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THE NIST SIMA INTERACTIVE MANAGEMENT WORKSHOP

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AND TECHNOLOGY
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SYSTEMS INTEGRATION FOR MANUFACTURING APPLICATIONS
INTERACTIVE MANAGEMENT WORKSHOP

EXECUTIVE SUMMARY

The *extended enterprise* is widely recognized as the competitive engine of the future. This vision identifies the competitive advantage of large and small firms coming together quickly to design, produce and market new, innovative products. Today many industries are realizing a competitive advantage by relying on the talents and capabilities of their suppliers. Further progress can only be made if we learn to organize supply chains into efficient design and production teams and to extend state-of-the-art business practices to supply chains. New technologies, standards and business practices that support design and manufacturing activities within and between firms are critical needs. Advances in systems integration for manufacturing are needed now as U.S. firms transition to agile manufacturing to meet global challenges. The challenge of accomplishing systems integration for manufacturing was addressed during an interactive management workshop in Fort Belvoir, Virginia.

Twenty-seven representatives from the National Institute of Standards and Technology (NIST) Systems Integration for Manufacturing Applications (SIMA) program, industry and other government program representatives came together at the Defense Systems Management College (DSMC) to discuss integration of manufacturing applications needs and research opportunities concerning the development of the SIMA program. Industry representatives included General Motors, Boeing, IBM, General Electric, SEMATECH, CAM-I, Industrial Technology Institute, Software Engineering Institute, and the National Center for Manufacturing Sciences. These organizations presently have programs in manufacturing and are working with the Manufacturing Systems Integration Division (MSID), at NIST, at some level. Other Government program representatives included the Advanced Research Projects Agency (ARPA), the DOE Technologies Enabling Agile Manufacturing Program (TEAM), and the Joint Center on Integrated Product Data Environment.

The major success of the workshop was that it brought together representatives from industry and government programs in the area of manufacturing systems integration to define actions for the SIMA program and identify leveraging opportunities between SIMA and other programs.

The workshop opened with a presentation by Mr. Mark Luce, SIMA Program Manager. Mr. Luce presented a SIMA background summary and the SIMA program goals and objectives to the group of participants. Workshop participants were also briefed on the following programs:

- Advanced Research Projects Agency (ARPA), Dr. Pradeep Khosla
- National Industrial Information Infrastructure (NIII), Mr. Richard Bolton
- Technologies Enabling Agile Manufacturing (TEAM), Mr. Richard Neal
- NIST National Advanced Manufacturing Testbed (NAMT), Dr. Merrill Hessel

After these background presentations were given, an overview of the Interactive Management (IM) Workshop process was provided, and the first step of the process, problem identification stage was initiated. The group identified seventy-four problem statements in response to the first focus question below.

1. In the context of advancing information technology for manufacturing systems and improving the effectiveness of the set of related programs, what are the critical problems that need to be addressed?

These problem statements were then grouped into eight categories: *Standards Process, Industry Adoption, Technical Strategy, Program Management, Vendor Commercialization, Requirements, Metrics,* and *Security.*

Through a pair-wise comparison process, the participants were asked if the problems in each category significantly aggravated the problems in other categories. The resulting Problem Structure explains the relationship between the problem categories. The Problem Structure revealed that problems in the category *Requirements* significantly aggravated problems in the categories *Technical Strategy*, *Program Management* and *Metrics*. *Technical Strategy* and *Program Management* occur in a cycle. Furthermore, statements in the categories *Technical Strategy*, *Program Management* and *Metrics* significantly aggravate statements in the categories *Standards Process*, *Industry Adoption* and *Vendor Commercialization*. Statements in these categories also occur in a cycle and should be addressed concurrently. The problem category *Security* does not significantly aggravate any other categories as defined.

After analyzing the Problem Structure, the participants addressed the second focus question below by identifying sixty-seven action statements which would help to overcome the problems.

2. In the context of advancing information technology for manufacturing systems and improving the effectiveness of the set of related programs, what are the actions that would overcome these problems?

These action statements were grouped into nine action categories: *Identify Requirements , Define Manufacturing Systems Integration (MSI) Strategy, Execute Technical Elements, Coordinate Programs, Define Technical Performance Metrics, Improve Standards Process, Promote Industry Adoption: Technical Activities, Promote Industry Adoption: Organizational and Management Activities,* and *Promote Vendor Commercialization.*

Through a pair-wise voting process, it was determined that performing those actions in the categories *Identify Requirements* and *Define MSI Strategy* would make it easier to accomplish those actions in the categories of *Coordinate Programs* and *Define Technical Performance Metrics,* which cycle each other. Furthermore, performing those actions in the categories *Improve Standards Process* and *Execute Technical Elements* would make it easier to accomplish those actions in the remaining categories of *Promote Industry Adoption: Technical Activities, Promote Industry Adoption: Organizational and Management Activities,* and *Promote Vendor*

Commercialization. These action categories also cycle each other and should be performed simultaneously.

The participants reviewed the results of the Action Structure to determine actions necessary to initiate identification of program goals. Because the Action Structure was generated via consensus decision making, ownership of the results was claimed by all participants, who indicated a willingness to continue the process. Through group consensus, the need to facilitate the development of a common set of requirements for integration of manufacturing software applications involving end-users, vendors, and systems integrators was identified as the most important action. As these actions are successfully implemented, the remaining actions will also become easier to implement. The Action Plan will be used to develop a strategy for accomplishing the goals of the SIMA program. As a result of this workshop, SIMA program management has revised long term program plans to incorporate methodologies that address many of the suggested actions.

I. BACKGROUND

In 1994, the National Institute of Standards and Technology (NIST) initiated the Systems Integration for Manufacturing Applications (SIMA) program. One objective of the SIMA program is to focus on integration technologies and product data exchange standards that can improve computer systems integration and advance information technology for manufacturing.

The SIMA program is part of a federal government initiative on Information Infrastructure for Technology Applications (IITA) within the High Performance Computing and Communications (HPCC). [1] The objectives of the IITA program are: 1) to accelerate the development and deployment of HPCC technologies required for the National Information Infrastructure (NII) and 2) to apply and test these technologies in application environments. The belief behind the SIMA program is that by applying advanced information-based systems and technologies to manufacturing, companies will be able to interact electronically as part of a "virtual enterprise" to produce world-class products for the 21st century.

The SIMA background study [2] identifies technical obstacles faced by industry in developing integrated manufacturing systems. Projects in the SIMA program examine integration requirements across a range of design, planning and production engineering activities to demonstrate the benefits of integration technologies and product data exchange standards which support systems integration. Throughout the integration activities, strong collaborations between NIST, industry, other government agencies, research institutions and standards organizations will be developed and maintained. The overall goal of the SIMA program is to provide industry with open architectures and interface specifications that will simplify implementation of Computer Integrated Manufacturing (CIM) systems built from commercially available software packages.

Defense Systems Management College (DSMC) provided experienced faculty members to lead an Interactive Management (IM) Workshop to assist a panel of manufacturing experts in accomplishing workshop objectives. Appendix C describes the IM process.

The IM Workshop was conducted at DSMC and utilized an IM methodology that included extensive use of computer-based facilitation tools, primarily Interpretive Structural Modeling Software and Group Systems Software. The DSMC facilitator, Stan Crognale and Bill McGovern, utilized the principles of Nominal Group Technique (NGT), an effective group oriented facilitation technique, to enable participants to collectively generate and clarify ideas. The process was utilized to achieve a disciplined discussion of the issues. Appendix A lists the workshop participants and Appendix B provides the agenda for the three day workshop.

Participants were selected for the workshop based upon technological expertise pertaining to integration needs within their respective areas. Each had a unique insight into the various aspects of the SIMA program and the problems associated with advancing information technology for manufacturing within their own program and among related programs. Participants were able to identify SIMA systems integration problems and actions.

Two Focus questions developed prior to the workshop were directly linked toward accomplishing objectives of the IM workshop. The major objectives of the workshop was to define actions for the SIMA program and to identify leveraging opportunities between SIMA and other programs. The desired outcome would provide a basis for further discussion of industry needs and solutions to systems integration problems.

II. PROBLEM IDENTIFICATION

Workshop deliberations began with the application of Nominal Group Technique (NGT) within the framework of Group Systems Software. [3] As previously stated in section I, NGT is a process for collectively generating and clarifying ideas. The process is initiated by carefully formulating a primary focus question. The ideas generated are in response to the focus question. The workshop process was initiated by formulating the primary focus question:

"In the context of advancing information technology for manufacturing systems and improving the effectiveness of the set of related programs, what are the critical problems that need to be addressed?"

Using Group Systems Software, the participants, each working on a laptop computer, identified seventy-four problem statements. After identifying the seventy-four problems, the authors/owners of each statement clarified them so that all participants had a common understanding of the meaning. At this stage, a thorough understanding of the statement's intent was developed. The problem statements and associated clarifications are presented in Appendix D.

To determine the importance of each problem statement, participants prioritized the seventy-four problems in rank-sum priority. From this process, the thirty-one problems that received the greatest number of votes in rank sum priority were placed on a white board. The participants then grouped the problems into similar categories. After the categories were formed, the remaining problem statements were added to the categories. The participants developed a name and corresponding definition for each category. This process resulted in the following list of eight categories:

1. *Standards Process*
2. *Industry Adoption*
3. *Technical Strategy*
4. *Program Management*
5. *Vendor Commercialization*
6. *Requirements*
7. *Metrics*
8. *Security*

A description of these problem categories is listed in Appendix E.

Each problem category was then related to one another in a pair-wise comparison to determine relationships between them. The graphical representation of those relationships is called the "Problem Structure." The question asked in the pair-wise comparison to generate the problem structure was:

"Do the problems in category X significantly aggravate the problems in category Y?"

The pair-wise comparison results are displayed as a Problem Structure in Figure 1.

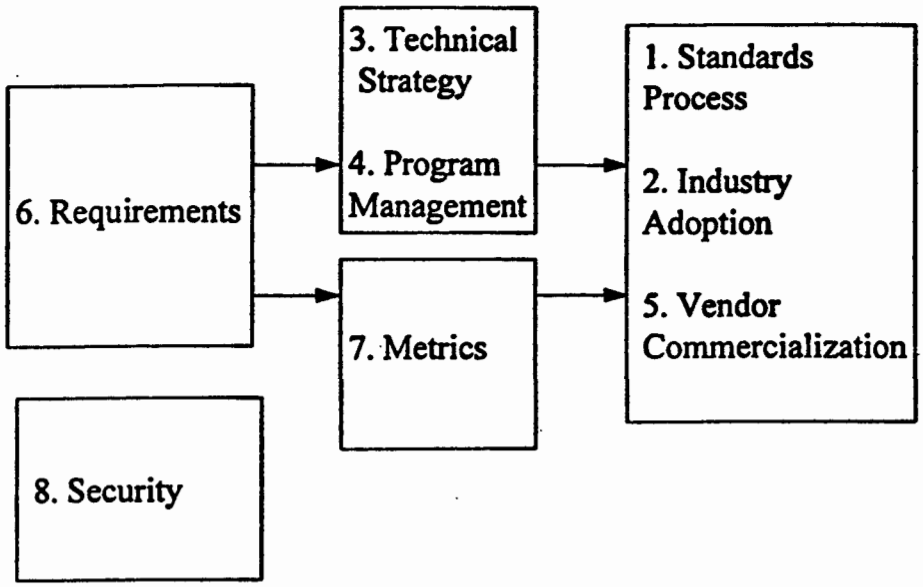

Figure 1. NIST SIMA Problem Structure

In Figure 1, the interaction portrayed in the Problem Structure depicts which problem categories contribute to making other problem categories worse. The problem statements associated with categories in the left boxes were said to significantly aggravate or make worse the problem categories in the right boxes. Problem categories contained within the same box are cycled.

A cycle is a subset of problems in which each problem category aggravates all other categories in the cycle. If problem categories are recognized as a cycle, the problem categories should be resolved as a unit, rather than separately.

In Figure 1, the problem statements associated with the category in the left box, *Requirements*, should be addressed before the problem category boxes to the immediate right which include *Technical Strategy, Program Management, and Metrics.* The categories *Technical Strategy* and *Program Management* are in a cycle. The Problem Structure also indicates that problems in the categories *Technical Strategy, Program Management,* and *Metrics* should be addressed before the problem categories within the right box: *Standards Process, Industry Adoption* and *Vendor Commercialization.* Since these categories negatively effect one another in a cycle, they should be addressed concurrently. The problem category *Security* does not significantly aggravate any other categories as defined and is not significantly aggravated by other categories; however, the group agreed that it is important and should be addressed independently.

III. ACTIONS

The same process used for developing the problems was employed to develop a set of actions necessary to overcome the problems in the Problem Structure. Workshop deliberations continued with the second focus question:

> ***"In the context of advancing information technology for manufacturing systems and improving the effectiveness of the set of related programs, what are the actions that would overcome these problems?"***

Again, using Group Systems Software, the participants, each working on a laptop computer, identified sixty-seven action statements in response to this question. After identifying the actions, the author/owner of each statement clarified them so that all participants had a common understanding of the meaning. Again at this stage, a thorough understanding of the statement's intent was developed. The action statements and associated clarifications are presented in Appendix F.

To begin the categorization process, each participant was asked to prioritize the action statements and select the five most important. The participants then grouped the actions that had more than two votes into similar categories. After the categories were formed, the remaining statements were also placed into categories. This process resulted in the establishment of nine action categories:

1. *Identify Requirements*
2. *Define MSI Strategy*
3. *Execute Technical Elements*
4. *Coordinate Programs*
5. *Define Technical Performance*
6. *Improve Standards*
7. *Promote Industry Adoption: Technical Activities*
8. *Promote Industry Adoption: Organizational and Management Activities*
9. *Promote Vendor Commercialization*

Numbering of the action categories does not reflect order of importance. A description of these categories is listed in Appendix G. Using a pair-wise comparison, the relationship between the nine action categories was established. The question asked for the pair-wise comparison was:

> ***"Does performing the actions in category***
> ***X***
> ***make actions in the category***
> ***Y***
> ***easier to accomplish?"***

The pair-wise comparison results are displayed as an Action Structure in Figure 2.

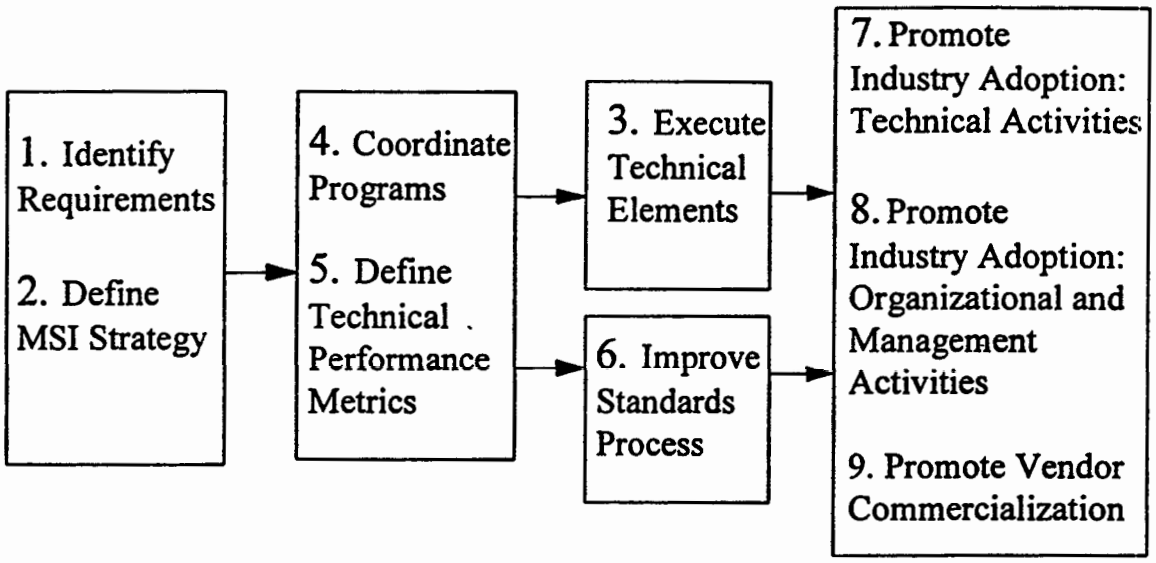

Figure 2. NIST SIMA Action Structure

The Action Structure shown in Figure 2 describes the relationship of action categories to one another. Successfully completing action categories to the left will make it easier to accomplish those actions in the categories to the right. The action categories, *Identify Requirements* and *Define MSI Strategy* are cycled and make it easier to accomplish actions in the categories *Coordinate Programs* and *Define Technical Performance Metrics*, which are also cycled. Performing those actions in the categories *Coordinate Programs* and *Define Technical Performance Metrics* would make it easier to implement actions in the categories *Execute Technical Elements* and *Improve Standards Process*. In addition, accomplishing actions in the categories *Execute Technical Elements* and *Improve Standards Process* would make it significantly easier to accomplish actions in the categories *Promote Industry Adoption: Technical Activities*, *Promote Industry Adoption: Organizational and Management Activities*, and *Promote Vendor Commercialization*. Action categories *Promote Industry Adoption: Technical Activities*, *Promote Industry Adoption: Organizational and Management Activities*, and *Promote Vendor Commercialization* are cycled.

IV. CONCLUSION

The NIST SIMA Problem Structure revealed what the Interactive Management (IM) Workshop participants determined to be the most critical problems associated with developing a strategy for accomplishing NIST SIMA program goals and improving collaboration among related programs. The NIST SIMA Action Structure describes the order of actions to be accomplished and can be utilized to monitor progress in completing the actions necessary to achieve program goals and deliver key SIMA products to industry. As the most important actions are successfully implemented, the remaining actions will also become easier to implement.

The initial approach to solving manufacturing integration problems is defining those areas where SIMA can bring NIST core competencies to bear while effectively coordinating with other programs to accomplish deployment of new technologies, standards and business practices that support design and manufacturing activities. In order to meet the needs for manufacturing systems integration, coordination with other key programs and industrial consortia is critical.

Workshop participants strongly agree that NIST has demonstrated expertise in standards development and facilitation, development of specification tools and reference implementations, rapid prototyping, testbeds, conformance and interoperability testing, systems integration methods, and manufacturing process simulation.

Finally, through the workshop process, participants agreed that the NIST SIMA program must include the following tasks in its long term plans.

1) Facilitate the development of a common set of requirements for integration of manufacturing software involving end-users, vendors, and systems integrators.

2) Jointly develop a reference architecture for manufacturing systems integration, identifying the important and useful standards, (i.e., formal, emerging, defacto standards).

3) Spearhead the development of a strategy for managing collaborations with industry consortia, government programs, Manufacturing Extension Partnership, and standards efforts.

4) Support the rapid development of standards by vendors, industry, and consortia.

5) Promote the adoption of technologies and standards in industry by participation in pilot programs.

Participants concluded that these tasks are associated with identified actions and are critical to achieving NIST SIMA program goals of integrating manufacturing software applications, both within an enterprise and throughout the supplier chain.

In response to item 1 above, NIST SIMA management will identify a "Suite of Specifications" as primary NIST SIMA deliverables. These specifications will include interface protocols, information models and process models. Secondary deliverables includes technical reports that provide support material that is referenced in the suite of specifications .

Additionally, an Advanced Manufacturing Systems and Networking Testbed (AMSANT) will be established at NIST to enable research and development into advanced manufacturing computer systems and networking. Listed among AMSANT objectives are challenges related to task 3 above. Specifically, the AMSANT will (1) test high performance computer and networking hardware and software to determine their suitability for use within the U.S. manufacturing community; (2) assist industry in the development and implementation of voluntary consensus standards; and (3) serve as a demonstration site that industrial technology suppliers and users can use to identify and overcome technical barriers leading to the successful and cost-effective implementation of these systems [4].

At the conclusion of the workshop, the participants prepared a final presentation based on the proceedings of the IM Workshop. This presentation is provided in Appendix I. The NIST SIMA program plan to develop an Implementation Plan as a result of this workshop to carry out the actions portrayed in the Action Structure. SIMA management is also interested in participating in more IM Workshops to evolve other aspects of the program focusing on integration of manufacturing processes.

APPENDIX A: Participants

No special demands are made of participants in an Interactive Management (IM) session other than hard work and a commitment to participate in problem solving. An IM session is typically conducted with a group of 8 - 12 participants who are knowledgeable about the issue being addressed and who represent a variety of views of the situation. The NIST SIMA IM session consisted of 19 participants because prior commitments required 6 members to depart the workshop early. During the session, participants contribute ideas about the problem being discussed, make judgements about relationships among ideas, engage in individual and collective leaning, represent the views of some special interest (when appropriate) and contribute to the ownership and application of the workshop products.

PARTICIPANTS	ACTIVITY
Neal, Richard	Martin Marietta Energy Systems
Bolton, Richard	International Business Machines Corp
Waddell, William	NCMS
Khosla, Pradeep	ARPA/SSTO
Yee, King	Boeing
White, Jack	Industrial Technology Institute
Hollowell, Glen	SEMATECH
Jordan, Jim	CAM-I/NGMS
Luce, Mark	NIST
Christopher, Neil	NIST
Ray, Steve	NIST
Mitchell, Mary	NIST
Knutilla, Amy	NIST
Barkmeyer, Ed	NIST
Kaminski, Mike	General Motors
Gagliardi, Mike	Software Engineering Institute
Erkes, Joe	GE Corporate Research
Leary, John	Software Engineering Institute
Mays, Jim	Navy Supply Command

OBSERVERS	ACTIVITY
Bloom, Howard	NIST
Hoffmann, Ray	NIST
Frechette, Simon	NIST
Goldstein, Barbara	NIST
Johnson, Clarence	NIST
Hessell, Merrill	NIST
McLean, Chuck	NIST
Sriram, Ram	NIST

WORKSHOP STAFF

McGovern, Bill	Crow, Dana
Crognale, Stan	Reevas, Kimberly

APPENDIX B: Workshop Agenda

Normally, an Interactive Management (IM) group meets for a period of 3 - 5 days. The scope of the NIST SIMA IM Workshop was limited to two and one half days for the purpose of assuring success of the workshop, accommodating travel schedules and other prior commitments of certain participants.

14-16 NOVEMBER, 1994

MONDAY, 14 NOVEMBER

8:00-8:30	Continental Breakfast
8:30-9:30	Welcome and Opening Presentation
9:30-12:00	Workshop Discussions: Problem Idea Generation and Categorization
12:00-12:30	Lunch
12:30-14:30	Workshop Discussions: Problem Categorization and Problem Structure

TUESDAY, 15 NOVEMBER

8:30-12:00	Workshop Discussions: Action Idea Generation and Categorization
12:00-12:30	Lunch
12:30-4:30	Workshop Discussions: Action Categorization and Action Structure

WEDNESDAY, 16 NOVEMBER

8:30-12:00	Preparation of Final Presentation
12:00-12:30	Lunch
12:30-2:00	Continued Preparation of Final Presentation
2:00	Final Presentation

APPENDIX C: Interactive Management (IM) Workshop Process

Overview

Interactive Management (IM) is a system specifically developed to assist organizations in dealing with complex issues. IM works with organizations to design responses to situations that demand integrations of contributions from individuals with diverse views, backgrounds, and perspectives. A group of participants who are knowledgeable of the situation are engaged in collectively developing a deep understanding of the situation, in establishing a clear basis for thinking about the future, and in producing a framework for effective action [5]. The benefit of the IM system is that it promotes *communication*, *consensus*, and *commitment* from participants involved in the planning effort.

Products

The conduct of an IM session typically results in both tangible products and significant learning on the part of the participants. Group work results in logical structures that can take the form of "maps" that show how elements such as problems or goals are interrelated, "fields" that present groupings of possible options for action, and "profiles" that depict alternatives plans for short or long-range efforts [6]. Information generated by the participants is fully documented during the process, allowing for a larger diffusion of the outcomes.

Specific Application

The IM Workshop was convened to provide a national forum for discussing major needs and research opportunities relating to the objectives of the NIST SIMA program. The major objectives of the workshop were that it brought together representatives from industry and government programs to define actions for the SIMA program and identify leveraging opportunities between SIMA and other programs.

The IM Workshop process was divided into two sections: "Problems Identification" and "Actions." Prior to the workshop, two "focus questions" were devised to guide the process. Each focus question served as an introduction to one of the two sections. The first section was used to define the problems and establish relationships between them. The second section was used to develop an Action Structure. The focus questions presented were:

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1)*"In the context of advancing information technology for manufacturing systems and improving the effectiveness of the set of related programs, what are the critical problems that need to be addressed?"*

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2)*"In the context of advancing information technology for manufacturing systems and improving the effectiveness of the set of related programs, what are the actions that would overcome these problems?"*

The opening workshop session began with Mr. Mark Luce presenting the workshop purpose and rationale for participant selection. It was important that the participants have a shared view of the objectives and direction of the SIMA program. It was agreed that this was a complex problem which needed to be discussed by those invited to attend the workshop. The opening presentations are provided in Appendix H.

Mr. Luce indicated that the IM Workshop would provide a forum which allowed for an open discussion of ideas for planning the SIMA program strategic plan and defining opportunities for collaboration among related programs. The workshop would lead to an Action Structure describing the actions to be taken and showing the relative importance of each action. After the IM Workshop, the Action Structure will be used as a reference in developing the details of an Implementation Plan leading to achieving NIST SIMA program goals. The Implementation Plan will provide a Work-Breakdown-Structure (WBS) that assigns responsibilities and timeframes, for SIMA related actions, for executing each action referenced in the Action Plan.

Subsequent to the opening statement, personnel introductions and administrative details were provided to the participants. The facilitators, Stan Crognale and Bill McGovern were introduced to the group. Stan Crognale provided an overview of the process while Bill McGovern provided instruction and guidance in using the computer equipment which was used to facilitate the workshop and help to document the decision-making process.

APPENDIX D: Problem Statements

Using Group Systems Software, the participants, each working on a laptop computer, identify problem statements in response to a focus question. After identifying the problems, the authors/owners of each statement clarify them so that all participants have a common understanding of the meaning. At this stage, thorough understanding of the statement's intent is developed. The focus question, seventy-four problem statements and associated clarifications developed by the NIST SIMA IM group are presented below.

ELEMENT LIST: PROBLEMS IDENTIFICATION

Focus Question 1: In the context of advancing information technology for manufacturing systems and improving the effectiveness of the set of related programs, what are the critical problems that need to be addressed?

1. Lack of evaluation metrics for alternative demonstrations.
Comparisons of different approaches to integrate systems become very difficult to compare economically and from a performance standpoint.

2. How to establish practical industry pull.
Pushed technologies will only result in additional competitive approaches.

3. Lack of well developed standards for product data exchange.
PDES/STEP is too archaic and is progressing too slowly. The products that will use PDES/STEP are progressing at a faster rate and need to do something to accelerate the development of the PDES/STEP standards.

I don't agree that the STEP standard is archaic. I will agree the ISO process is slow and needs improvements.

4. How can we get programs to build on common reference foundation?
Within government and private industries, the critical issues are acceptance of public data modeling schema and sharing core technical competency. Until these barriers are resolved, improvements on a global scale will be very limited.

5. The gap between ideas and implementation.
Visionaries define programs. Technologists do work. The bridge between the two is very hard to cross. The difficulty with converting the definition of what must be done into programs that perform and people that execute is immense.

6. Lousy integration of human intelligence with machine intelligence.
There is a lot of emphasis on the technology without much thought regarding integration of human cognitive processes.

7. Inadequately understood and stated requirements.
Because requirements aren't well understood, reasonable people can and will disagree over details of IT "solution". Need experiments and sharing of results to refine requirements.

8. Need the ability to upgrade existing systems safely and reliably. The ability to upgrade existing systems in spite of the inevitable bugs in the upgraded components without comprising the safety and reliability of the system would eliminate a major barrier in system upgrades.

9. Manufacturing subsystems do not work together effectively. Subsystems include human, machine, and software. A systems is the set of subsystems working together, regardless of the level of integration, towards a common objective.

10. Lack of a common point to set goals, objectives and, resources. There are a number of different approaches to provide manufacturing technology and a resulting duplication of efforts and expenditure of resources.

11. Lack of measures to determine if changes are effective. Are there solid enough evaluation criteria developed to determine the impact of changes in technologies, standards and business practices? Some of the most concrete measures such as cost benefit are also some of the most business sensitive (unwillingness to share). Other benefits may be difficult to quantify or may take time to determine the true impact.

12. Technology: the lack of shared process models for joint virtual systems. Without familiar, commonly understood process models, it is difficult to plan for sharing a virtual process for any virtual or integrated manufacturing activity.

13. Little or no interoperability of manufacturing software applications. There is no commonly accepted manufacturing architecture or general interchange API that is specific to all phases of manufacturing.

14. Each program stretches too thinly to adequately solve a problem.
Each program stretches too thinly to demonstrate entire solution. The pressure to market these programs forces each one to sell itself as solving a broad swath of the problem. A mechanism is needed by which a program can tackle only a focused aspect of the problem, which in itself may not be demonstrable.

15. Multiple approaches inhibit implementation.
Industry is faced with competing approaches/solutions and is forced to pick a winner. This is high risk for implementers---for example... beta versus VHS, 8 track versus.....

16. How can we take advantage of the cultural diversity of the workforce?
In a global manufacturing environment, different life styles and cultural values must be taken into account. Differences in learning styles and communication styles need to be understood.

17. What is the mechanism for the initiatives to communicate?
No formal means exist to establish linkages.

18. Little interaction of technical experts working on similar problems.

19. The development and acceptance of standards is slow.
We need "fast path" mechanisms to put standards in place early enough to be useful in shortened product cycles.

20. System upgrades should not incur additional system downtime.
The potential risk of system downtime is a major barrier for performing system upgrades for those systems with high availability requirements. In many instances an upgrade is not even attempted due to upgrade failures in the past which caused extensive downtime; therefore, systems are left antiquated and productivity does not progress.

System upgrades should not incur additional system downtime.

There are often ripple effects on other systems in the enterprise: changes in data content and format affect other systems and users.

21. Identifying functional boundaries of software systems.
Many vendor's products build in whatever the vendor feels will assist the customer. Users want their responsibilities to cover their favorite activities.

22. Lack of mechanisms to share and exchange solution fragments.
Many interesting solution fragments are emerging as a result of public and private initiatives. Few mechanisms exist for sharing these across industry, academia and government. Natural selection can "weed" the enterprise integration garden and develop confidence and consensus around approaches and proto-standards that "work".

23. There is no roadmap for manufacturing information technology.
t is difficult to predict the direction of systems development. Technology is rapidly changing. We lack a unifying "shared vision" of where we want to go and spend too much time arguing about implementation details.

24. Tools emphasize technology, not productivity. Present tools (eg. solid modeling systems) emphasize the technology more than the usability which actually impacts productivity. Tool development must pay significant attention to human computer interfaces. (USABILITY!)

25. The provision of funding to the right programs.
All mechanisms of which I am aware that provide government funding to important programs involve an up-front investment in program development funds (internal) and have a high risk of failure to "win", etc.

26. Change has to be addressed on an industry by industry basis.
Too often the adoption of new integration technologies is addressed by a national effort. In fact, industries adopt technologies in the context of improving the flow of product and information through supply chains in their industries. Ways that bring large and small members of specific industries together to address adoption, business process change and business case development are needed.

This is being accelerated by the present government obsession with industrial sectors!

27. Collaboration among federal programs is difficult.
Too many programs have the same vision that is very general but does not succinctly capture the contents of the program. This is a big hindrance to collaboration.

28. Organizational change to take advantage of new technologies.
Groups of trading partners cannot gain full benefit from new technologies that support enterprise integration without changing the ways in which they relate. Effective change begins with an identified business problem.

Industries need ways to reach consensus on critical integration problems and reach agreement on ways to migrate to new technologies and new business processes.

True within organizations as well. Some changes are small, some large.

29. Need to accelerate the development & adoption of IT Standards for Mfg.
Developing consensus standards takes too long and there is no guarantee of adoption.

30. An agreed implementation road map is required.

31. Boundaries between organizations.
The turf issues have greatly reduced - Thank goodness. However, there is still the necessity of organizational survival. Sharing of ideas without ownership is mandatory for success.

This is, however, difficult since it removes incentives for participants to participate in some organizations - ("What is in it for them? Why not just wait on the sidelines and reap the benefits?")

32. No roadmap to federal and related programs.
This is the bafflement in dealing with related programs that are defined with conflicting jargon. We need some access to information regarding these programs with hypertext linkages, some cross-referencing of language, etc.

33. Limited disciplines and standards for process data exchange.
Lots of emphasis on Product Data Exchange, not much on Process Data Exchange..

Process descriptive data? Process control data? Process results?

A sufficiently complete product description makes a process description unnecessary.

34. Lack of defined Leadership.
The plate is full. There is much to do, and a coordinated effort is the only way we will succeed. However, all synergistic solutions require leadership. Leadership in the national agenda requires definition and cooperation. Someone must lead!

35. Technology insertion is terribly slow.

36. Inability to commercialize our innovations.
Demand drives the market. Profits are what matters to industry. We need to supply the world with the next innovative necessity, or we need to create demand for a new exciting product. What is it and how do we win the race?

37. Local integration strategies are not applied on a larger scale.
Local integration strategies aren't shared on a larger scale.

38. How to establish which advanced technologies are to be addressed.
Priority and mechanism.

39. Reluctance to participate in international meetings.
This is particularly evident in the STEP effort. Travel overseas is viewed as a vacation by industry and government.

In general, management does not accept the global village view of business and technical work.

40. No shared vision for information technology future.
Most initiatives get hung up too early on specifics, (KQML vs. its competitors), rather than the overarching assumptions.

A given integration mechanism requires a particular view of WHAT systems will cooperate and HOW they will cooperate, so it is not clear exactly what the "overarching assumptions" are.

41. How do we deploy the ideas/technologies that are on the shelf?
The deployment decisions are conservatively made with lots of factors that include culture, ROI, legacy investment, etc. Deployment of infrastructure technologies is critical for "raising the baseline". However, the public sector cannot dictate what the private sector does. There must be incentives.

There is also a tendency to separate "consumer" approaches (e.g. Lotus Notes) from manufacturing needs. We need to migrate and adopt approaches arising in the "consumer" market.

42. Little known of advances outside the U.S.
There is a multi-level NIH syndrome at work. Companies have difficulty accepting outside ideas (as do work groups within companies); consortia and programs tend to be inward-looking. In the U.S., there is little encouragement to understand advances outside the U.S.

43. Standards process is too slow for current pace of technology advances.
The consensus process is too unwieldy to move at the pace needed today. Skunkworks approaches make the breakthrough advances, which is inherently not a broad consensus.

44. The standards development process is very inefficient.
Standards development lags behind technology development. Industry needs to deploy technology often before standards are developed. Voluntary development process has inherent problems. There are often overlapping goals among standards organizations.

45. Technology: lack of shareable design contexts for joint work.
Lack of a basis for establishing and sharing product models, and for negotiating shareable priorities for resolving design trade-offs regarding product quality, prevents virtual manufacturing activity.

Technology: shareable design contexts for joint work.

Lack of a basis for establishing and sharing product models, and for negotiating and sharing priorities for resolving design tradeoffs regarding product quality, impedes virtual manufacturing activity.

46. Development efforts do not include scenarios for deployment.
The process of moving technology from development to commercial deployment is not well defined.

47. Technology: inability to form virtual enterprises.
There is not yet a market place within which prospective partners can negotiate (electronically) for complementary parts in a prospective virtual enterprise.

48. Technology: lack of trusted ops on distributed networks of heterogeneous platforms. When the platforms (operating systems and cpu/hardware) are heterogeneous, and the application environment is distributed, it becomes increasingly difficult to enforce a security policy from the top down. Without some level of assurance that a virtual enterprise will not have its access compromised or denied at critical times, or its (proprietary or competition sensitive) data spoiled, destroyed, or compromised, enthusiastic investments in virtual enterprises are unlikely.

49. The conflict between Open systems vs. Proprietary systems.
How can we motivate private product vendors to buy into providing open system component based products when it is in their best interest to provide their own proprietary solutions?

Standards frequently lag technology. Many companies lose information by adhering to standards or think they are giving away their competitive advantage by aiding in the inclusion of their technology into the standard.

50. Joint effectiveness: difficulty in knowing future results.
Unless related programs have a published relationship, including visibility into some level of detail regards individual commitments for producing specific results, neither the opportunity for leverage, nor the process of collaboration is possible.

51. Joint effectiveness: shortage of means to share roadmaps of activities.

52. Joint effectiveness: lack of means to formulate related goals.
The concept of joint effectiveness is very weak without a related concept of 'common goals'. Statements of 'related goals' and shared vision cannot be produced without some agreement on a means or a process for framing these statements. So what may be lacking in the focus statement is agreement on where to find or create a picture of what the 'related goals' for manufacturing systems integration are.

53. There are still related programs: not knowing what a "related" program is.
In our focus question, the phrase "related programs" is ambiguous. It can be made more specific by using a reference list of programs that are declared to be "related", or it can be amplified by some qualitative description (for instance 'HPCC Programs' or 'programs in information technology for manufacturing'). Each of these is disadvantageous: one may include too few, the other may include too many. But some clarification is necessary.

54. Joint effectiveness: lack of mechanisms for working level interaction.

55. The difficulty in anticipating opportunities for leverage.
Without a shared forum for interaction, it is difficult for partners and participants in related programs to anticipate opportunities for leverage.

Electronic forums for programmatic interaction are rare, especially at the technical level.

56. Technology: lack of scenarios for validating emerging standard interfaces.
Forming a consensus on which attributes of emerging standards are most desirable requires a shared context within which is illustrated the value added by various attributes. Scenarios in general provide context for understanding relationships. However, there may not be enough widely accepted reference scenarios which apply to understanding emerging standards in the area of manufacturing systems integration.

57. Little or no interoperability of heterogeneous software environments.
Adversely affects manufacturing software, but is not specific to manufacturing.

58. Lack of a common source/repository of "related programs" definition.

There are a myriad of programs in existence which are aimed at enhancing U.S. manufacturing capabilities from the government, industry associations, consortia, and various vendors. There is no common source of information about them. Therefore there is a high degree of redundancy and overlap.

59. Still many gaps in information exchange and communication standards.
There is still a huge amount of information which is not being shared because there is no agreed upon way of representing it. Usually there is disagreement on WHAT information must be shared and WHO must share it as well.

Standardization efforts focus on too high a degree of detail.

60. Major programs often replicate efforts of each other.
Looking back on half a dozen major systems integration programs, they all start to sound alike in their objectives and efforts.

61. Absence of standards strategy in major vendors.
Vendors routinely support many conflicting standards efforts for integration technologies, hoping to have experience in whatever "wins", but creating appearance of XYZ support for ALL of them.
NIST and related government sponsored projects must state the approved standards. This will encourage vendors to optimize their resources.

Vendor strategy regarding standards is often very 'private' for reasons of competitive advantage.

62. The difficulty of commercialization without vendor involvement.

63. Incompatible technology development and vendor implementation cycles.
Vendors still remain relatively uninvolved in these programs.

It sometimes seems that vendors invest in very near term approaches that sell and are unwilling to work on approaches that may (or may not) be valid five or more years in the future.

We must not forget the vulnerable position of vendors and SMEs in standards implementation, government support for commercialization, etc. They also have longer term development efforts which are underway while the new standards are being developed. The standards arrive along with the incompatible new products.

64. Lack of a business case to support commercialization of standards.

65. Undercapitalization of the vendor's community.

66. Poor interoperability of pet integration methodologies.
Systems that will ALL be centered on a given ORB or a central "distributed database" or an "autonomous agent coupling" mechanism don't work with any others.

67. New systems are implemented before infrastructure is mature.
New systems are implemented before infrastructure upgrades have fully implemented open systems standards that are needed for integration with other systems or databases.

68. The difficulty in reaching SME with new solutions.
Outreach efforts must be much better coordinated with the efforts of specific industries to adopt new technologies, standards and business practices. Once industry "best practice" is defined, linkages should be formed with existing state and federal outreach efforts.

69. Lack of manufacturing insight in SW standards bodies.
General software standards developers have little interest in the manufacturing needs for such standards.

70. Unable to match system architecture to organizational structure.
There may be a best fit for certain types of system architectures and certain types of organizational structures. For example, distributed systems may not work in some places where hierarchical organizational structures exist.

Organizational structures are evolving. Keeping manufacturing systems architectures in synch with organizational structures (and vice versa) is very hard and demands an ability to change both, quickly. This also implies the need for multi-disciplinary, enterprise-wide approaches.

71. Lack of Reliable tools to assess conformance AND interoperability.
The validation of standards and products needs to focus on interoperability. The leadership for testing needs to be moved to the vendor community. The relationship between conformance testing and interoperability testing needs to be developed. Testing methods and tools need to be put in the hands of technology vendors and users.

72. There is no way to quantify maturity of integration mechanisms.
Industry must have a basis for comparing the maturity (i.e. commercial and standards support) of integration technologies. This capability will enable industry to track the maturity of the technology and choose the most appropriate time for deployment (as well as replacement).

73. Expectations of users & vendor capabilities of technology are inconsistent.
New technologies get oversold leading to unrealistic expectations by users and claims by vendors which do not accurately reflect the state of implementation.

74. End users do not know when standards are ready to be implemented.

APPENDIX E: Problem Categories

To determine the importance of each problem statement, participants prioritize the problems in rank-sum priority. From this process, the problems that receive the greatest number of votes in rank sum priority are placed on a white board. The participants then group the problems into similar categories. After the categories were formed, the remaining problem statements are added to the categories. The participants develop a name and corresponding definition for each category. This following list of eight categories were formed by the NIST SIMA IM Workshop participants:

Focus Question 1: In the context of advancing information technology for manufacturing systems and improving the effectiveness of the set of related programs, what are the critical problems that need to be addressed?

1. Standards Process

The standards process needs to: keep pace with advances in technology, demonstrate value added by a standardized solution to ensure adoption, and provide a means of testing to ensure high quality and interoperable products.

- The standards development process is very inefficient. (44)
- Need to accelerate the development & adoption of IT Standards for mfg. (29)
- Lack of well developed standards for product data exchange. (3)
- The development and acceptance of standards is slow. (19)
- Lack of reliable tools to assess conformance AND interoperability. (71)
- Standards process is too slow for current pace of technology advances. (43)
- Technology; Lack of scenarios for validating emerging standard interfaces. (56)
- Absence of standards strategy in major vendors. (61)
- Lack of manufacturing insight in SW standards bodies. (69)
- Limited disciplines and standards for process data exchange. (33)
- End users do not know when standards are ready to be implemented. (74)

2. Industry Adoption

Gaining business consensus on adapting technologies, standards, and business practices that promote improvements in business processes within and between manufacturing firms. Industry adoption must address: a unified business case, individual firms, migration issues, organizational and management change and cost justification for change.

- Need the ability to upgrade existing systems safely, reliably. (8)
- System upgrades should not incur additional system downtime. (20)
- Change has to be addressed on an industry by industry basis. (26)
- Organizational change to take advantage of new technologies. (28)
- The conflict between open systems vs. proprietary systems. (49)
- New systems are implemented before infrastructure is mature. (67)

- Lousy integration of human intelligence with machine intelligence. (6)
- Multiple approaches inhibit implementation. (15)
- How can we take advantage of the cultural diversity of the workforce? (16)
- Technology insertion is terribly slow. (35)
- How do we deploy the ideas/technologies that are on the shelf? (41)
- Development efforts do not include scenarios for deployment. (46)
- Technology: inability to form virtual enterprises. (47)
- Little or no interoperability of heterogeneous software environments. (57)
- The difficulty in reaching SME with new solutions. (68)
- Unable to match system architecture to organizational structure. (70)
- Expectations of users & vendor capabilities of technology are inconsistent. (73)
- End users do not know when standards are ready to be implemented. (74)

3. Technical Strategy

There is no common vision of how manufacturing software, equipment, and human users should interact at some point in the future. Neither is there any roadmap of integration infrastructure for reaching a useful level of interaction.

- How can we get programs to build on common reference foundation. (4)
- Little or no interoperability of manufacturing software applications. (13)
- There is no roadmap for manufacturing information technology. (23)
- An agreed implementation roadmap is required. (30)
- No shared vision for information technology future. (40)
- Manufacturing subsystems do not work together effectively. (9)
- The gap between ideas and implementation. (5)
- Lousy integration of human intelligence with machine intelligence. (6)
- Technology: lack of shared process models for joint virtual systems. (12)
- Identifying functional boundaries of software systems. (21)
- Limited disciplines and standards for process data exchange. (33)
- Local integration strategies are not applied on a larger scale. (37)
- Technology: lack of shareable design contexts for joint work. (45)
- Technology: inability to form virtual enterprises. (47)
- Little or no interoperability of heterogeneous software environments. (57)
- Poor interoperability of pet integration methodologies. (66)

4. Program Management

There is a lack of unifying vision, roadmap, and of sharing mechanisms to enable all manufacturing programs to work in concert.

- Each program stretches too thinly to adequately solve a problem. (14)
- No roadmap to federal and related programs. (32)
- Lack of a common point to set goals, objectives, and resources. (10)
- Multiple approaches inhibit implementation. (15)
- Lack of mechanisms to share and exchange solution fragments. (22)

- What is the mechanism for the initiatives to communicate? (17)
- Little interaction of technical experts working on similar problems. (18)
- The provision of funding to the right programs. (25)
- Collaboration among federal programs is difficult. (27)
- Boundaries between organizations. (31)
- Lack of defined leadership. (34)
- Reluctance to participate in international meetings. (39)
- Little known of advances outside the U.S. (42)
- Joint effectiveness: difficulty in knowing future results. (50)
- Joint effectiveness: shortage of means to share roadmaps of activities. (51)
- Joint effectiveness: lack of means to formulate related goals. (52)
- Related programs: not knowing what a "related program" is. (53)
- Joint Effectiveness: lack of mechanisms for working level interaction. (54)
- The difficulty in anticipating opportunities for leverage. (55)
- Lack of a common source/repository of "related programs" definition. (58)
- Major programs often replicate efforts of each other. (60)
- The difficulty in reaching SME with new solutions. (68)

5. Vendor Commercialization

Vendor will not invest without strong thrust in return and users/standards groups do not commit to use program.

- Inability to commercialize our innovations. (36)
- The difficulty of commercialization without vendor involvement. (62)
- Incompatible technology development and vendor implementation cycles. (63)
- Lack of a business case to support commercialization of standards. (64)
- The conflict between open systems vs. proprietary systems. (49)
- Absence of standards strategy in major vendors. (61)
- Undercapitalization of the vendor's community. (65)
- Expectations of users and vendor capabilities of technology are inconsistent. (73)

6. Requirements

Industry and user needs and requirements have not been clearly defined or prioritized.

- How to establish practical industry pull. (2)
- Lousy integration of human intelligence with machine intelligence. (6)
- Inadequately understood and stated requirements. (7)
- Tools emphasize technology, not productivity. (24)
- How to establish which advanced technologies are to be addressed. (38)
- Joint effectiveness: lack of means to formulate related goals. (52)
- Still many gaps in information exchange and communication standards. (59)

7. Metrics

There are no metrics to determine/predict the effectiveness of technology development programs and technology deployment programs.

- Lack of evaluation metrics for alternative demonstrations. (1)
- Lack of measures to determine if changes are effective. (11)
- Multiple approaches inhibit implementation. (15)
- There is no way to quantify maturity of integration mechanisms. (72)

8. Security

Lack of trusted OPS in distributed networks of heterogeneous platforms. When platforms are heterogeneous (ops systems, cpu's/hardware), it is difficult to enforce/assure a security policy "from the top down" without assurance that a virtual enterprise will not have compromises, losses, or spoiling of competition (sensitive data & processes, there will be less investment in virtual enterprises).

- Technology: lack of trusted operations on distributed networks of heterogeneous platforms. (48)

APPENDIX F: Action Statements

Again, using Group Systems Software, the participants, each working on a laptop computer, identify action statements in response to a focus question. After identifying the actions, the author/owner of each statement clarify them so that all participants have a common understanding of the meaning. Again at this stage, a thorough understanding of the statement's intent is developed. The focus question, action statements and associated clarifications identified by the NIST SIMA IM Workshop participants are presented below.

ELEMENT LIST: ACTIONS

Focus Question 2: In the context of advancing information technology for manufacturing systems and improving the effectiveness of the set of related problems, what are the actions that would overcome these problems?

1. SIMA should work with Industry consortia to define business case scenarios and metrics for demos.
NIIIP TRP - good candidate.

The probability of industry adoption of one approach over another is enhanced by clear business metrics that allow fair and objective comparisons between the choices.

An industry consortium is well suited for this role.

The agility forum is developing metrics for agile manufacturing and should participate in this activity along with NIST.

1a. Industry should define business case metrics for demonstrations.
Note related work being done on virtual enterprise metrics under the Agile Manufacturing Program and the Agility Forum.

2. Vendors propose, adopt de facto standards.
Standards process should be more willing to adopt industry accepted defacto standards to accelerate standards process.

Perhaps government should "recognize" defacto standards.

Perhaps SIMA should routinely "poll" widely representative membership of the "MSI vendor / user industry community" on their views regarding defacto standards.

Perhaps the "opportunity" of defacto standards is related closely to the "opportunity" of identifying "emerging" standards ...

3. Government programs should consider use of de facto standards.
Government programs should consider and encourage the development of defacto industry standards much like the case of FORTRAN and Internet.

3a. NIST should encourage voluntary standards development.
There are good examples in the realm of high performance computing (Parallel FORTRAN, message-passing operating systems) of de facto standards developed quickly (about 1 year) with wide industry acceptance.
What is involuntary standard development? (e.g., Mil-Standard)

4. NIST/SIMA should participate in and support efforts such as Agile BAA.
Industry pilots will give SIMA the opportunity to work with manufacturing firms on real problems in integration and supplier coordination. The SIMA program would provide evaluation, testing and demonstration of new technologies.

The Agile Manufacturing program offers excellent opportunities for leveraging.

5. Government/Industry/Vendors consortium funds standardization activities.
This will move the standardization function away from reliance on intermittent resources, thereby uncoupling the aggravation cycle with industry adoption and vendor commercialization.

5a. Fund vendors to cooperate in standards activities.
Provide funding for vendors to actively participate in standards activities with incentive to work towards consensus quickly.

6. Government should fund additional core STEP development and testing.
There are core product application protocols that could be accelerated with additional development and testing. Government should provide resources to work with industry to ensure it is done in the context of the real world.

7. Government must lead, establish and enforce standards.
Government must provide incentives to vendors and users to adopt standards.

"Enforcing" standards sounds like a dangerous move, given the pace of technology advances.

8. Federal program managers should develop an integrated requirements process.
An integrated requirements acquisition process would provide a common background for the several Federal/Industry programs. It should be done in the next 90 days. The integrated process should include mechanisms for gathering inputs from at least 100 large, geographically dispersed, companies, 500 SMEs, 25 academic groups, and 20 vendors, perhaps through a set of regional councils.

8a. Multi-agency team will lead creation of requirements definition.
A multi-agency task force will synergize the creation of an industry-led statement of requirements for achieving global competitiveness. This statement must be owned by all, not by one or two "experts" who promote philosophies.

9. SIMA to facilitate demos of technology solutions to MSI problems.
The first stage in the adoption process is awareness. With demos of promising technology solutions to industry problems in Manufacturing Systems Integration (MSI), vendors should become more aware of technology potential. User assessments should begin to converge on top priority problems. SIMA will learn where emerging standards may have greatest potential to meet industry needs with highest leverage technology.

10. Joint Industry, end user, and Govt task force (TF) should develop a Stratrgic Definition for Manufacturing Industy Infrastructure.
A joint (TF) chartered by the White House and a steering committee of high level executives from all constituencies can provide the common basis for reaching consensus on a MFG Infrastructure. Given a pre-competitive charter, this TF can reach conclusions that will make all other identified problems go away.

I doubt that the problems would all go away. I've been told there are legal restraints against doing this; i.e., it would require legislation. Also need academic inputs.

Is this a broad consensus of industry, academia and government on top down direction regarding how and where to focus national (national?) resources to enable more competitive manufacturing capabilities in the U.S ....?

10a. Keep the unifying vision a little loose, to allow some diversity.
Too rigid a definition will kill off promising alternatives too early.

Need to carry reasonable alternative IT approaches until enough user testing and "natural selection" can enable consensus for down-selection.

11. SIMA should establish an industry steering group.
The industry steering group should be comprised of end-user and vendor executives to provide *regular input to requirements,* deliverables, demonstrations, etc.

12. Program Managers need to be trained in Requirements Specification & Analysis.
Program managers need training on determining requirements, setting goals and quantifying objectives for the implementation of a project. They need to be given tools to help document user needs.

13. All should define technical performance metrics for IT architecture.
Need common ways to compare reality of inevitable declared "successes".

To carry out this action, a forum is needed which accelerates, broadens, and deepens the scope of meaningful technical interaction on what performance is desired, practicable, achieved.

All = Industry, Government, Academia, and end-user populations. Need to provide basis for fair "survival of the fittest" down selection of integration technology approaches.

The Agility Forum is developing metrics for assessing "agility". NIST should cooperate with them.

14. Industry identify target organizational structure.
Industry partners in technology development programs must identify target organizational structures to which new technology will be applied.

15. SIMA should conduct a series of standard operating action and standard operating practices workshops.
SIMA should conduct workshops for the purpose of assessing state of technology and standards in support of systems integration.

16. NIST should conduct regional workshops to develop requirements.
While meetings should be open, manufacturing firms in the region should be specifically invited. It is important that participants can "walk across the street" versus travel to a central point.

Keep from being surrounded by "Technology Providers."

Need to involve sub tier suppliers in the requirements process.

This is a reasonable role for the NIST Manufacturing Technology Centers (MTC's) to assume.

Meetings should be easy to attend and should be attended by a widely representative sample of industry (vendors, producers,manufacturers).

Results should be widely disseminated for comment.

Would it be helpful to have electronic (NII) support for building invitation lists, circulating results for comment, and publishing results?

17. Government must take a more pro-active role and work with users.
There must a partnership between NIST and the users to develop and understand user requirements.

HOW? How to identify "users"? How to "work with" users?

18. Government agencies should educate Program Managers on standards (FIPS).
I have talked to many DoD program managers of weapons systems at places like Dahlgren, Crane, and China Lake that have never heard of CALS. Many local information technology projects are being implemented by people who are not familiar with what a Federal Information Processing Standard is.

This action item includes the notion of standards promotion.

19. NIST will host an information repository for programs.
All relevant manufacturing systems integration programs will supply and maintain detailed online descriptions, documentation and status reports that are linked to a single access point maintained at NIST.

How do we define which programs should be included in ALL?

And do what with it? Somehow programs need to LOOK AT what one another are doing and encourage USE of the results to AVOID duplication.

This would be a tactical roadmap to provide understanding of technical approaches and assure identification of overlaps and opportunities for leveraging technical solutions. The roadmap(s) would require updates as programs progress.

Good idea! Right now it is extremely difficult to find out what others have done in order to leverage one anothers' successes and failures. Until we start doing so, we will continue to reinvent wheels.

Should NIST take advantage of other government funded programs and industry consortia in creating and operating this repository? Yes!

Will this implementation mean that NIST manages online forums whose members are committed (even paid) to assimilate, review, provide feedback on content of repository, for the benefit of those who posted information? Yes!

Most consortia have developed a substantial amount of information that can go into the public domain; conversely, consortia would regard other information as proprietary and would withhold it properly.

19a. SIMA should help to electronically publish information on related programs.
Programs related to SIMA will be known to SIMA. Goals, objectives, planned results, and milestones from related programs which have potential value for participants in the SIMA program should be published electronically, perhaps via Internet World Wide Web, and kept up-to-date for the benefit of the industry community interested in manufacturing systems integration.

20. Government should set up "national repository" of IT enablers.
Enablers are "glue", examples: case studies, tools, and services.

21. Electronic posting of industry requirements.
Industry and government technology development programs should set up a nationwide electronic bulletin board for industry to post system requirements (e.g., industry manufacturing system wish list).

22. SIMA should lead related programs workshop to define technical roadmap.
The workshop should have required attendance of at least one program manager and at least one technical person to prepare a common roadmap indicating plans, milestones, and technology gaps.

Perform analysis of related programs, publish document containing reviews, focus, objectives, etc..use a reference for joint workshop.

Roadmaps should include metrics for determining "success".

23. SIMA should establish a thrust area in human/machine system integration.
The integration of human intelligence with machine intelligence will be critical in 21st Century manufacturing systems. There are few efforts that look at cognitive models and other deeper aspects of human intelligence as used in collaborations.

24. Standards Developer (for example.: Application Protocol) should be required to show evidence of implementability.
Standards should contain no more than what is needed to get the job done but frequently they contain wish lists that create too much complexity for the problem. There must be a requirement to demonstrate implementability and actual capabilities. Vendor involvement is needed at this point. APs should be justified by a strong business case.

Even better, do not standardize anything that has not already been implemented! User feedback from Alpha-test sites should be required.

25. NIST must develop more specific STEP application protocols.
Current standards are too general. Existing commercial tools do not interface as a result of broad specification.

Vendors must use the existing STEP conformance tools.

Vendors should have a stronger hand in defining conformance classes

26. Industry should provide scenarios for technology deployment.
Industry should provide technology development programs with scenarios for technology deployment and validation.

Use industry-based pilots (a la the Agile BAA), support the development of deployment tools (training material, implementation guides, cost justification tools) and use the MEP program.

27. Government must take a greater role in the international standards process.
NIST or other government agencies must be more pro-active and influence the directions in establishing international standards.

28. Industry roadmaps will be created by product, process, sector.
Under the leadership of a multi-agency task force, and using the diverse resources of various industry, technical societies and consortia, industry roadmaps will be created by process, product, and sector; these roadmaps will be integrated into a composite technical roadmap by a select committee representing the participants.

This is the tactical view. The strategic level will be defined by the high- level task force that includes government agencies and industrial participants. This task force will charter and support the development of these tactical roadmaps and will support the funding and cooperation between programs that achieve the defined goals (goals defined in the roadmaps).

29. Programs provide technology migration paths from legacy systems.
Technology development programs must provide industry partners with migration paths from current technical systems to proposed technical systems. We are going to make errors in exchange standards and protocols.... planning for their eventual low-cost replacement is mandatory to prevent a reimplementation "disaster".

Do we intend this as a mandatory requirement on Government-sponsored manufacturing programs?

Include an emphasis on organizational change.

30. NIST should solicit input on streamlining standards process.
This input should come from a wider community than just the "usual suspects" in the standards community.

31. Federal program managers should commission studies of new manufacturing organizations.
There are many ideas emerging empirically and out of academia relating to the organization of manufacturing enterprises. Work on manufacturing systems should reflect our best understanding of the trends in organizational development.

Who should collect and publish these emerging ideas; to whom should they be disseminated for feedback; how should they be disseminated?

SIMA should facilitate collection, publication, dissemination, and collection of feedback from a widely representative sample of industry (vendors and manufacturers).

Should dissemination be electronic, via NII?

Should coordinate with Agile Manufacturing Research Institute (AMRI).

32. SIMA should exchange technical staff with industry collaborators and other government programs.
Work with industrial consortia and other partnerships.

33. Government must closely synchronize separate branch & agency initiatives.
Who will be in charge of synchronizing the synchronizers?

The National Science and Technology Council (NSTC) has a process in place, with multi-agency leadership of various manufacturing related technology areas.

34. Government should insist that all demos build business cases.
Need a library of compelling business cases to build interest / involvement on part of business.

Should this library be made available online? Yes!

What would it take to validate a business case? Acclaim, logic, a CPA, an industry council, ...?

Answer: Industry pilots judged by a single set of metrics.

Business cases should be made from the point of view of supplier firms, not just OEMs.

We must be careful here! Proposals must stand on their technical merit, and defining "business case" often becomes an exercise in creative writing. The ability to separate valid business case definition is critical.

35. Standards groups must provide seamless migratable new technology.
Who determines what is 'seamless'; who determines what is 'migratable'? Answer: Interoperability

How? Determined by the users.

Is consensus necessary; among whom? Also determined by the users.

Problems are:
- interpretation of "conforming" exchanges, organization-specific additions and interpretations.
- most "exchanges" are files or databases with more recipients and viewers than are formally identified in "interoperability" tests.

36. Government should establish a manufacturing programs advisory body.
Some agency (Commerce?) should establish a formal programs clearinghouse, along the lines of the ANSI CIM standards board, to identify the programs, the specific problems they are

addressing, and their planned deliverables. Ideally, the interactions should also be defined.

Is this another opportunity for an online forum?

37. Users must initiate a formal quasi legal user requirements organization.
What is quasi-legal (partly legal / partly illegal?; chartered versus incorporated?; purely philanthropic or based up commitments to donate resources; ? etc.)

38. SIMA will lead the creation of an integration architecture.
The major deliverable from the SIMA program will be a unified integration architecture and regional and virtual testbeds with national business cases for manufacturing software. SIMA should create a technical paper which examines the potential scope of "unified" and circulate it widely among industry vendors and manufacturers for comment and feedback -- perhaps via brief interactive electronic forums using the NII.

39. Industry must emphasize human, organizational & BPR changes in requirements.
Research on new integration technology and standards without coordination with teams working on BPR severely limits potential impact. NIST need not develop deep competence in this area but should build links to organizations working in this area (e.g., manufacturing. consulting firms (Booz, AT Kernney, etc.)

What would it cost NIST to pay various manufacturers for brief studies of business process reengineering implications derivative from new integration technologies? Would it be reasonable for SIMA to do this? How should 'various manufacturers' be selected? Could grants be issued versus contract competitions?

Focus on cross-organizational issues between customers and suppliers (e.g., concurrent engineering teams, supply-chain logistics management, etc.).

40. Disseminate standards information to users quicker.
Establish a system to quickly communicate the latest standards to users.

Is this another online forum item?
Answer: Yes.

How does one get identified as a user?
Answer: By subscription.

Are users who talk to the 'system' paid for taking the time to talk? What kind of advertising is needed to assure that the truly representative sample of
users are provided early with the latest standards information?

Understand the issue, but there is no definitive answer now.

40a. SIMA should enable its community to technically interact on NII.
The standards process should improve with wider visibility in to technical details of emerging standards. As SIMA works with these emerging standards, it should facilitate electronic technical interchange among members of the industry community who would otherwise be unfamiliar with the technical detail of the emerging standards. This could be used to encourage vendor commitment of personnel to interact with the standards process, as well as simply to advertise potential technology opportunities to industry.

41. Federal program managers should develop ways to acquire best non-U.S. thinking.
We need mechanisms for getting the best ideas from whatever source, worldwide.

CIA is working on this.

42. Technology development programs share deployment scenarios.
Technology development programs should share deployment and validation scenarios. This is important for both programs sharing a common technology approach and for those working on dissimilar strategies.

There is a good opportunity for the federal government to fund demonstrations of government-fostered and developed technology. This technology is critical for the "dual use" needs of the government.

This utilization is critical to industry and the assurance that it works is mandatory for the Government. The emphasis on "dual use" ignores the majority of manufacturers who operate strictly in the commercial sector and skews the discussion.

43. Industry consortia should take responsibility for managing development of standards.
Industrial groups should be the most motivated and best equipped to develop the business case for a prospective standard and manage the development in a fiscally responsible manner. They will also be the first to kill an effort that is not going anywhere.

Are industrial consortia accepted for such a role? We may need new players without questions of their track record.

44. SIMA should lead effort to facilitate workshop on Advanced Manufacturing Challenge under IITA.
Government should allow natural selection based on market selection. Many good ideas are suggested which sound plausible; as a result good men can disagree on approaches. Fair field testing can provide objective evidence for a fair decision process.

45. Provide program managers tools from project start-up (CASE).
Tools such as systems engineering and CASE tools are needed to assist program managers from the requirements stage.

Standard for requirements sharing and archiving among CASE tools would be helpful.

Should SIMA provide access to 'beta' level CASE tools, via World Wide Web / MOSAIC?, to members of the MSI programs community? Answer: Later

46. NIST should support industry consortia in working on standards.
NIST needs to support consortia by working on the management process, validation of standards, test beds, and conformance/interoperability testing.

Define "working on."
Supporting consortia, consulting, providing testbeds, and tools.

47. ATP should be open to programs focused on standards and industry pilots.
ATP could be the vehicle for funding industry groups to work on needed standards. Can corporations and companies propose to ATP that a 'formulation ideas' workshop should be held to identify topics in which industry groups should be funded by ATP for standards work?

48. NIST needs to look for roles in industry adoption.
NIST should avoid reports and workshops in favor of supporting industry in solving the problems of moving new technologies and business practices into the supplier base. This should include much closer coordination between MEL and MEP.

What are examples of NIST sponsored activities which would support solving problems of moving new technologies, etc., into supplier base?
Answer: Industry pilot programs, execution of pilots, providing testbeds, Agile castings initiative.

49. Standards process should be redefined.
Standards are developed and adopted by voluntary groups of very detailed technical people. The realities of economy and time are frequently of little concern to these excellent people. Standards development needs to be fostered by industry-led groups with user and vendor leadership - with a strong view of the business process.

Standards may need to establish high level views of inter-operability to avoid the pitfalls of the agonizing definition of details that have little impact.

50. Government and Industry support for ANSI.
Government and industry must provide MORE support for ANSI. We need a strong INDUSTRY LED standards organization.

51. Standards bodies should revamp procedures to expedite the process.
There are a number of actions that could be used to accelerate the process such as: increased use of the canvas method, electronic balloting, use of electronic forums for discussion, standards repositories for emerging drafts, and a long list. NSSN (an ATP) is a forum for some of these ideas.

52. The Government needs to make standards part of its efforts to reorganize.
Like any large business with a huge supplier base the government should re-engineer their procurement, support processes, and look at the critical standards needed. Every effort should be made to coordinate with and support commercial practices.

53. NIST should fund a repository of emerging process technologies.
The repository should describe the technology, its stage of development (e.g., academic research, industry applied R&D, pilot implementation, standard practice), integration requirements, and human contact points.
54. Formal standards activity should require a base document at start.
Too many standards development activities are researched by committee. What is needed is a document proposed as a standard and a vote to accept, reject, or polish it by committee within a fixed time frame, e.g., 2 years to get an acceptance vote or automatically drop the project. (This also destroys the "standards career" stuff.)

55. SIMA needs to decide if its ultimate role is to enable or to constrain.
Emerging standards, technology applications, vendor strategic thrusts, technical interaction, definition of an "MSI" community, "MSI" requirements, ...and a host of other possible activities and results -- SIMA then needs to publish the decision widely so that it can be known by how it intends to act.

56. SIMA and MEP should focus on broad/deep deployment to small/medium manufacturing firms.
If integration technology is to impact U.S. manufacturing, there is a need to get it into the small/medium firms that make up 80% of U.S. manufacturing, value added. The key to this is close cooperation with MEP.

SIMA should be responsive to the requirements of the SMEs and any testbeds should model the realities of distributed manufacturing in which SMEs participate. But SIMA should not be charged with the outreach activities that are the MEP's charter.

57. Increase SIMA budget

58. Government should establish R&D programs that deal with systems integration.
Most programs deal with R&D of discrete technologies, and systems integration issues do not rate high on the normal evaluation criteria for R&D. (This is analogous to the difficulty in doing multi-disciplinary research in academia; systems integration R&D does not fit in the boxes in which we generally think about R&D.)

59. WE should not plan forever, but have to get down to specifics early.
One of the characteristics of prior failed enterprise integration activities is a focus on high level activities, with specifics deferred to much later. We need to get down to reality as soon as possible.

Suggestion: Let SIMA "cooperate" with funded demonstrations in concrete ways as part of team (Agile Castings example).

WE = this group.

Should SIMA get "on-board" with other demonstration activities?60. SIMA and TEAM should formulate reference architecture for manufacturing software.
As a concrete step, SIMA and TEAM, possibly with assistance of CAM-I and other interested parties should formulate a proposed reference architecture for manufacturing software, i.e., identify software "systems" and the information interchanges required among them and with other enterprise systems. Formulating an "engineering architecture" -- HOW the interchanges will take place -- should follow and leverage NIIIP, et al.

Should also consider points at which information is distributed to the supplier for refinement.

There is the potential for SIMA to work with TEAM, NIIIP, and SEMATECH on this issue since SIMA has the individual collaborations in place already.

61. SIMA should establish a thrust area in distributed, enterprise systems.
The model for manufacturing systems adopted by SIMA should encompass the product realization processes, spanning the product lifecycle, recognizing that they stretch from the floor level to the enterprise level and that they can be expected to internationally, geographically disperse.

62. SIMA should establish a distributed set of Testbeds.
Internal facilitator linked via NII used for testing integration scenarios.

Engineering functions within organizations should be viewed as services to be made available to multiple constituents. SIMA should work on technologies that enable the distribution of these services.

63. Govt programs should agree on common mechanisms disseminating results.
To increase sharing of solutions, results need to be accessible and well structured to increase searching.

64. SIMA should enable the broad sharing of design/manufacturing information. SIMA should prototype data structures/objects (based on standard information schema), populate those structures, and validate by creating interfaces that allow application software to use the data.

65. SIMA should lead in development requirements for process data exchange standards.
There are aggressive non-U.S. activities (especially in Europe), oriented to process data exchange standards.

66. Place much more emphasis on market building to support standards.
Without a broad set of products that conform to an IT standard, it will not impact industry. More emphasis has to be placed on the role of vendors in carrying standards to the marketplace and users as the major purchasers in that market. This means that there has to be a lot more emphasis on marketing, awareness building, and gaining the consensus among end users that they will buy if the standard is completed.

The role of the Government is primarily a big user/buyer.

67. SIMA should focus on supply chain integration.
Most durable goods industries are characterized by well-established supply chains managed through contracting, release and payment mechanisms that have grown up over many years. Agility for these industries means creating and managing Agile supply chains. Agile supply chains is a necessary step in moving these industries to greater agility. New technologies, standards, and business practices are needed. The focus will be on reducing product development time, response to schedule changes, and inventory reductions.

APPENDIX G: Action Categories

To begin the categorization process, each participant is asked to prioritize and select the five most important action statements that address the focus question. The participants then group the actions that had more than two votes into similar categories. After the categories were formed, the remaining statements were also placed into categories. This process enabled the NIST SIMA IM Workshop participants to establish the nine action categories shown below.

ACTION CATEGORIES

Focus Question: In the context of advancing information technology for manufacturing systems and improving the effectiveness of the set of related programs, what are the actions that would overcome these problems?

1. Identify Requirements

Identify and publicize industry requirements for manufacturing application, data, and user integration.

- SIMA should establish an industry steering group (11).
- Federal program managers should develop an integrated requirements process (8).
- NIST should conduct regional workshops to develop requirements (16).
- Electronic posting of industry requirements (21).
- Industry must emphasize human, organizational, and BPR changes in requirements (39).
- Users must initiate a formal quasi legal user requirements organization (37).
- Government must take a more pro-active role and work with users (17).

2. Define MSI Strategy

MSI Strategy (* indicates statements made but not voted on)

* Include strategic direction, goals, roadmap, vision, and role.
* Address new kinds of manufacturing organizations, seamless & migratable technology and R&D for systems integration.
* Use of workshops (industry and related programs).

- Joint industry, End user, Government task force develop strategic definition for Manufacturing

Industry Infrastructure (10).

- SIMA should lead related programs workshop to define technical roadmap (22).
- SIMA decides if its ultimate role is to enable or to constrain (55).
- Industry roadmaps will be created by product, process, and sector (28).
- Federal program managers should commission studies of new manufacturing organizations (31).
- Standards groups must provide seamless migratable new technology (35).
- Government should set up "national repository" of Integration Technologies enablers (20).
- NIST should conduct a series of standard operating actions & standard operating practices workshops (15).

- Government should establish R&D programs that deal with systems integration (58).

3. Execute Technical Elements

(With other programs) Specify and implement Reference architecture for MSL; encompassing design, Manufacturing engineering, and production information sharing. The specification should include relationship to other activities of the manufacturing organization and to interchanges with supplier.

- SIMA and TEAM should formulate reference architecture for manufacturing software (60).
- SIMA will lead the creation of an integration architecture (38).
- SIMA should establish a thrust area in human/machine system integration (23).
- SIMA should establish a distributed set of Testbeds (62).
- SIMA should enable the broad sharing of design manufacturing information (64).
- SIMA should establish a thrust area in distributed, enterprise systems (61).
- NIST should fund a repository of emerging process technologies (53).

4. Coordinate Program(s)

SIMA will coordinate its activities with other programs in planning/execution, deployment, and technology transfer.

- NIST will host an information repository for programs (19).
- Program Managers trained in Requirements Specification & Analysis (12).
- Government must closely synchronize separate branch and agency initiatives (33).
- Technology development programs share deployment scenarios (42).
- Government should insist that all demos build business cases (34).
- Government should establish a manufacturing programs advisory body (36).
- Provide program managers tools from project start-up (CASE) (45).
- ATP should be open to programs focused on standards and industry pilots (47).
- Government programs should agree on common mechanisms disseminating results (63).
- Federal program managers should develop ways to acquire best non-U.S. thinking (41).
- SIMA should exchange technical staff with Industry collaborators & other Government programs (32).
- WE should not plan forever, but have to get down to specifics early (59).

5. Define Technical Performance Metrics

- All should define technical performance metrics for integration technology architecture (13).

6. Improve Standards Process

SIMA will work with Industry to identify and gain adoption of standards process improvements to accelerate and improve relevance of standards.

USE:

-industry consortia

-adoption of defacto standards

- Government should fund additional core STEP development and testing (6).
- Government programs should consider use of defacto standards (3).
- Industry consortia should take responsibility for managing development of standards (43).
- Government and Industry support for ANSI (50).
- Government take a greater role in the international standards process (27).
- Government/Industry/Vendors consortium funds standardization activities (5).
- NIST should support industry consortia in working on standards (46).
- Disseminate standards information to users quicker (40).
- Standards Developer (i.e. Application Protocol) should be required to show evidence of implementation (24).
- Formal standards activity should require a baseline document at start (54).
- Standards process should be redefined (49).
- Standards bodies should revamp procedures to expedite the process (51).

7. Promote Industry Adoption: Technical Activities

Work with individual pilots to develop technical migration path from legacy systems, focusing on supplier chain integration.

Programs provide technology migration paths from legacy systems (29).
NIST/SIMA should participate in and support efforts such as Agile BAA (4).
SIMA should focus on supply chain integration (67).

8. Promote Industry Adoption: Organization and Management Activities

Initiate SIMA project activities that support adoption and use of compatible technologies, standards, and business practices among teams of customers and suppliers.
Specifically support industry pilots; Reengineering of federal government procurement activities and deploy results through the MEP program.

- SIMA should work with Industry consortia to define business case scenarios and metrics for demos (1).
- Industry should provide scenarios for technology deployment (26).
- NIST needs to look for roles in industry adoption (48).
- Government must lead, establish, and enforce standards (7).
- SIMA and MEP should focus on broad/deep deployment to small/medium manufacturing firms (56).
- Industry identify target organizational structure (14).
- Government agencies should educate program managers on standards (FIPS) (18).
- SIMA should lead effort to facilitate workshop on Advanced Manufacturing Challenge under IITA (44).

9. Promote Vendor Commercialization

The SIMA program will be executed to promote manufacturing systems integration (MSI) solutions (which are built with STEP APs and defacto standards) with a clear path to commercialization.

- Vendors propose, adopt defacto standards (2).
- Place much more emphasis on market building to support standards (66).
- NIST must assist in the development more specific STEP application protocols (25).
- SIMA to facilitate demos of technology solution to MSI problems (9).

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[6] Ibid, p. 2.

NIST PROGRAM

Systems Integration for Manufacturing Applications (SIMA)

The NIST program in support of the National Information Infrastructure (NII) and the government initiative on Information Infrastructure Technology and Applications (IITA)

Information Infrastructure Technology and Applications (IITA)

Focus: Advanced Manufacturing

- Supports work in advancing manufacturing technologies through HPCC capabilities in:
  - Design, Planning, and Production
  - Quality Control, marketing & user services
- Develop infrastructure necessary to make information accessible
- Demonstrate capabilities through testbeds integrated on the NII

Research Areas:

- Concurrent Engineering
- Protocols for electronic exchange of product data
- Virtual design technologies

SIMA Program Objectives

- Develop technology solutions which support the integration of design, planning, and production applications.
- Assist industry with the development and implementation of information exchange standards
- Provide testbeds which support technology development and promote industry collaborations

NIST Role

Assist Industry by...

- **Producing new methods for developing standards for integrating manufacturing systems.**
- **Developing, demonstrating and recommending prototype standards**
- **Leading national and international standards efforts**
- **Producing test methods and services for information exchange standards**
- **Performing research on infrastructure technology**

Program Status

- Initiated November 93
  - Eight NIST laboratories (20 projects)
- Established program office and council
- Completed first year review September 94
  - Focused MEL program around three major areas :
    - Infrastructure Technologies, Testbeds & Technology Transfer, Standards
    - Mechanical products
  - Underscored need for
    - Program Roadmap
    - External collaborations

Manufacturing Engineering Laboratory Focus !!

- MECHANICAL (Workshop Scope !!)
  - Design, Planning and Production Applications
  - Integration Mechanisms
  - Standards
- APPAREL (MEL)
- PROCESS PLANTS (BFRL)
- ELECTRONICS (EEEL)

MEL Program Focus Areas

Infrastructure Technologies

- Defining architectures, interface protocols, and other specifications for integrating manufacturing applications

Standards Development

- Developing tools and testing of emerging interface standards for product and process data exchange

Testbeds & Technology Transfer

- Developing facilities to support and promote NII access, technology testing, industry collaborations, and information dissemination.

Infrastructure Technologies

Goals:

- Develop, test and implement solutions to achieve manufacturing data integration across engineering applications such as design, planning & production using:
  - systems architecture for product and process data exchange (ex: CORBA)
  - interface specifications and communication protocols (ex: SDAI)
  - new methods of deploying information models for manufacturing processes & resources (ex: OODB)

Infrastructure Technologies

Target Milestones

- Demonstrate a base implementation of integrated software applications for design, planning and production
- Demonstrate integrated set of computer based process models supporting design, planning, and production of mechanical parts
- Demonstrate on-line visualization laboratory through user interface technologies for manufacturing applications
- Define requirements, develop reference models and architectures, specify interface designs in the domains of mechanical manufacturing and process plants

Standards Development

Goals:

- Develop and assist industry with the implementation of information exchange standards to support:
  - Sharing of product data across commercial software systems
  - Development of application protocols for STEP
  - Methods and procedures used to validate commercial implementations of STEP
  - Accreditation of testing laboratories
  - Manufacturing process data exchange

Standards Development

Target Milestones

- Demonstrate conformance testing accreditation and certification procedures
- Demonstrate implementation of remote access to integrated application protocol development environment using AMSANT
- Initiate new standards support in areas of process modeling, systems architectures, standards harmonization (STEP/EDI)

Testbeds &Technology Transfer

Goals:

- Construct NIST wide distributed Advanced Manufacturing Systems and Networking Testbed (AMSANT) equipped with:
  - High speed communications network
  - Manufacturing software systems
  - Advanced computing hardware
- to support:
  - Technology and standards development
  - Industry collaborations & collaboratories concept
  - Electronic information dissemination
  - Virtual Manufacturing Demonstrations

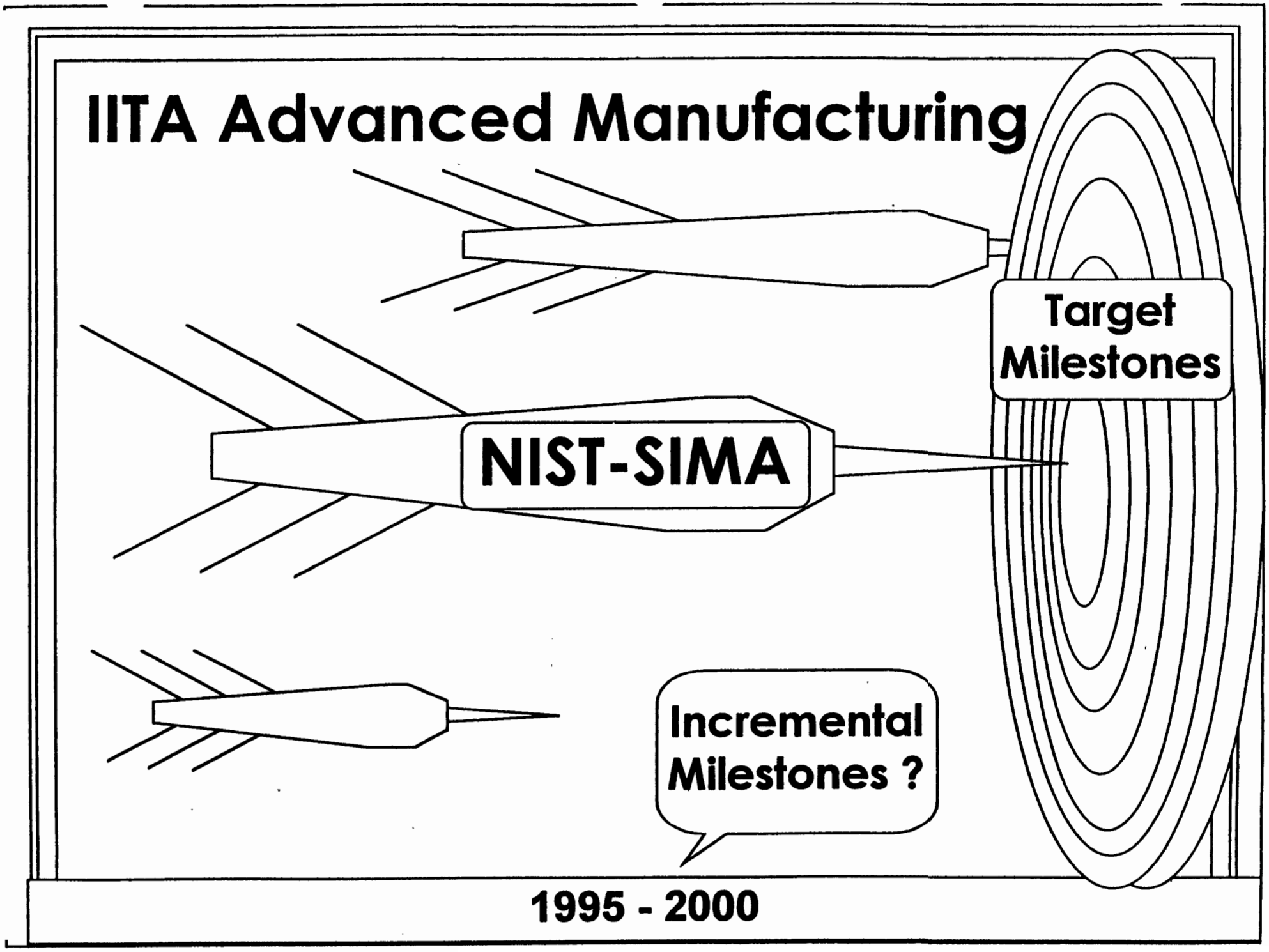
Testbeds &Technology Transfer

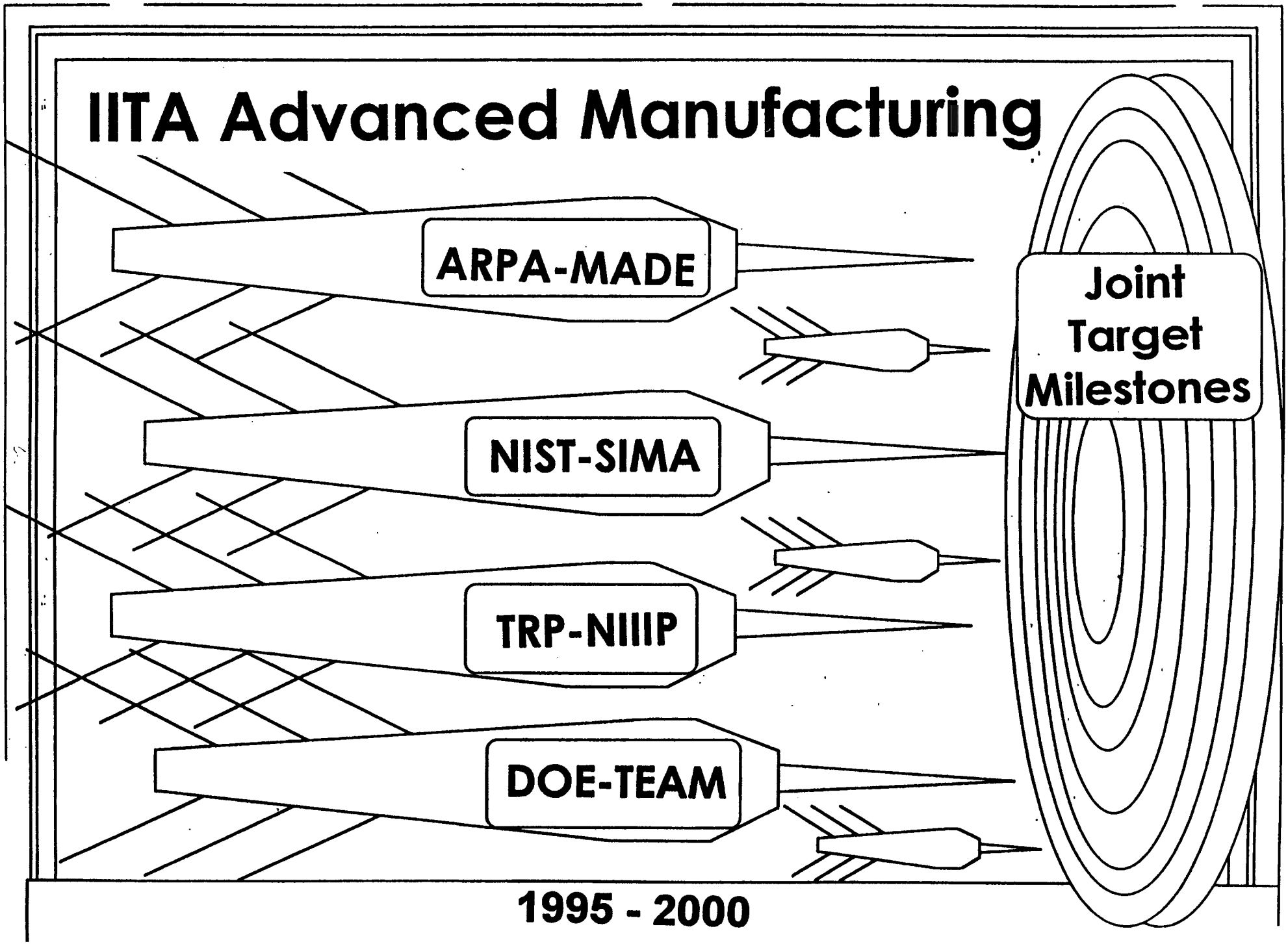
Target Milestones

- Demonstrate two operational AMSANT's for mechanical, and process plant Industries within NIST.
- Perform remote experiments with industry and other agency collaborators on manufacturing software systems.
- Implement advanced networking and communications with external testbeds, extend software applications & tools
- Implement an infrastructure for electronic information dissemination
- Establish one or more focused collaboratories (process planning, design, or production)

Summary

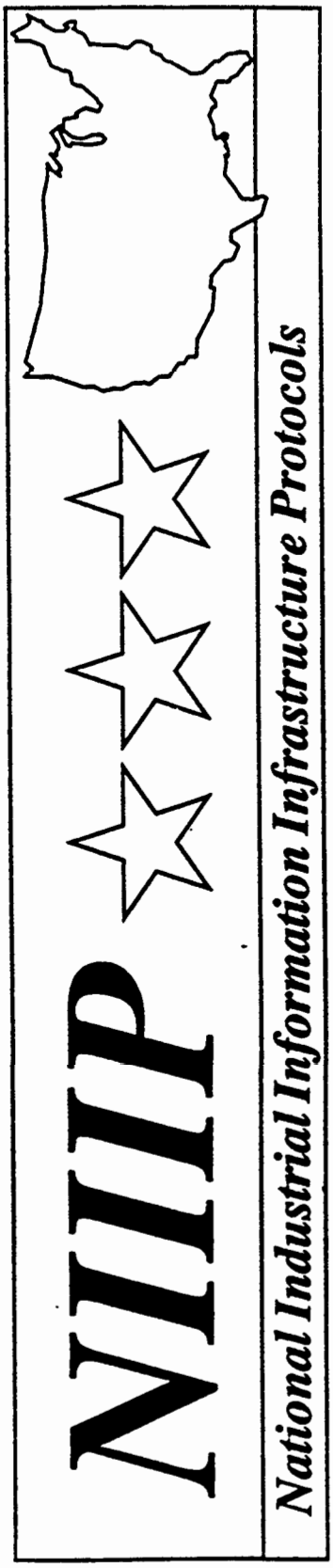
- Overview of SIMA program
- MEL focus is on mechanical environment
  - Integration of design, planning & production applications
  - Protocols for electronic exchange of product data
  - Infrastructure to make information accessible
- Defined three major thrusts
  - Infrastructure technologies
  - Standards development
  - Testbeds & technology transfer
- Identified five year target milestones


IITA Advanced Manufacturing
Target Milestones
NIST-SIMA
Incremental Milestones ?
1995 - 2000


IITA Advanced Manufacturing
ARPA-MADE
NIST-SIMA
TRP-NIIIP
DOE-TEAM
Joint Target Milestones
1995 - 2000

CALL TO ACTION !!!

- Is SIMA on target with proposed milestones ?
- What incremental milestones must happen to support goals ?
- Are the proposed target milestones in line with industry needs ?
- What other programs can be leveraged ?
- How do we do work together ?


NIIIP
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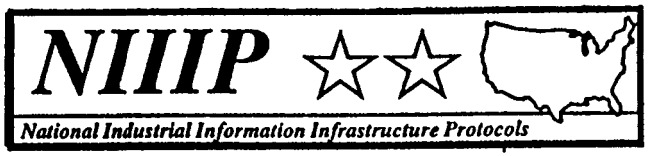


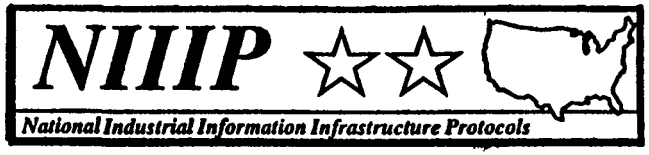
NIIIP Project - Overview

- Vision
- Goals
- Objectives
- Who is NIIIP Consortium
- What is NIIIP
- DOD Benefits
- Path to Products
- Management Structure
- Success Criteria

NIIIP
National Industrial Information Infrastructure Protocols

NIIIP Vision

- The NIIIP Vision is to enable the Virtual Enterprise across the U.S. industrial base.
- The NIIIP will enable innovative suppliers throughout America's industrial base to come together without regard for size or organizational, geographic and technical boundaries to provide the most cost effective and competitive products and services in the world.
- The NIIIP will allow individuals, enterprises and organizations, or their subdivisions, to assemble themselves into Virtual Enterprises in order to provide products, services, or solutions without being constrained by the use of different data, processes, information technologies or computing environments.



NIIIP TRP Goals

- **Establish an open, standards based software infrastructure protocol which will integrate heterogeneous and distributed processes, data, and computing environments across the U.S. manufacturing base.**
- **Document and distribute the NIIIP reference architecture and technology needed for a Virtual Enterprise to interested parties using the national information infrastructure.**
- **Implement NIIIP from emerging, existing and defacto standards and information system technology by selecting, exploiting, integrating and promoting those elements that facilitate Virtual Enterprises.**

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NIIIP TRP Goals *(cont'd.)*

- Demonstrate the feasibility and practicality of NIIIP through pilot projects in both commercial and defense enterprises.
- Accelerate consensus on standards that promote deployment of the Virtual Enterprise.
- Provide the technical foundation for practical implementations of Virtual Enterprises and actively promote its commercialization.

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Consortium Objectives & Approach

■ NIIIP Objectives

- Promote deployment, commercialization and use of NIIIP across the U.S. industrial manufacturing infrastructure.
- Enable modernization of legacy manufacturing information systems through process and object oriented technology in order to preserve existing investments.
- Provide functionality and usability such that end users can readily participate in the Virtual Enterprise.
- Encourage widespread adoption of NIIIP technology by minimizing barriers to its use by software vendors, systems integrators and end users.

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Consortium Objectives & Approach *(cont'd.)*

■ Approach

- Establish the NIIIP Consortium as a Virtual Enterprise through the use of existing consortium technology and incremental development.
- Manage and integrate the consortium work into a cohesive and tangible result in an impartial, cost effective and timely manner utilizing the NIIIP project office.
- Use spiral development techniques, to reduce development time and risk, to produce appropriate technology and functionality that demonstrates tangible results quickly.

NIIIP

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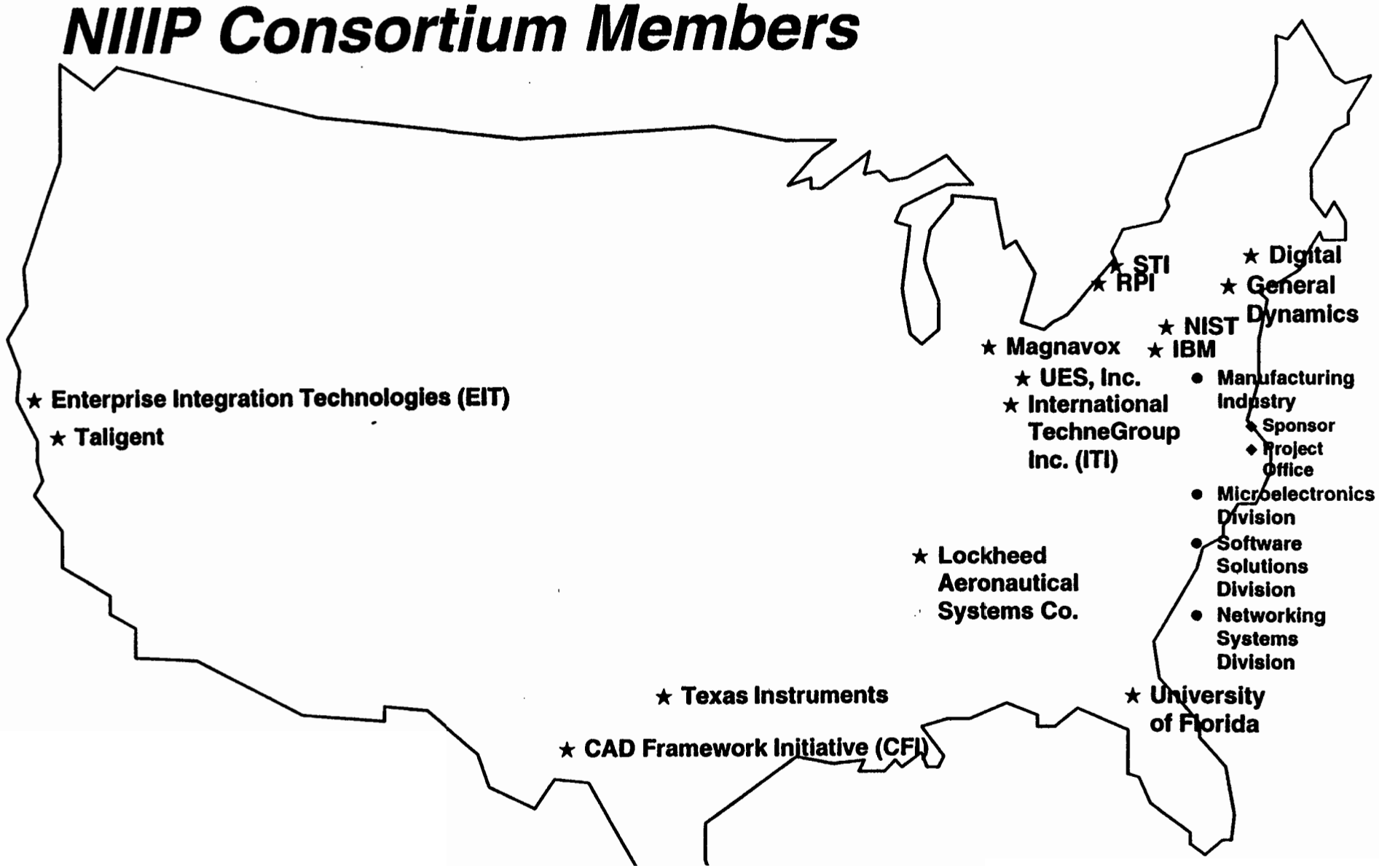
NIIIP Consortium Members



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What is NIIIP?

- **Industrial Information Infrastructure**
  - **NIIIP is Interoperability**
  - **Enables the Virtual Enterprise**
    - **Removes Barriers**
    - **Promotes Teaming/Cooperation**
  - **Integrates/Interoperates**
    - **Processes**
    - **Data**
    - **Computing Environments**
  - **Focus on the Industrial Domain**
    - **Product and Process Information**

NIIIP
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What is NIIIP? (cont'd.)

- **National**
  - **Scalable**
    - **Small to Large**
  - **Usable**
    - **Implementers**
    - **End Users**
    - **Feasible/Practical**
  - **Available**
    - **Public Forums**
    - **Open Architecture**
    - **Technology Transfer**
    - **Standards**
    - **Pre-Competitive**

NIIIP
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What is NIIIP? (cont'd.)

- **Protocols**
  - **Rules of Behavior**
  - **Adopted/Implemented by Choice**
  - **Public**

NIIIP Path to Product

- **Spiral Development**
  - Iterative Development
  - Incremental Increases in Function
  - Reduced Risk
  - Rapid Prototyping
- **Reference Architecture**
  - Defines NIIIP
  - Framework for Consortium
    - Distributed Development
    - Guide for Implementation of VE
- **NIIIP Toolkit/Enabler Development**
  - Virtual Enterprise Toolkit
  - PDES/STEP Toolkit
  - Internet Enabler

NIIIP Path to Product (cont'd.)

- **NIIIP/CIM Enabler**
  - Enables to Virtual Enterprise
  - Builds on Existing CIM Environments
  - Proof of Concept
  - Systems Integration
- **Pilots/Prototypes**
  - NIIIP Consortium as a Virtual Enterprise
  - Commercial/Defense Pilots
  - Research Prototypes

NIIIP Path to Product (cont'd.)

- **Technology Transfer/Acceptance**
  - **Public Forums**
  - **Standards Convergence/Acceleration**
  - **Project Documentation**
- **Deployment**
  - **Education**
  - **Commercialization**

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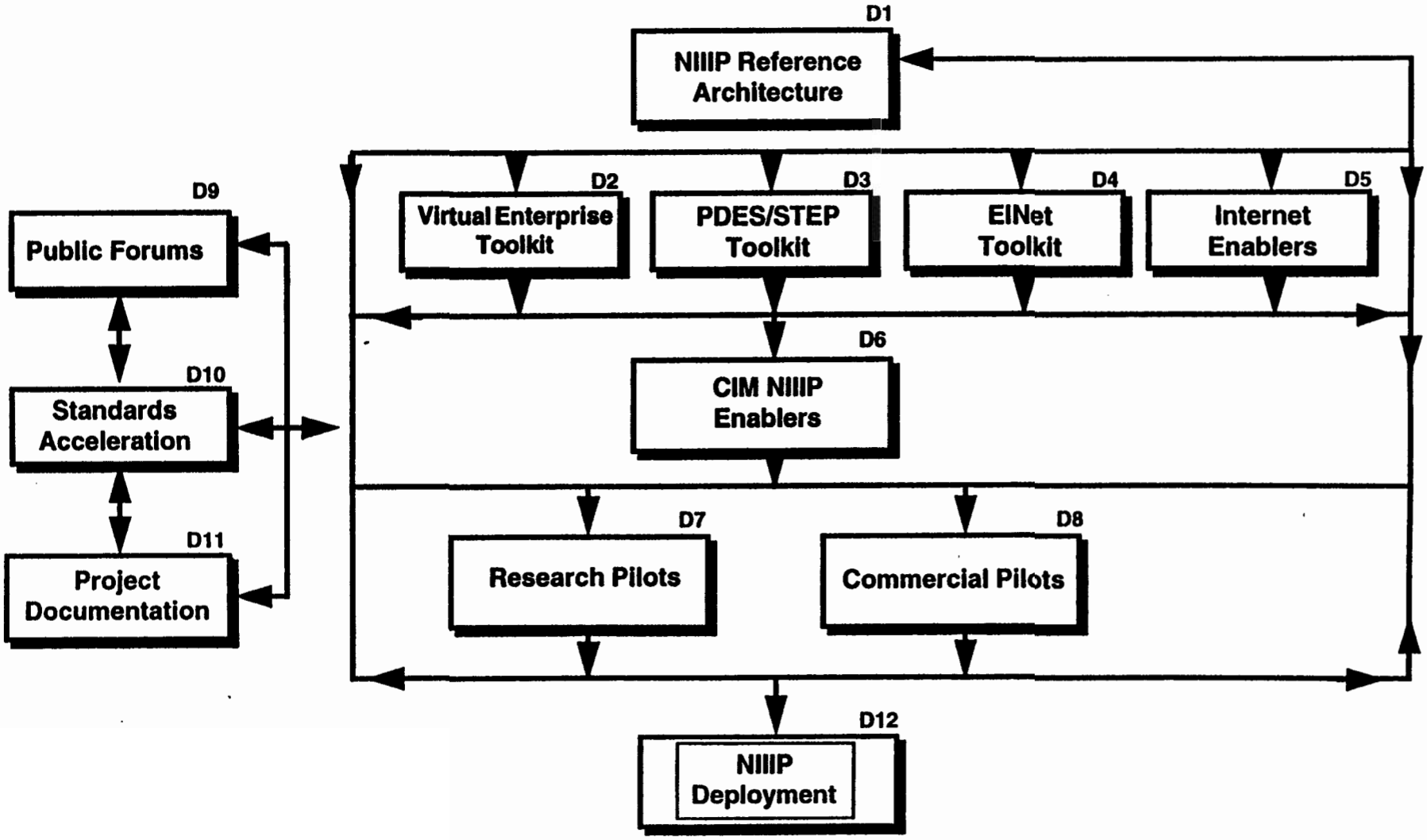
NIIIP Deliverables



NIIIP
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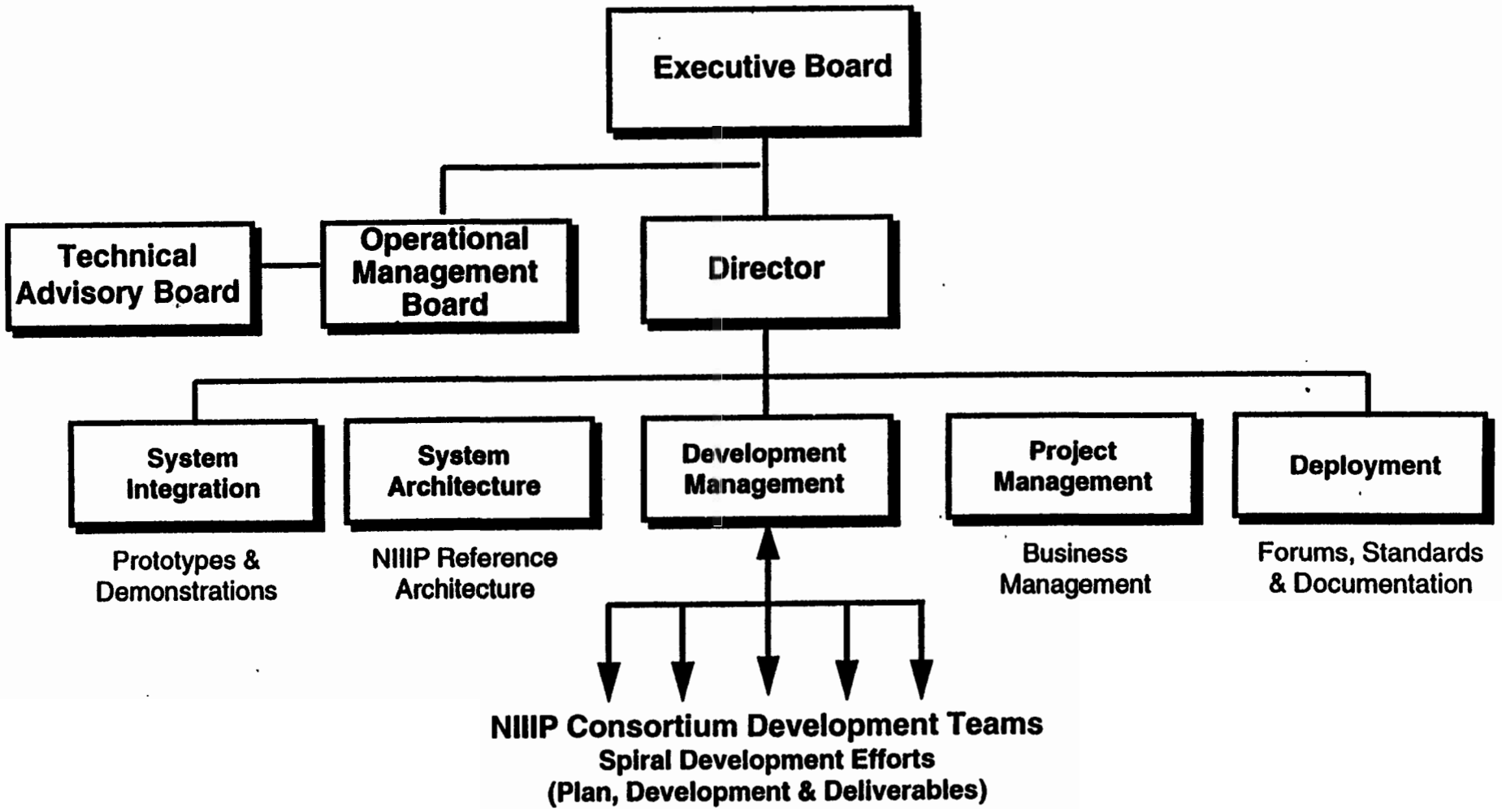
NIIIP Project Management



NIIIP
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NIIIP Project - Success Criteria

- **Phase I - 7/94 - 6/96**
  - **Technical**
    - **Deliver Reference Architecture**
    - **Deliver Toolkits/Enablers**
    - **Demonstrate Integration**
    - **Pilot Virtual Enterprise**
    - **Standards Submission**
  - **Marketplace**
    - **Endorsement by Pilots**
      - **Follow-on Commitments**
    - **Forum Activity**
    - **Conference Attendance**

NIIIP
National Industrial Information Infrastructure Protocols

NIIIP Project - Success Criteria

- **Phase II - 7/96-6/98**
  - **Technical**
    - **Standards Acceptance**
    - **Full Virtual Enterprise Capability**
    - **Taligent Agile Manufacturing**
  - **Marketplace**
    - **Commercial NIIIP Products**
    - **Enabled Software**
      - **End User**
      - **Operating Systems/DMBS**
    - **Support Structure**
      - **Education**
      - **Consulting/Services**
    - **Full Implementation of VE**
      - **10 Virtual Enterprises**

VISION

Increasing global competition and technological advances are creating a dramatic shift in manufacturing technologies and business practices. These changes require more competitive manufacturing enterprises, with core business strategies focused on assuring the ability to succeed in an environment of continuous, dynamic change. Enterprise survival will depend increasingly on the ability to respond quickly to demands for high-quality, market-driven products at the lowest possible cost.

MISSION STATEMENT

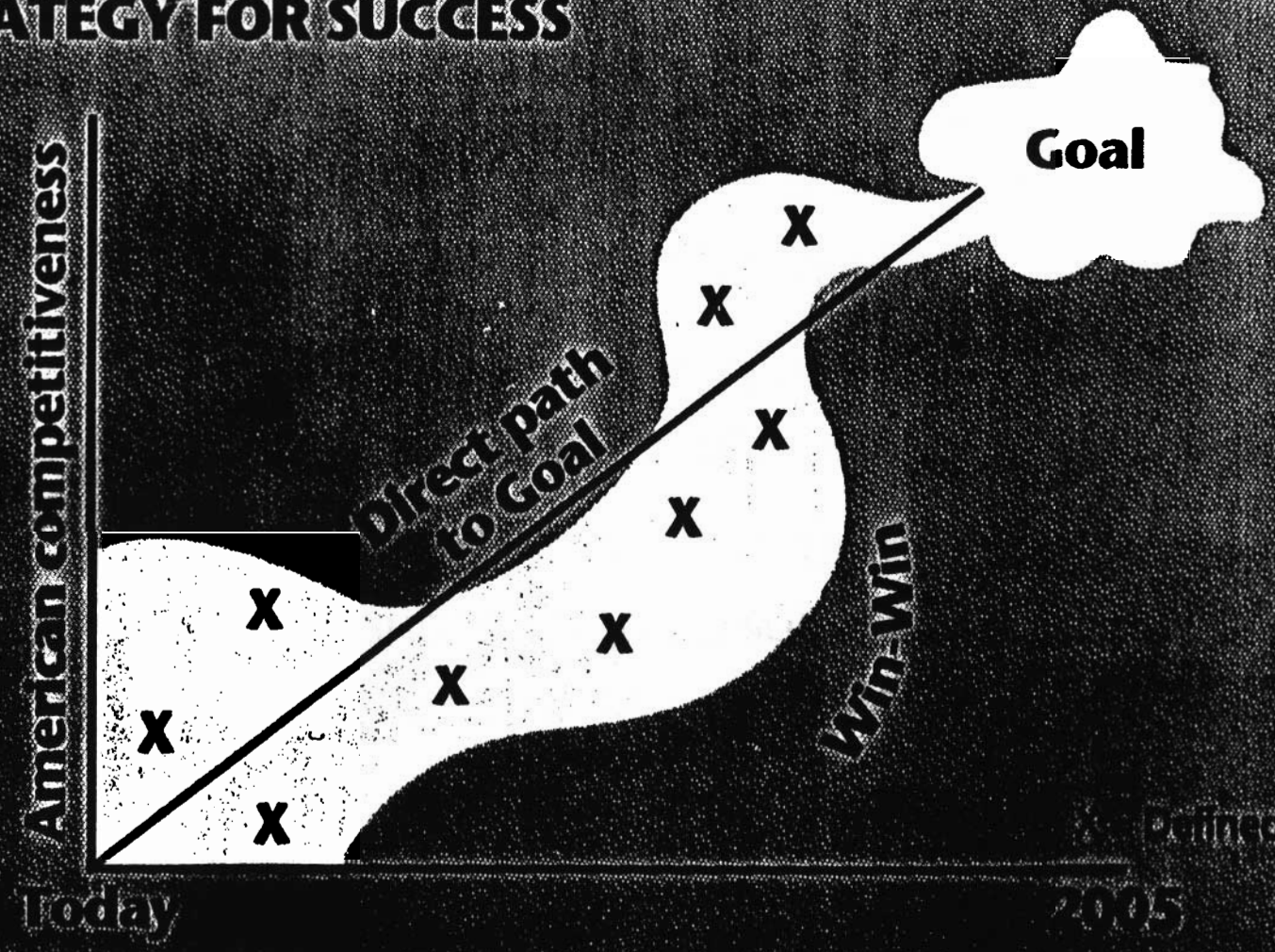
The mission of TEAM is to provide American industry with the critical, enabling technologies needed to implement Agile Manufacturing concepts that will enhance the global economic competitiveness of U.S. industries. TEAM will develop and demonstrate solutions to high-priority needs of industry, and bring the enabling technologies to the point of commercialization for widespread implementation.

GOALS

By the year 2000, TEAM will develop, validate, and deploy technologies that enable an information-driven, agile industrial base. Key goals are to:

- Integrate design and manufacturing processes to streamline product development, thus reducing costs, enhancing quality, and shortening time-to-market
- Provide robust, flexible, modular tools that are readily accessible and implementable
- Maximize near-term deployment of enabling technologies within the evolving framework of TEAM's long-term vision

A STRATEGY FOR SUCCESS



- Satisfy today's needs
- Keep solutions consistent with the path to the future

TEAM Will Deliver

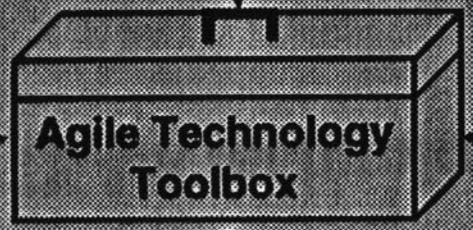
- Enabling Technology Toolkit
- Implementation of Toolkit in a virtual enterprise (backbone for agile, virtual enterprises)
- Validating demos of TEAM technologies via Product Vehicles
- Low-cost, easy access to capabilities needed by industry – but not configured for value-added exploitation

TEAM CONCEPT

Technology Backbone for Integrated Agile Enterprise

- **Product Design & Enterprise Concurrency**
- **Virtual Manufacturing**
- **Manufacturing Planning & Control**
- **Intelligent Closed-Loop Processing**
- **Integration**

Thrust Area Teams



Government Agencies, National Labs, and Consortia

- Contribute to requirements definition
- Provide resources to support technical agenda

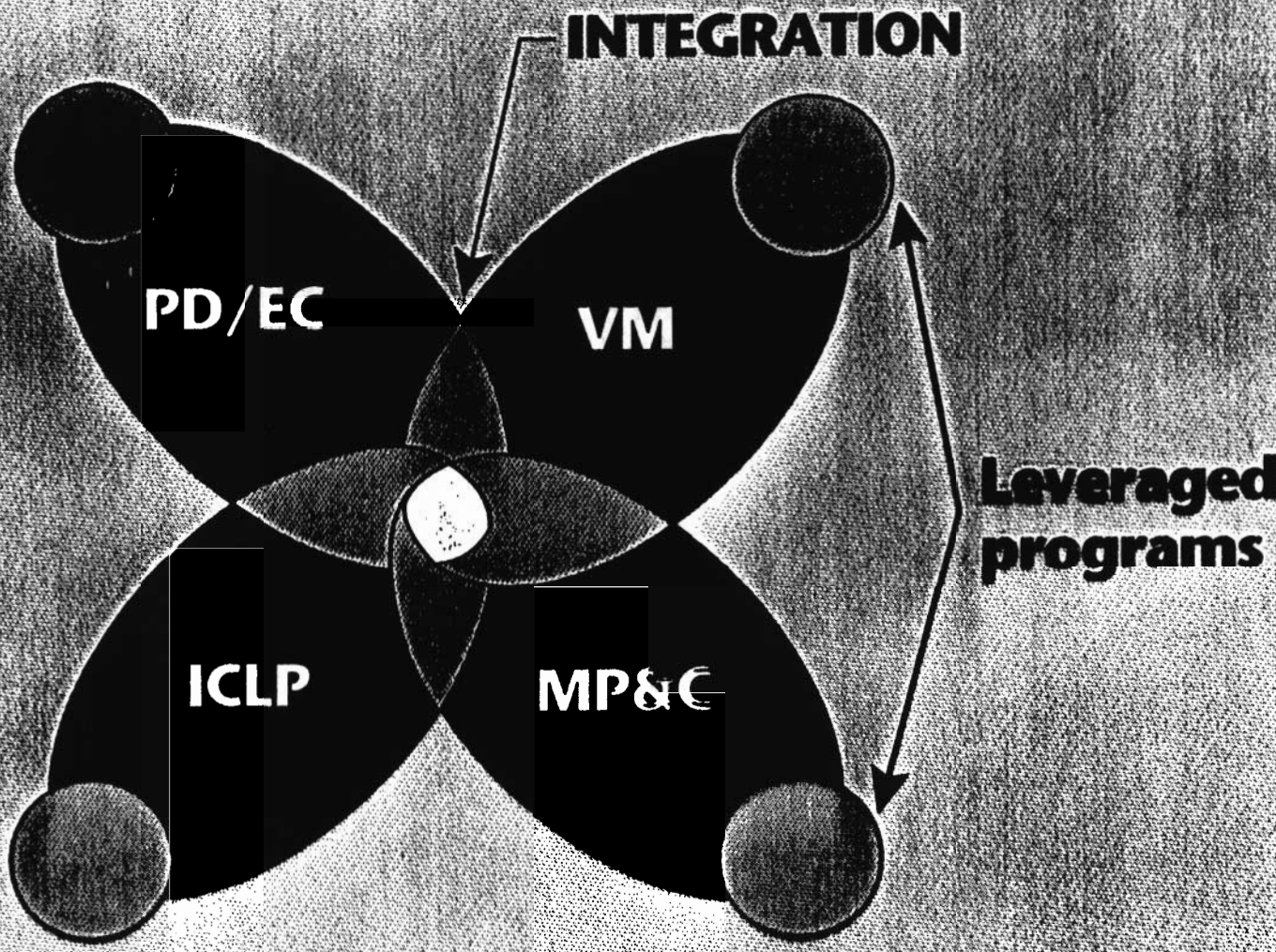
Technology Suppliers

- Provide tools for task teams
- Develop extensions/modifications to optimize agility
- Develop new, agile products
- Commercialize new and improved tools

Industry Partners (Technology Users)

- Define technical agenda requirements
- Contribute to accomplishment of thrust area tasks
- Host demonstrations to validate tools/approaches
- Draw on TEAM technologies as needed based on
  - competitive demands
  - investment vs ROI
  - company-specific tools and process needs

THRUST AREAS ARE TOOLS FOR FOCUSED YET UNITED RESPONSE:

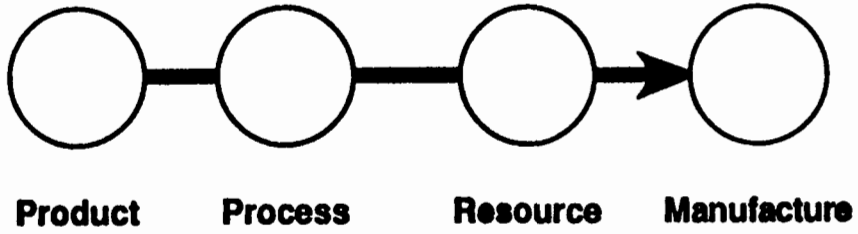


TEAM is a PROGRAM

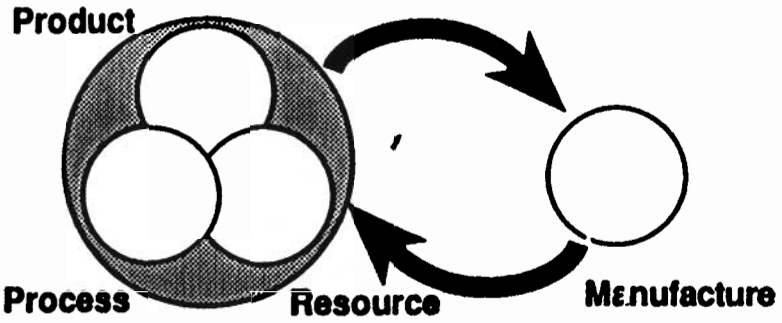
	Core	Milling	SM	EM
PDEC	√	√		√
VM	√	√	√	√
MPC	√	√		
ICLP	√	√	√	
INT	√			

TEAM: Deploying Technologies That Make an Impact on How We Do Business

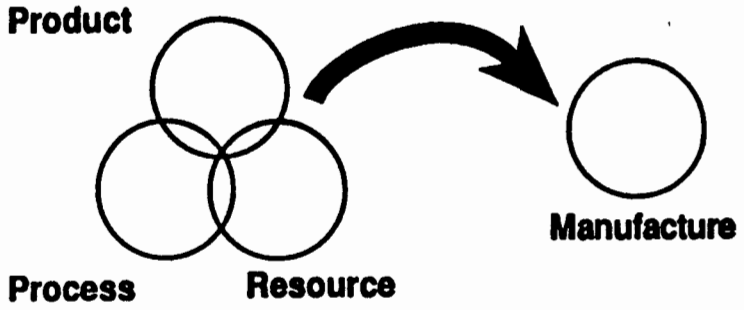
PAST



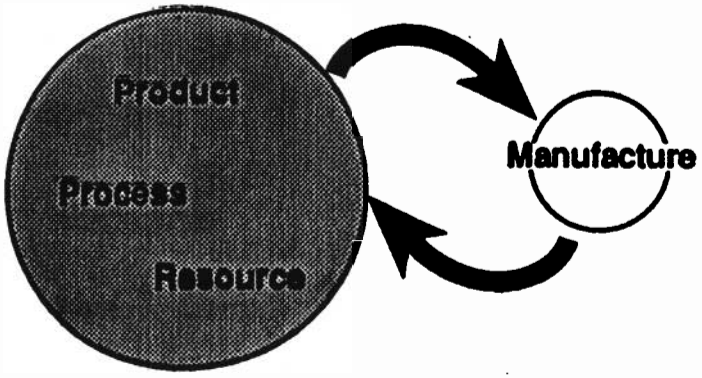
STATE/EDGE OF THE ART

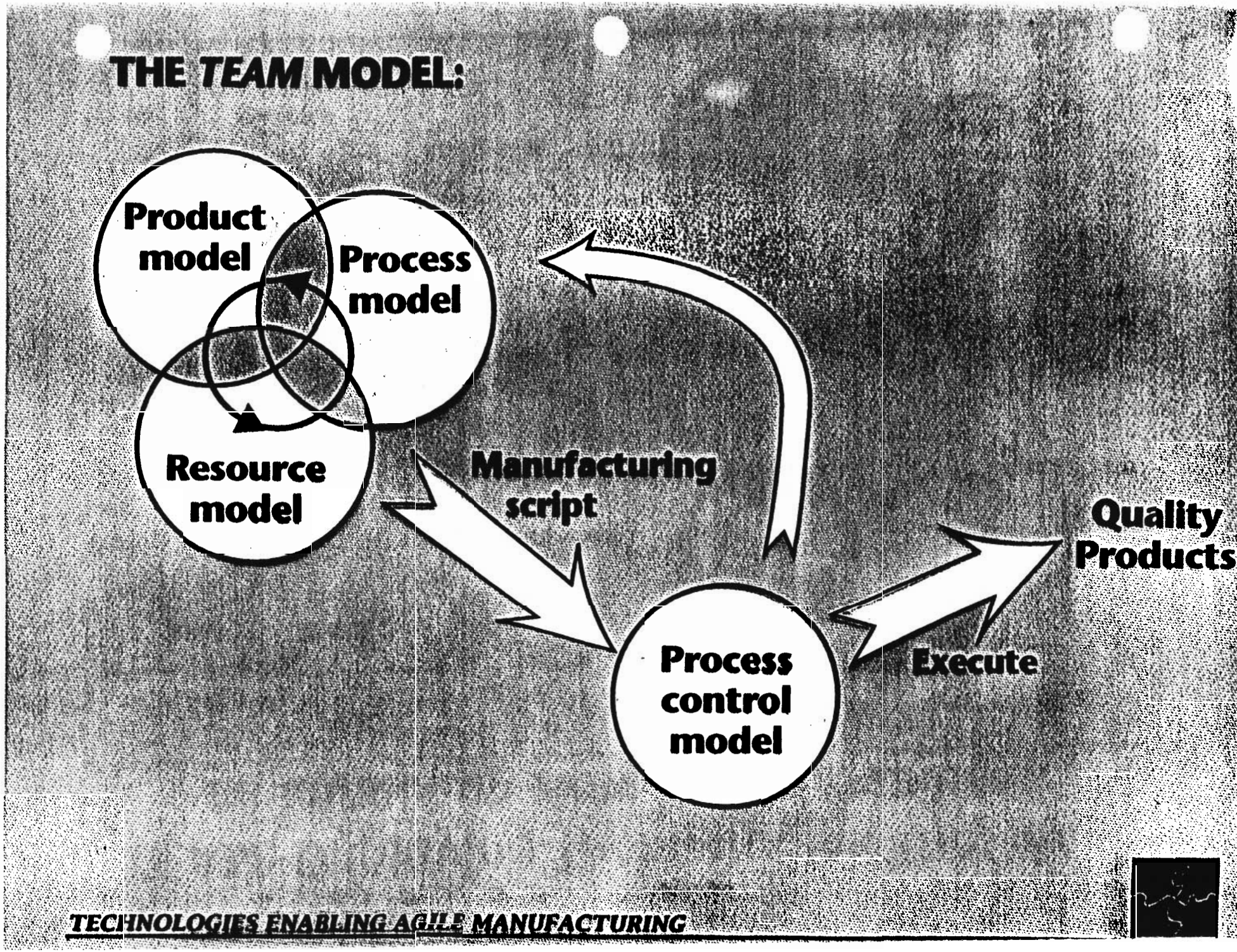


STATE OF PRACTICE

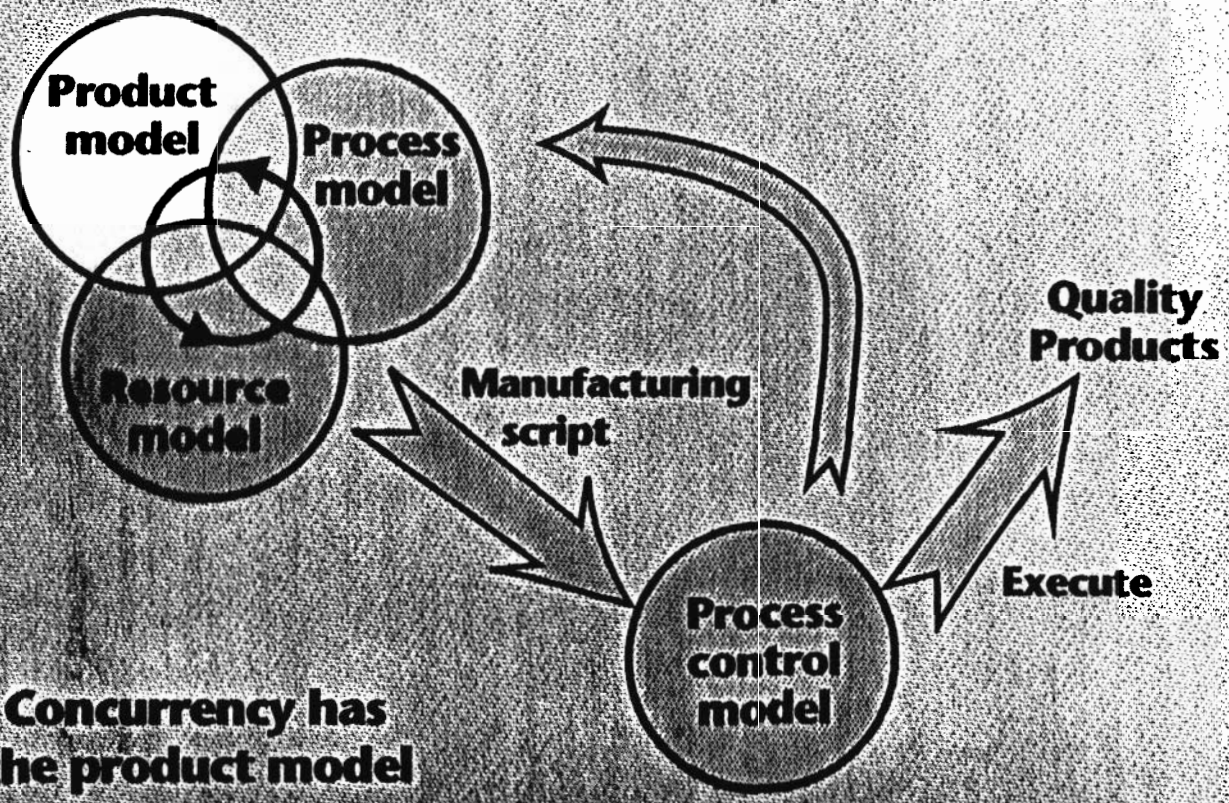


THE FUTURE




THE TEAM MODEL:
Product model
Process model
Resource model
Manufacturing script
Process control model
Execute
Quality Products

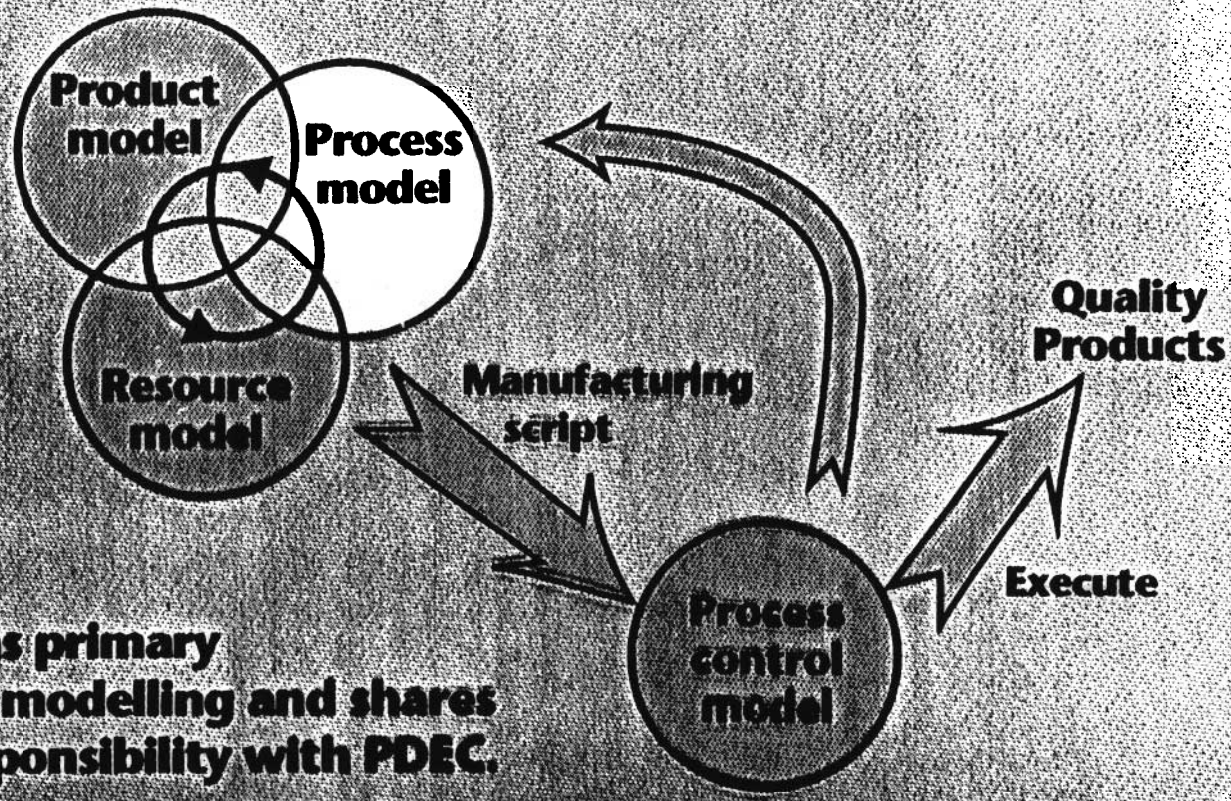
THE *TEAM* MODEL:



Product Design/Enterprise Concurrency has primary responsibility for the product model and the concurrent environment.

- **Receives process cost and performance information fron the process model**
- **Receives resource availability and performance information from the resource model**

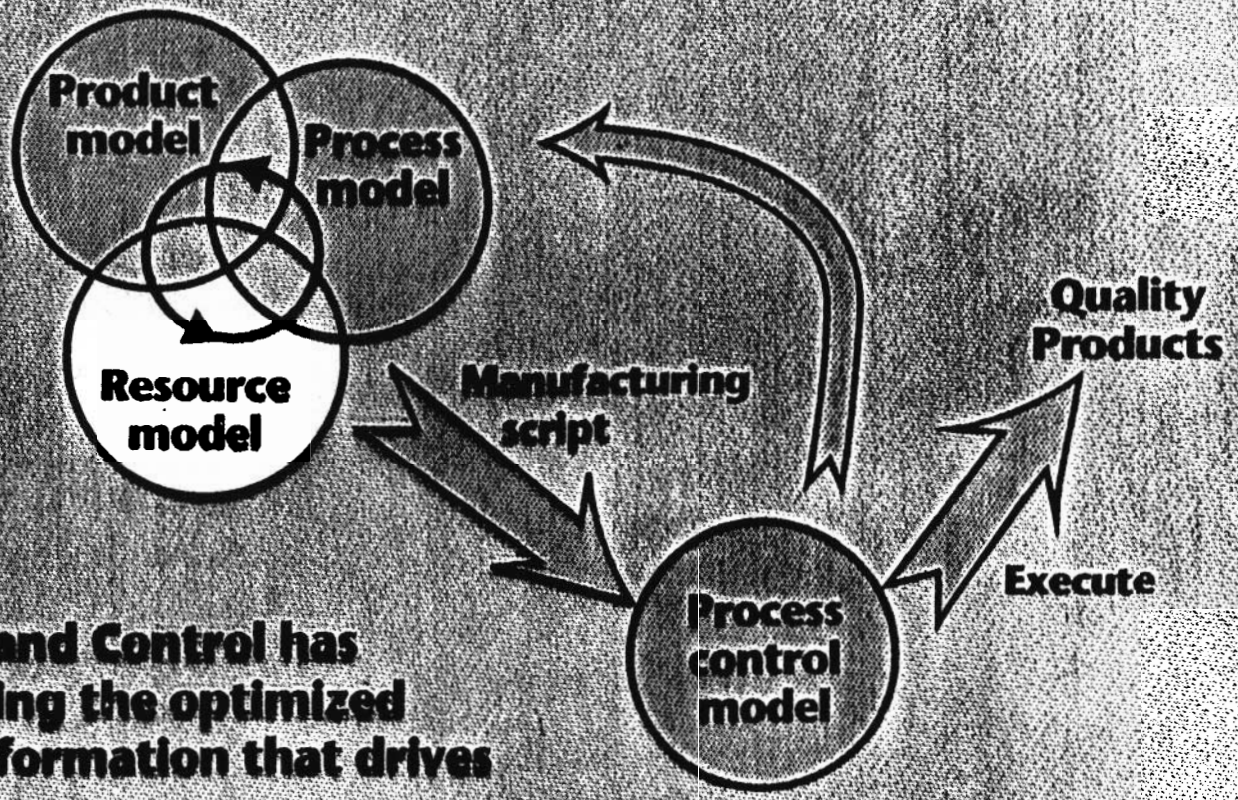
THE *TEAM* MODEL:



Virtual Manufacturing has primary responsibility for process modelling and shares product performance responsibility with PDEC.

- **Interactively assesses manufacturability for conceptualization.**
- **Optimized for cost, performance, resource availability, etc.**
- **Provides parameters for the process control model**

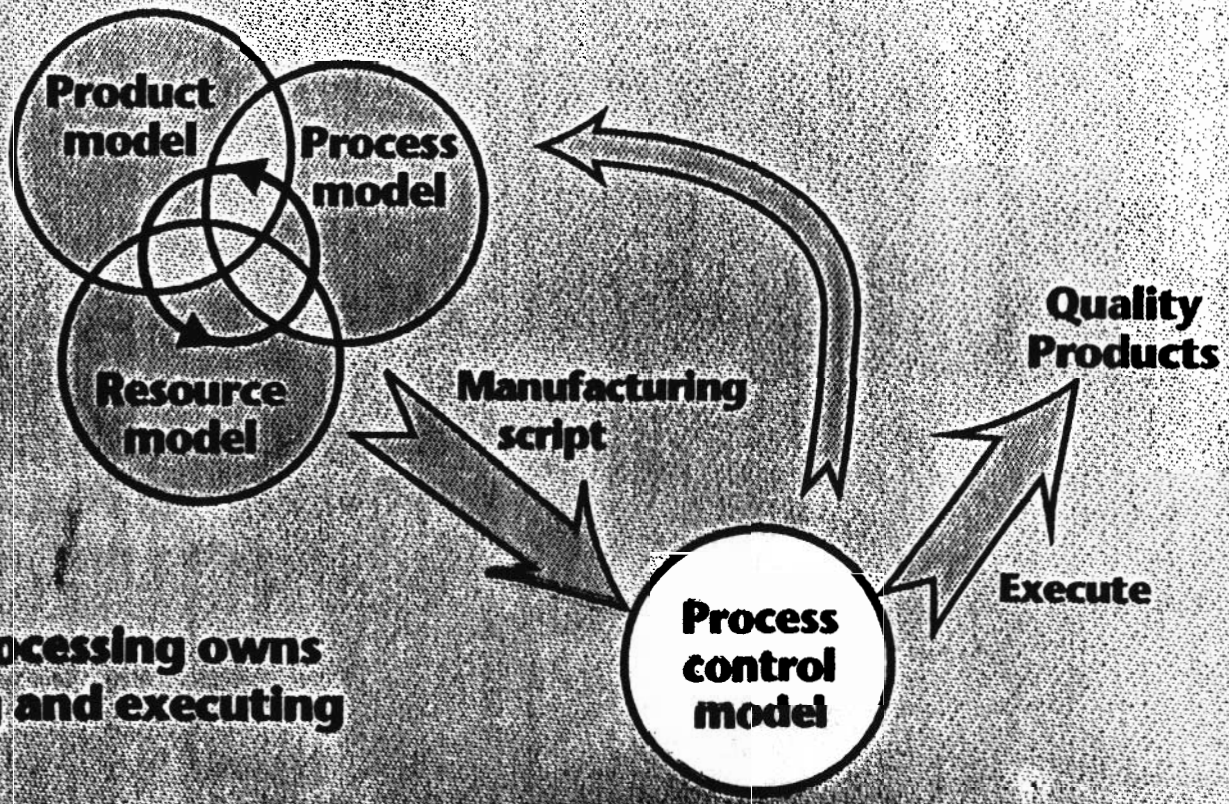
THE *TEAM* MODEL:



Manufacturing Planning and Control has responsibility for converting the optimized processes selected into information that drives the factory.

- **Shares knowledge with the process model**
- **Releases and controls the manufacturing script**

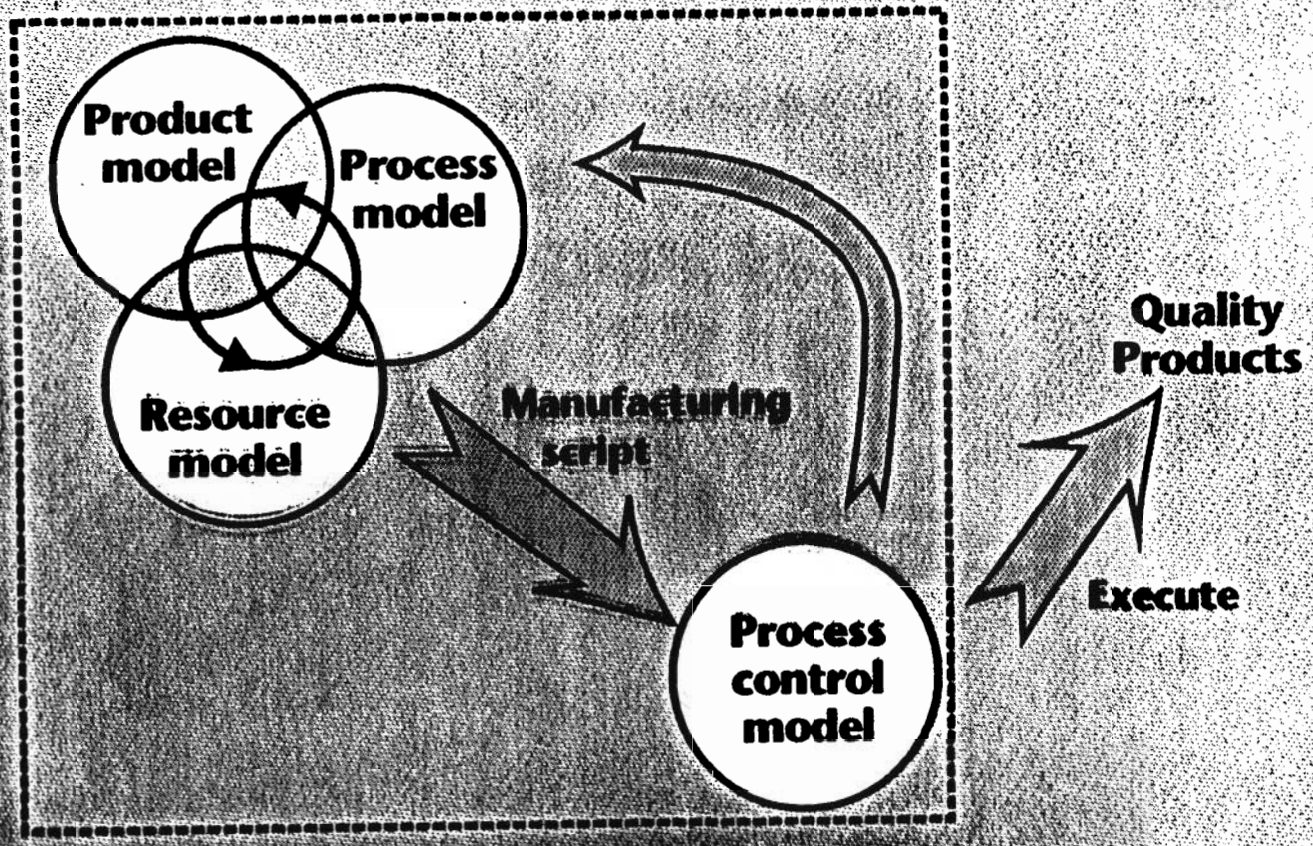
THE *TEAM* MODEL



Intelligent Closed-loop Processing owns responsibility for creating and executing processes.

- **Manufacturing script is inclusive**
- **Both past knowledge and in-process data is used in execution**
- **Performance feedback updates other models**

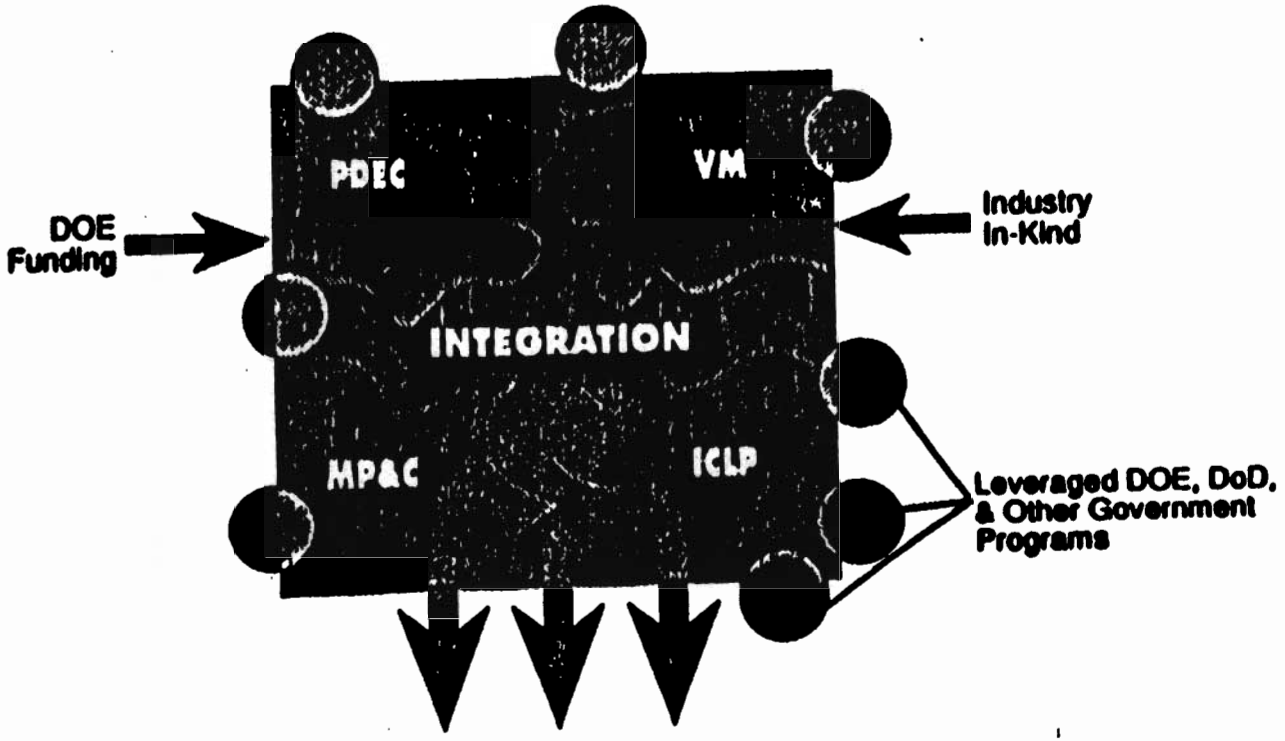
THE *TEAM* MODEL:



Integration assures that the enterprise works with available tools.

- **Uses available standards**
- **Selects the best tools and assures compliance with a technical architecture specifications**
- **Assures awareness of agile business practices**

Near-Term Focus, Long-Term Vision



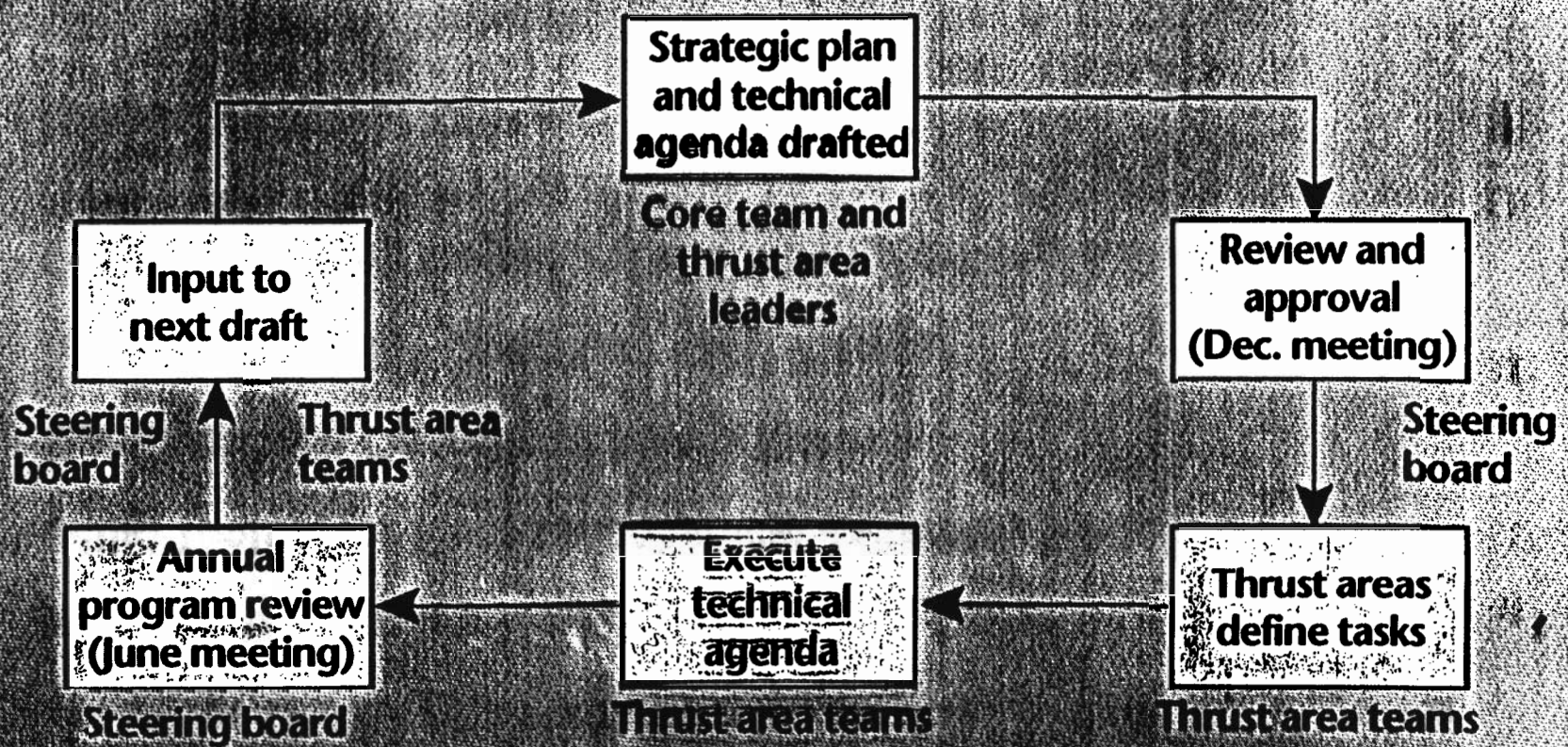
Near-Term & Long-Term Deliverables

- Enabling Technologies for Agile Toolkit
- Integrated Solutions for Agile Enterprises

Near-Term Results (1994-95)

- Prototype Design Assistant, Scoring Engine, & Electronic Sign-off
- Initial Virtual Factory Model
- Initial Toolset for Electromechanical Assembly Modeling
- Manufacturing Operations Macro Planner
- Rule-based, STEP-Compliant CMM Planner
- OAC1 controllers integrated into milling/ drilling & sheet metal processes
- Material Removal ICLP demo
- Communications Network, Data Repositories, & Technical Architecture Spec

TEAM ANNUAL PLANNING CYCLE



Preliminary Concept

National Advanced Manufacturing Testbed

A Distributed and Virtual Manufacturing Testbed

NIST MEL Planning Team
Merrill Hessel, Team Leader
Dennis Swyt
Jim Albus
Howard Bloom
Mike Wozny, Director MEL

October 26, 1994

Purpose of Presentation

- Introduce you to a manufacturing program we are proposing for development at NIST.

- Ask you to participate in the following ways:
  - Act as sounding board for our preliminary ideas today
  - Have you engage in December 15 workshop and formal planning
  - Take part in the conduct of the R&D program

Interviews to Discuss NAMT Concept & Prospectus

Bob Booth	GM	Director of Manufacturing Information Systems
Ted Merrill	AIAG	Executive Director
Frank Tidaback	Caterpillar	Senior Executive Manufacturing
Chris Klomp	Boeing	Director, Product, Factory & Process Information Systems
Robert Kiggans	SCRA	Director, Advanced Technology Group, Genl Mgr. PDES, Inc.
John Decaire	NCMS	Acting President
Joe Bordonga	NSF	Director, Engineering
Bjorn Andersen	IBM	Director, Architecture and CIM
Jack Jones	Sandia	Director, Information Processes Center
Bill Henghold	HMS	President (Small Consulting Firm)
Jack White	ITI (MI)	Director, Enterprise Integration
J. Boudreaux	ATP NIST	Program Manager for Manufacturing
A. Melissaratos	Westinghouse	Vice President Corporate Research & Quality
Mfg. Eng. Sys.	DoD	Program Managers
Ric Hayes-Roth	CIMFLEX	President
Mel Cohen	AT&T	Vice President Research Effectiveness
Dianne Bird	DoE	HQ TEAM program manager
Alex Larzelere	DoE	HQ Technology Transfer Program Manager
+ Mike McGrath	ARPA	Program Manager
+ John Cassidy	UTC	Director Corporate Research
+ Mike Coffey	NMTA	President
*Jeff Bostock	Oak Ridge Y12	Vice President
*Dave Mitchell	Rockwell	Vice President Engineering & Manufacturing
*Bill Alzheimer	Sandia	Director, Advanced Technology Center
*Stewart Miller	GE	Vice President Research (retired) & Chair, MEL Panel

\+ Scheduled during the weeks of 11/1 and 11/7

* Date not yet set

What Problem Does the NAMT Address?

- Ability to rapidly introduce affordable quality products that the customer wants

Major Roadblocks

- Inability to develop and identify a team of suppliers with the suitable technical expertise and to integrate their systems, procedures and methodologies to design, manufacture, support and market the product.
- Lack of capability to rapidly and realistically design and test products and processes using computer-based simulation methodologies and validated by physical prototypes, where appropriate.

Definitions

- **Distributed Manufacturing**
  - **At geographically separated sites network-linked organizations which are nodes on the system will perform different tasks to design, manufacture and support a product**
- **Virtual Manufacturing**
  - **Computer simulation (as well as other computer-based methodologies) of realistic products and processes**
- **Rapid Prototyping**
  - **Physical realization of a product either to validate the virtual manufacturing description of a process or product or realize the product if this is not feasible.**

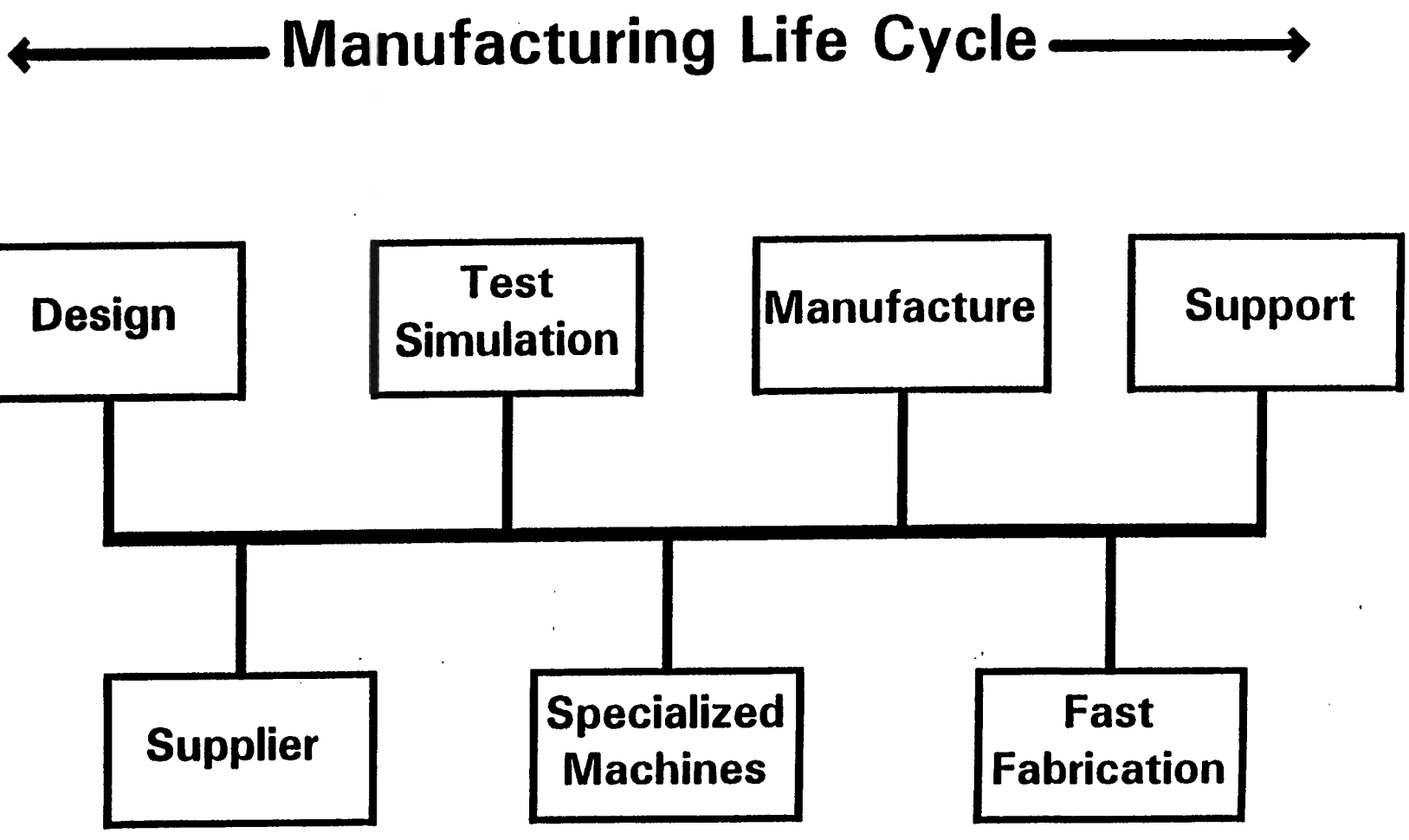
Capsule Summary

- Industry, NIST, Other Agencies - A Distributed and Virtual Manufacturing Testbed (Multi-site Multi-organzational)
- NAMT would consist of geographically distributed networked linked nodes
- Each node would specialize in an aspect of an enterprise which integrates the functions to produce a product

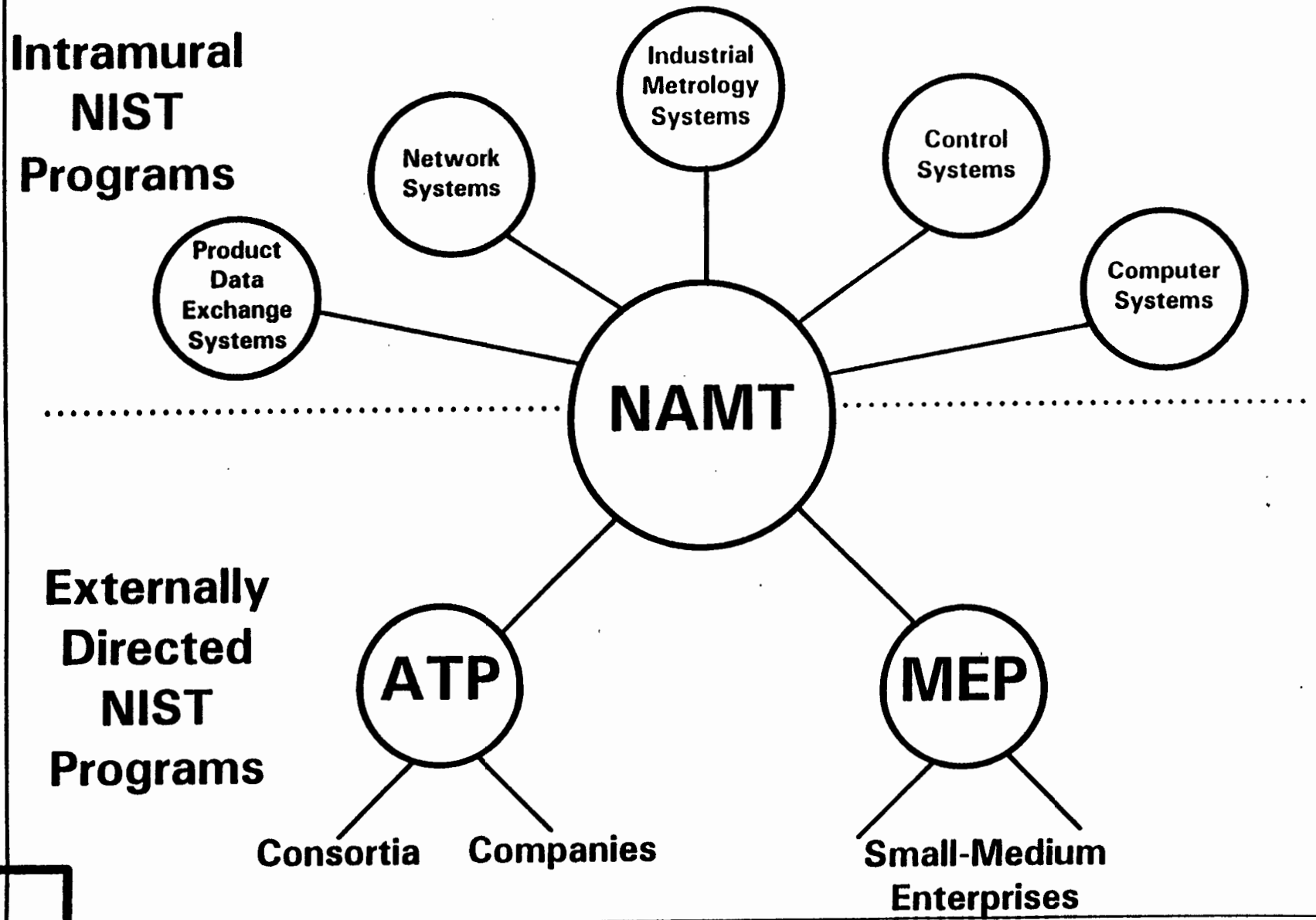
NIST Role is to:

- Test interface standards, perform in-process metrology, measure system performance, integrate systems, simulate processes and products
- MEL program manager, consortium builder, system configuration manager, provide a window on technology for industry leaders, DoC, Congress

Possible NAMT Nodes



NAMT/NIST Resources

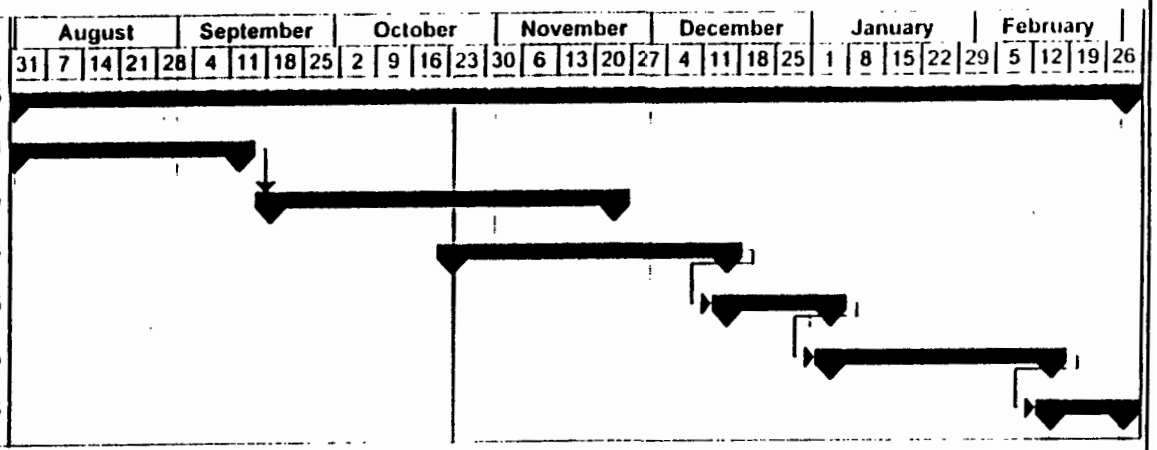


Possible Scenario's

- Build to order capability within supplier-OEM
- Demonstrate agile manufacturing of castings
- Demonstrate assembly technology for a variety of processes
- Demonstrate feature-driven process planning and automated scheduling

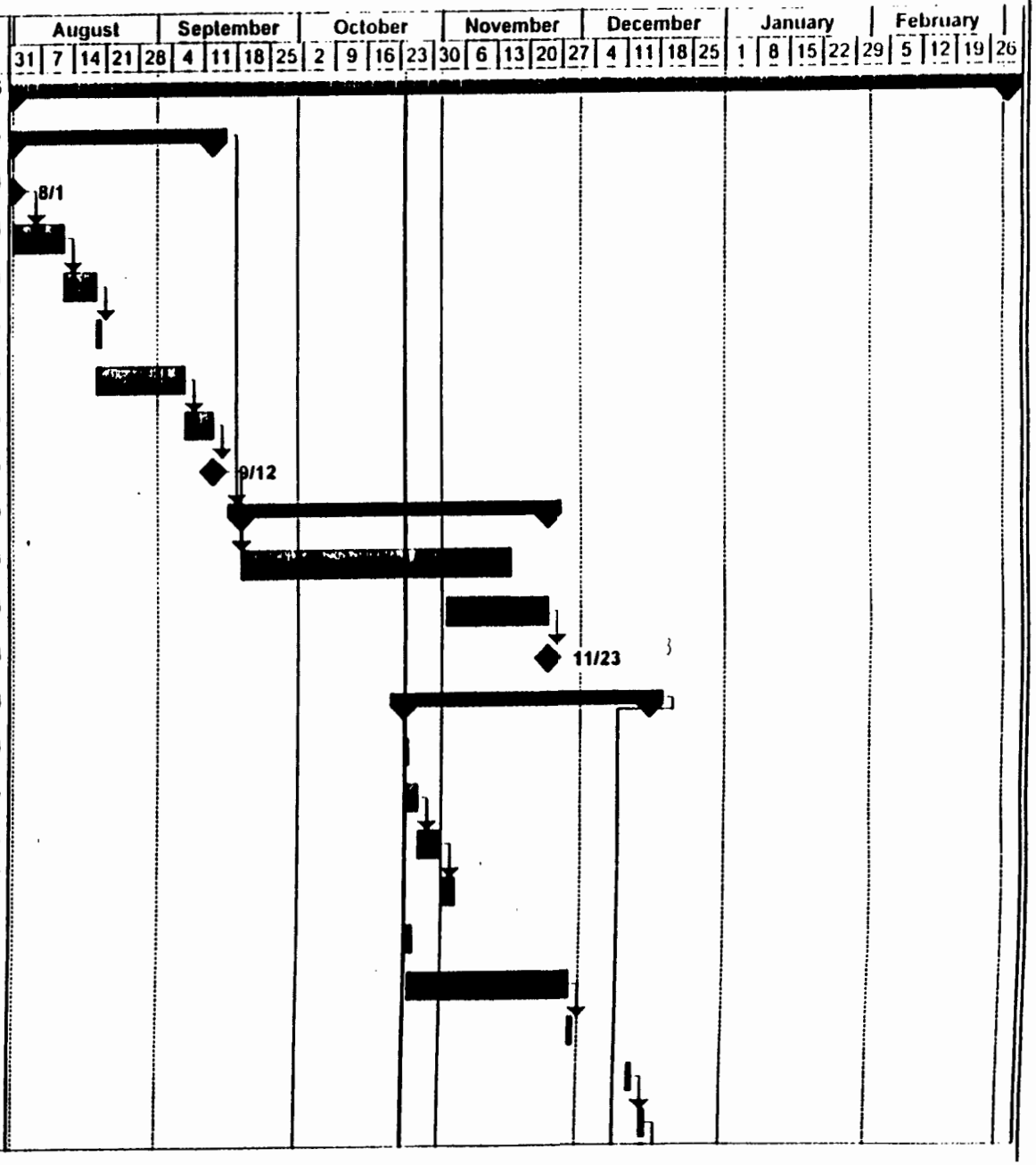
National Advanced Manufacturing Testbed

ID	Task Name	Durat	Start	Finish
1	Plan for NAMT	153d	8/1/94	3/1/95
2	Define Preliminary Objectives	31d	8/1/94	9/12/94
10	Alpha Test Prospectus	48d	9/19/94	11/23/94
14	Plan and Conduct Workshop	39d	10/24/94	12/15/94
24	Commitment to Formal Plan Dev.	14d	12/16/94	1/4/95
29	Formal Plan Development	30d	1/5/95	2/15/95
39	Management Approval of Plan	10d	2/16/95	3/1/95



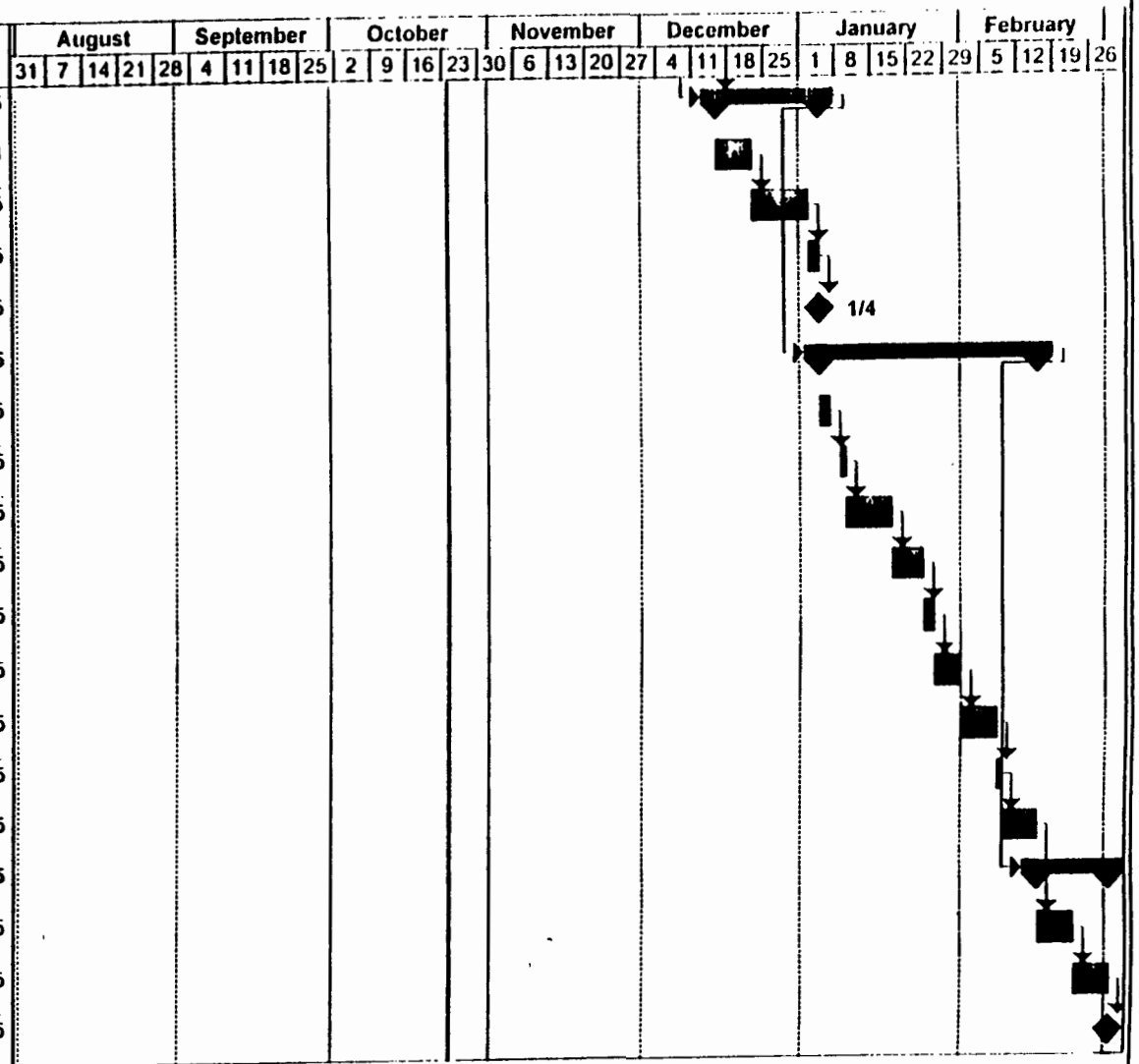
National Advanced Manufacturing Testbed

ID	Task Name	Durat	Start	Finish
1	Plan for NAMT	153d	8/1/94	3/1/95
2	Define Preliminary Objectives	31d	8/1/94	9/12/94
3	Assemble MEL team	0d	8/1/94	8/1/94
4	Draft Prospectus	9d	8/1/94	8/11/94
5	Incorporate Changes	5d	8/12/94	8/18/94
6	Present to MEL Council	1d	8/19/94	8/19/94
7	Incorporate Changes(Version1)	13d	8/19/94	9/6/94
8	Incorporate Changes (Version 2)	4d	9/7/94	9/12/94
9	Final Review/Approval by Team	0d	9/12/94	9/12/94
10	Alpha Test Prospectus	48d	9/19/94	11/23/94
11	Visit selected individuals	42d	9/19/94	11/15/94
12	Revise Prospectus	16d	11/2/94	11/23/94
13	Team Approval	0d	11/23/94	11/23/94
14	Plan and Conduct Workshop	39d	10/24/94	12/15/94
15	Reserve Conference Room	1d	10/24/94	10/24/94
16	Compile Invitee List	3d	10/24/94	10/26/94
17	Select & Phone Invitations	3d	10/27/94	10/31/94
18	Mail Confirmations	3d	11/1/94	11/3/94
19	Decide Form of Wshp product	2d	10/24/94	10/25/94
20	Develop Materials	25d	10/25/94	11/28/94
21	Mail Materials to the Attendees	1d	11/29/94	11/29/94
22	Dry Run Presentations	1d	12/12/94	12/12/94
23	Conduct workshop	1d	12/15/94	12/15/94



National Advanced Manufacturing Testbed

ID	Task Name	Durat	Start	Finish
24	**Commitment to Formal Plan Dev.**	14d	12/16/94	1/4/95
25	Write Workshop report	5d	12/16/94	12/22/94
26	Review Report	7d	12/23/94	1/2/95
27	Analyze and Distribute Report	2d	1/3/95	1/4/95
28	GO/NOGO	0d	1/4/95	1/4/95
29	**Formal Plan Development**	30d	1/5/95	2/15/95
30	Develop Plan Outline	2d	1/5/95	1/6/95
31	Assign Sections to Team	1d	1/9/95	1/9/95
32	Develop First Drafts of Chapters	7d	1/10/95	1/18/95
33	Integrate Chapters	4d	1/19/95	1/24/95
34	Distribute Draft to Team	2d	1/25/95	1/26/95
35	Incorporate Comments	3d	1/27/95	1/31/95
36	Distribute to Red Team for review	5d	2/1/95	2/7/95
37	Red Team 1st Review Meeting	1d	2/8/95	2/8/95
38	Incorporate Comments for 2nd Dr	5d	2/9/95	2/15/95
39	**Management Approval of Plan**	10d	2/16/95	3/1/95
40	Present Plan to Management	5d	2/16/95	2/22/95
41	Incorporate Comments	5d	2/23/95	3/1/95
42	GO/NOGO	0d	3/1/95	3/1/95



NATIONAL INSTITUTE OF STANDARDS & TECHNOLOGY

SYSTEMS INTEGRATION for MANUFACTURING APPLICATIONS WORKSHOP

Fort Belvoir, Virginia
November 14-16, 1994

Workshop Process

- *Focus Questions*
- *Problem Identification*
- *Prioritization & Categorization of Problems*
- *Action Generation*
- *Prioritization & Categorization of Actions*
- *Summary & Presentation*

Participating Organizations

- Boeing
- Martin Marietta
- IBM
- NCMS
- ARPA
- DOE TEAM
- Industrial Technology Institute
- NIIIP
- General Motors
- SEMATECH
- CAM-I
- Software Engineering Institute
- GE
- Navy Supply Systems Command (FCIM)

APPENDIX A: PARTICIPANTS/OBSERVERS

PARTICIPANTS	ACTIVITY
Neal, Richard	Martin Marietta Energy Systems
Bolton, Richard	International Business Machines Corporation
Waddell, William	NCMS
Khosla, Pradeep	ARPA/SSTO
Yee, King	Boeing
White, Jack	Industrial Technology Institute
Hollowell, Glen	SEMATECH
Jordan, Jim	CAM-I/NGMS
Luce, Mark	NIST
Christopher, Neil	NIST
Ray, Steve	NIST
Mitchell, Mary	NIST
Knutilla, Amy	NIST
McLean, Chuck	NIST
Barkmeyer, Ed	NIST
Goldstein, Barbara	NIST
Kaminski, Mike	General Motors
Gagliardi, Mike	Software Engineering Institute
Erkes, Joe	GE Corporate Research
Leary, John	Software Engineering Institute
Mays, Jim	Navy Supply Command

OBSERVERS	ACTIVITY
Bloom, Howard	NIST
Hoffmann, Ray	NIST
Frechette,Simon	NIST
Johnson, Clarence	NIST
Hessell, Merrill	NIST
Sriram, Ram	NIST

WORKSHOP STAFF

Crognale, Stan

Crow, Dana

Reevas, Kimberly

Focus Question

- *In the context of advancing information technology for manufacturing systems and improving the effectiveness of the set of related programs,*
- *What are the critical problems that need to be addressed?*
- *What are the actions that would overcome these problems?*

Focus Question

- *In the context of advancing information technology for manufacturing systems and improving the effectiveness of the set of related programs,*
- *What are the actions that would overcome these problems?*

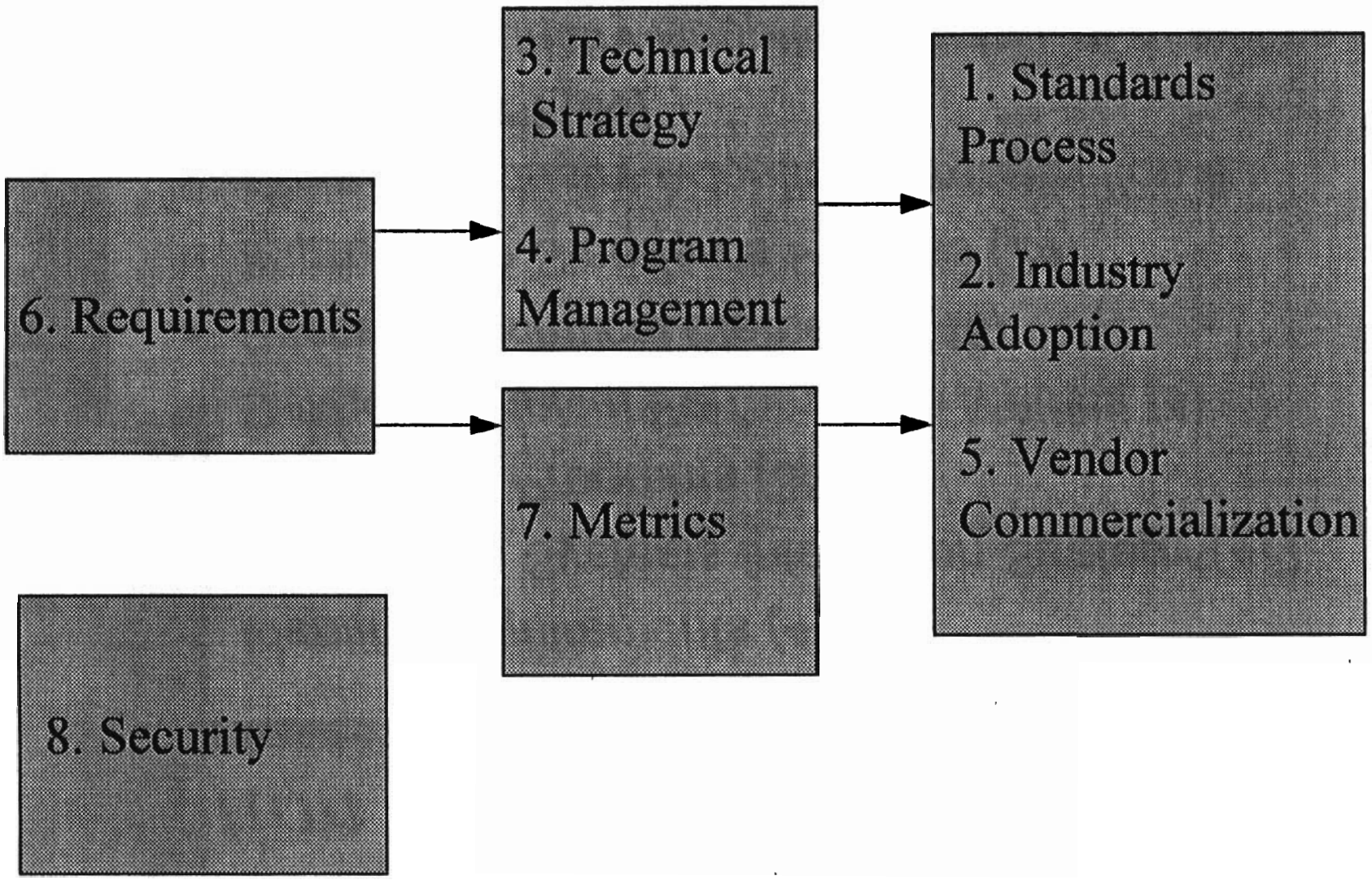
Focus Question

- *In the context of advancing information technology for manufacturing systems and improving the effectiveness of the set of related programs,*
- *What are the critical problems that need to be addressed?*

Problem Categories

- Requirements (16)
- Technical Strategy (48)
- Program Management (43)
- Metrics (21)
- Standards Process (43)
- Industry Adoption (47)
- Vendor Commercialization (32)
- Security (5)

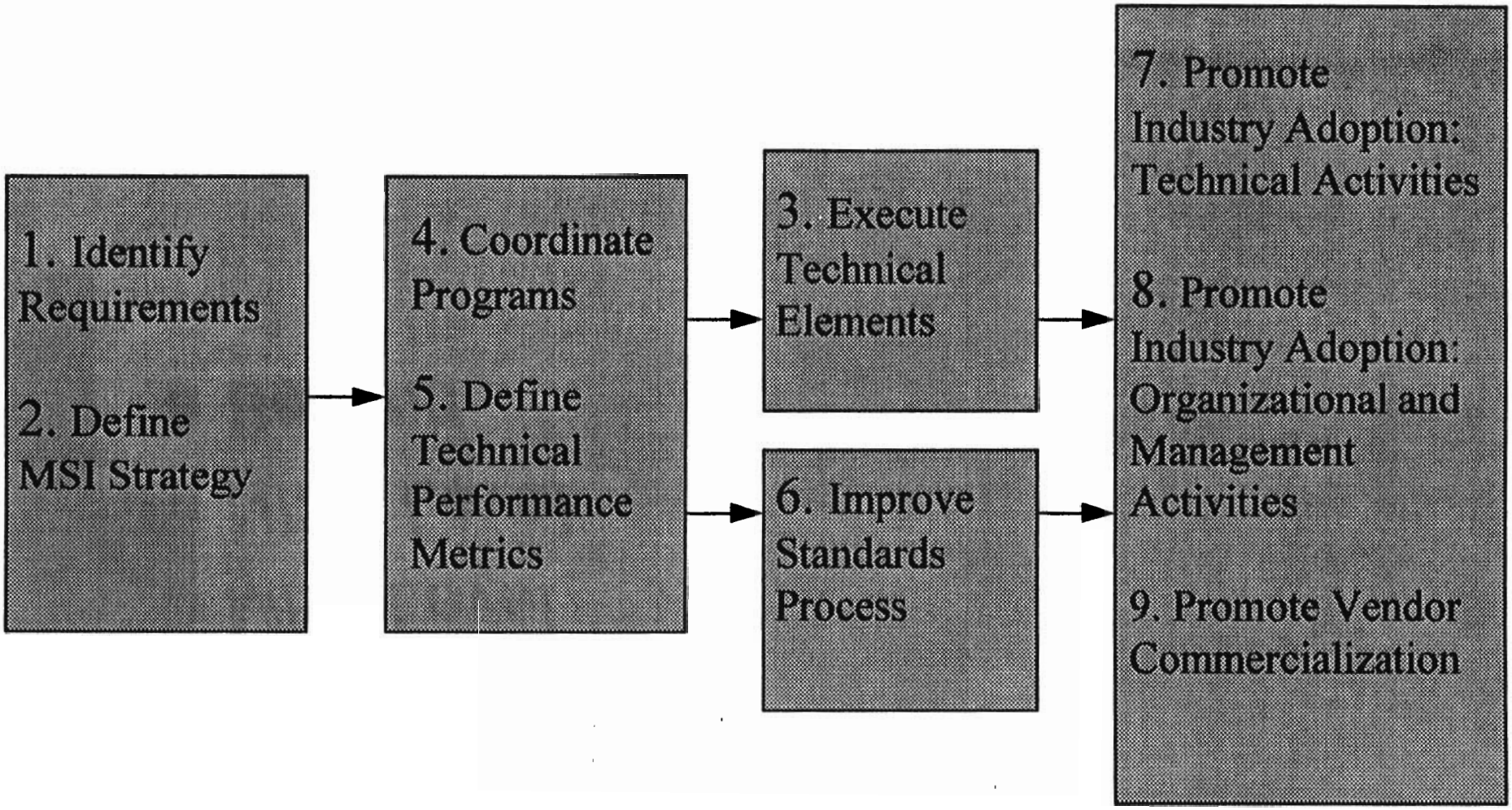
NIST SIMA PROBLEM STRUCTURE



Action Categories

- *Identify Requirements (41)*
- *Define Mfg. Systems Integration Strategy (47)*
- *Coordinate Programs (35)*
- *Define Technical Performance Metrics (4)*
- *Execute Technical Elements (46)*
- *Improve the Standards Process (24)*
- *Promote Industry Adoption: Organization & Management (20)*
- *Promote Industry Adoption: Technical Activities (34)*
- *Promote Vendor Commercialization (7)*

NIST SIMA ACTION STRUCTURE



Determine Action Responsibility

- *SIMA Level*
- *MEL Level*
- *NIST Level*
- *Beyond*

Top Recommended Actions

- *Develop an Integrated Requirements Process*
- *Conduct Regional Requirements-Workshops*
- *Establish Joint Strategic Definition Task Force*
- *Create Roadmaps by Product Process Sector*
- *Define Integration Architectures*
- *Identify and Support Underlying Standards*
- *Form an Information Repository*
- *Support / Fund Consortia for Standards Development*
- *Establish Technology Migration paths*
- *Define Business Case Metrics*

Recommended SIMA Actions

- *Form industry steering group*
- *Lead related programs workshop*
- *Create an architecture*
- *Identify integrating standards*
- *Conduct "Do It" demonstrations*
- *Establish coordination plan*
- *Set up repository of program information*
- *Link up with related programs*

Recommended SIMA Actions (cont.)

- *Include metrics in all demonstrations*
- *Participate in pilots*
- *Identify migration paths*
- *Empower consortium inputs*

Workshop Deliverables

- *Workshop Proceedings Document*
  - *SIMA Program Background*
  - *IM Workshop Process*
  - *Conclusions*
  - *Program Action Plan*
  - *Final Presentation*

Follow-Up

- *Create SIMA Implementation Team*
- *Develop Implementation Plan*
- *Publish Workshop Proceedings Document*
- *Continued Involvement of the Workshop Participants*