, <u>Systems Research</u> 4(2), 127-137.

1987   Warfield, J. N., **"Implications of Scale for Systems Design"**, <u>Proc. Society for General Systems Research</u>, Budapest: SGSR, 1205-1211.

1987   Warfield, J. N., **"What Disciplines Large-Scale Systems Design?"** <u>Proc. 1987 Conference on Planning and Design in Management of Business and Organizations</u> (P. C. Nutt, Ed.), New York: American Society of Mechanical Engineers, 1-8.

1987   Warfield, J. N., **"A Complexity Metric for High-Level Software Languages"**, <u>Proc. International Conference on Systems, Man, and Cybernetics</u>, New York: IEEE, October, 438-442.

1987   Warfield, J. N., **"Developing a Design Culture in Higher Education"**, <u>General Systems</u>, XXX, 63-68 (reprinted from the 1985 conference version).

1988   Warfield, J. N., **"On the Design of Language for Systems Design"**, <u>Cybernetics and Systems '88, Proc. 9th European Meeting on Cybernetics and Systems Research</u> (R. Trappl, Ed.), Dordrecht: Kluwer, 133-140.

1988   Warfield, J. N., **"Criteria for a Science of Design"**, <u>Proc. 19th Annual Pittsburgh Conference on Modeling and Simulation</u>, Research Triangle Park: Instrument Society of America, 643-646.

1988   Warfield, J. N., **"Implicit Aspects of Much Systems Thinking"**, <u>Systems Research</u> 5(4), 333-342.

1989   Warfield, J. N., **"Design Science: Experience in Teaching Large System Design"**, <u>Proceedings of the Annual Meeting of the American Society for Engineering Education</u>, June, 39-41.

1990   Warfield, J. N., **"A Course in Generic Design for Engineers"**, <u>Projektowanie i Systemy</u> XI, 26-43 (in Polish).

1990   Warfield, J. N., **"Generic Planning: Research Results and Applications"**, in <u>Managing Knowledge for Design, Planning, and Decision Making</u> (W. F. Schut and C. W. W. van Lohuizen, Eds.), Delft: Delft University Press, 109-128 and in <u>Knowledge in Society</u> 3(4), Special Issue, Winter, 1990-91, 91-113.

1990   Warfield, J. N., "**Thinking About Systems**", Editorial in <u>Systems Research </u>4(4), 227-234, reprinted in <u>General Systems</u>.

1990   Warfield, J. N., <u>**Annotated Bibliography: Generic Systems Design and Interactive Management**</u>, Fairfax, VA: IASIS, 141 pp.

1992   Warfield, J. N., "**Design and Manufacturing Methodologies: A Comparison of American and Japanese Developments**", Working Paper Number 92-9, The Institute of Public Policy, George Mason University (62 pages), 1992

1992   Warfield, J. N., "**Dwie postawy projektowania**" ("**Dual-Basis Design**) (in Polish), <u>Prakseololgia</u> 1-2(114-115), 43-58.

1990, 1994 Warfield, J. N., <u>**A Science of Generic Design: Managing Complexity Through Systems Design**</u>, 1st Ed., Salinas, CA: Intersystems; 2nd Ed., Ames, IA: The Iowa State University Press.

D. PUBLICATIONS PRIMARILY ON COMPLEXITY

1973   Warfield, J. N., <u>**An Assault on Complexity**</u>, Columbus: Battelle Memorial Institute, Monograph No. 3, April.

1974   Warfield, J. N., <u>**Structuring Complex Systems**</u>, Columbus: Battelle Memorial Institute Monograph No. 4, April.

1975   Warfield, J. N., "**Profiles of Metapolicy**", <u>Proceedings of the 1975 Conference on Cybernetics and Society</u>, September, 114 ff.

1977   Warfield, J. N., "**Crossing Theory and Hierarchy Mapping**", <u>IEEE Transactions on Systems, Man, and Cybernetics</u>, July, 502-523.

1978   Warfield, J. N., "**Notes on Conceptual Science**", <u>IEEE Transactions on Systems, Man, and Cybernetics</u>, October, 744-745.

1979   Warfield, J. N., "**Some Principles of Knowledge Organization**", <u>IEEE Transactions on Systems, Man, and Cybernetics</u>, June, 317-325.

1979   Warfield, J. N., "**The Interface Between Models and Policymakers**", <u>Journal of Policy Analysis and Information Systems</u>, 3(1), June, 53-64.

1980   Warfield, J. N., "**Science and Systems Science: A Technology Perspective**", <u>Proc. Society for General Systems Research </u>, January, 212-218.

1980   Warfield, J. N., "**Modeling Management**", <u>IEEE Transactions on Systems, Man, and Cybernetics</u>, April, page 197.

1981   Warfield, J. N., "**Learning Through Model Building**", in <u>Computer-Assisted Analysis and Model Simplification</u> (H. J. Greenberg and J. Maybee, Eds.), New York: Academic Press, 69-78.

1985   Warfield, J. N., "**Structural Analysis of a Computer Language**", <u>Proc. 17th Annual Southeastern Symposium on Systems Theory</u>, New York: IEEE, 229-234.

1986   Warfield, J. N., "**Micromathematics and Macromathematics**", <u>Proc. 1986 International Conference on Systems, Man, and Cybernetics</u> 2, New York: IEEE, 1127-1131.

1988   Warfield, J. N., "**The Magical Number Three--Plus or Minus Zero**", <u>Cybernetics and Systems</u> 19, 339-358.

1988   Ohuchi, A., I. Kaji, and J. N. Warfield, "**Structural Analysis and a Complexity Metric for High-Level Software Languages**", <u>1988 Proceedings of the Conference of the Japan Information Processing Society</u>, 646-647 (in Japanese).

1989   Warfield, J. N., "**Underconceptualization**", <u>Proceedings of the Conference on Support, Society, and Culture: Mutual Uses of Cybernetics and Science</u> (G. De Zeeuw and R. Glanville, Eds.), Univ. of Amsterdam, March, 15-39 (see 1991 for formal publication).

1989   Warfield, J. N., "**Artificial Philosophy and the Decline of Technology**", <u>Simposio Internação de Communição, Significão e Conhecimento</u>, Seccão I, Set. 13/15, Lisbon, Portugal.

1990   Warfield, J. N., "**Presuppositions**", in <u>Cybernetics and Systems '90</u>, (R. Trappl, Ed.), Singapore: World Scientific, 213-219.

1991   Warfield, J. N., "**Complexity and Cognitive Equilibium: Experimental Results and Their Implications**", <u>Human Systems Management 10(3)</u>, 195-202.

1991   Warfield, J. N., "**Underconceptualization**", in <u>Mutual Uses of Cybernetics and Science,</u> Special issue of Systemica: Journal of the Dutch Systems Group (R. Glanville and G. de Zeeuw, Eds.), Amsterdam: Thesis Publishers, 415-433.

1993   Warfield, J. N., "**Structural Thinking: Producing Effective Organizational Change**", a Silver Anniversary Paper, commemorating 25 years of research on complexity by the author, Fairfax, VA: IASIS, 65 pages.

1993   Warfield, J. N., and Carol Teigen, "**Groupthink, Clanthink, Spreadthink, and Linkthink: Decision-Making on Complex Issues in Organizations**", Fairfax, VA: IASIS, 68 pages.

1993   Warfield, J. N., "**Complexity and Cognitive Equilibrium: Experimental Results and Their Implications**", Chapter 5 in Dennis J. D. Sandole and Hugo van der Merwe (Eds.): <u>Conflict Resolution Theory and Practice: Integration and Application,</u> New York: University of Manchester Press, pages 65-77.

1994   Warfield, J. N., **The IASIS File: A Bibliography of Books and Papers Relevant to Complexity, Organizations, and Design**, Fairfax, VA: IASIS.

1995 Warfield, J. N., "**Spreadthink: Explaining Ineffective Groups**", Systems Research 12(1), 5-14.

1995 Warfield, J. N., "**A Course in Generic Design for Engineers**", a chapter in the following book. Arne Collen and Wojciech W. Gasparski (Eds.), **Design and Systems: General Applications of Methodology**, New Brunswick, NJ: Transaction Publishers, 415-437.

1995 Warfield, J. N., "**Demands Imposed on Systems Science by Complexity**", Proceedings of the United Kingdom Systems Society 4th International Conference: Critical Issues in Systems Theory and Practice, Hull, United Kingdom, July, (Keith Ellis, Amanda Gregory, Bridget Mears-Young, and Gillian Ragsdell, Editors), 81-88.

1996 Warfield, J. N., and S. M. Staley: "**Structural Thinking: Organizing Complexity Through Disciplined Activity**", Systems Research 13(1), March, *to appear*.

Submitted to: Systems Research, July 13, 1994,

Scott M. Staley and John N. Warfield, "**Case Study in Conflict Management in Concurrent Engineering: Ford Motor Company Experience**"

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He has 38 years of university faculty service, of which the past 12 years have been at GMU. He has spent a total of 20 years as a faculty member in Virginia, and during that time has had the designation "eminent scholar" in the Virginia system. He has about 10 years of industrial experience: Director of Research, Wilcox Electric Company (1965-66); Senior Research Leader, Battelle Memorial Institute (1968-74); Senior Manager, Burroughs Corporation, (1983-84). This experience included research of both theoretical and experimental nature, electronic development and reliability testing of navigational equipment for jet aircraft, and management experience in overseeing research projects and industry-university contracts.

He has served as elected President of the Systems, Man, and Cybernetics Society of the Institute of Electrical and Electronics Engineers, and is a Life Fellow of that organization. He has served as elected President of the Society for General Systems Research (later renamed the International Society of Systems Sciences). He served 9 years as founding editor of Systems Research and four years as editor of the IEEE Transactions on Systems, Man, and Cybernetics.

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