



Intelligent and Integrated Manufacturing Systems

Presented to the NDIA Modeling and Simulation Committee

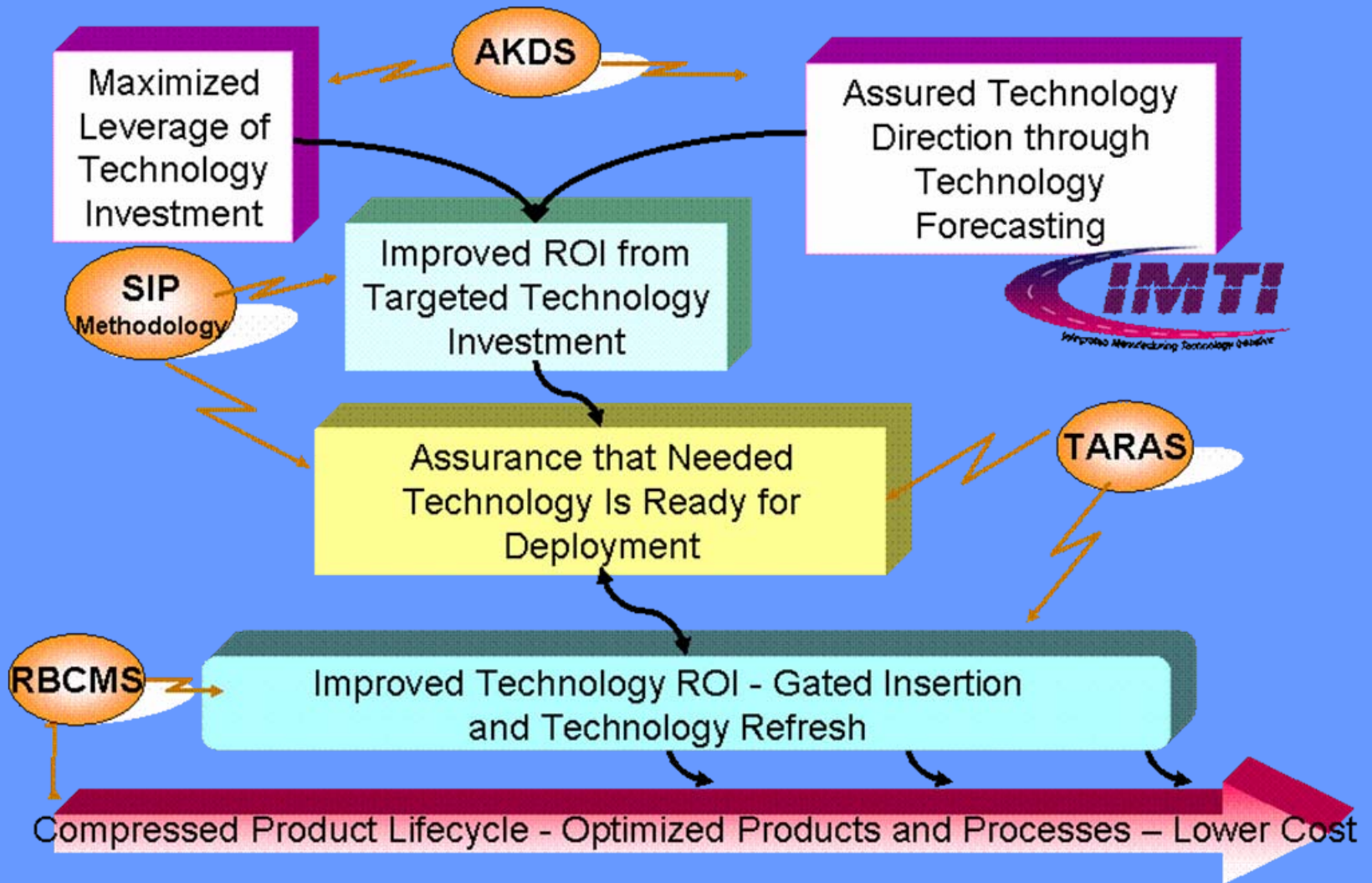
Prepared by IMTI

April 23, 2007

IMTI: Dedicated to comprehensive methodologies and toolsets for technology management

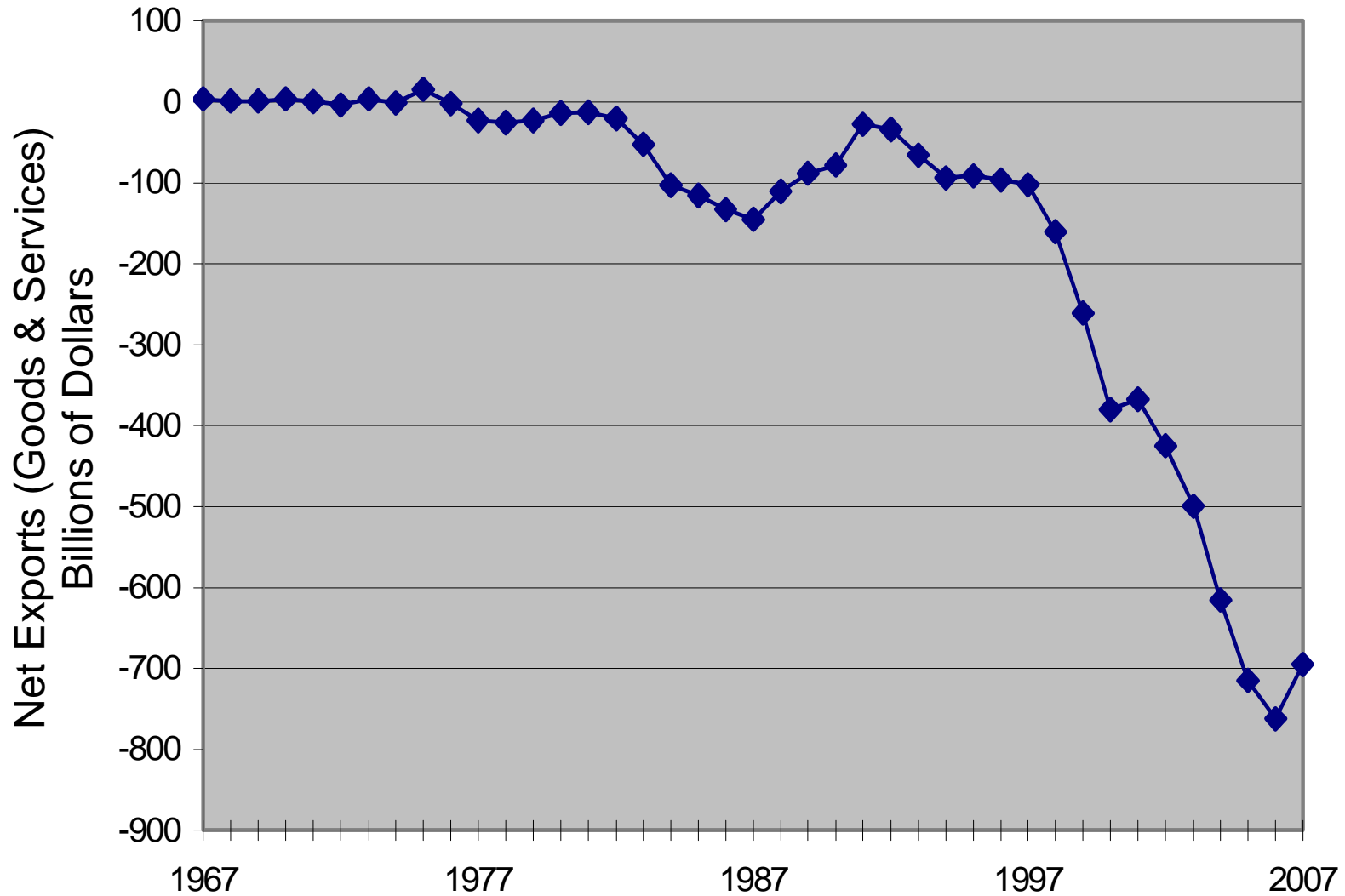
- Technology roadmaps
- White papers, project plans, & deployment support
- Tools for managing roadmaps & investments
- A vision for manufacturing: building programs around that vision

Technology Management System





Why is Our Common Work So Important?



IIMS In Perspective

- A contract with NIST to define the IWG topic
- A document that presents A vision for the future
- A starting point for an improving definition
- IMTI is offering the document as a foundation for a “coming together”
 - No pride of ownership
 - No fees or rules
 - Just an invitation to collaborate and a willingness to provide a strategic forum
 - IMTI has funding from DoD and NASA for this role
- IIMS Forum III in Huntsville on June 10 and 11

Sources Of Information



- A Survey of Manufacturing Professionals
- Discussion with Experts
- Workshops and Conferences
- Analysis of Existing Projects
- Over 20 Documents

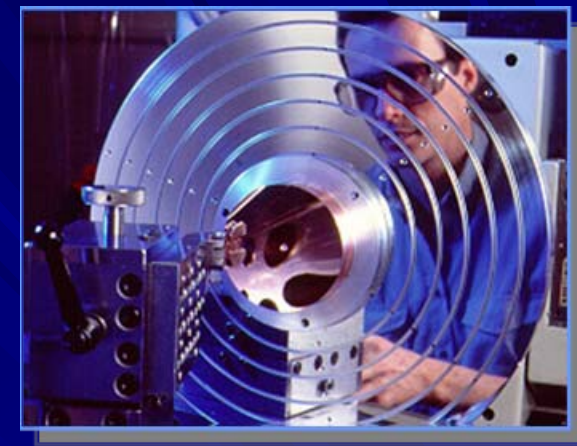
The Call To Action

- **The World has Changed Forever**
 - **The World is Flat and Freedom Reigns**
- **Jobs Lost Will Not Return – One for One, But**

Wealth Creation Must Not Be Lost

- **The New Competitiveness Battleground is for the Imagination**
- **The Battle will Be Won with New Manufacturing Toolsets**
 - *Dramatically Increased Productivity, and*
 - *A Rapid Stream of Innovative Products*
 - *A balance of social responsibility*
- **Integrated, Intelligent Manufacturing Systems Should Be the Rallying Cry for a National Emphasis on Winning this Battle**

Intelligent and Integrated Manufacturing Systems

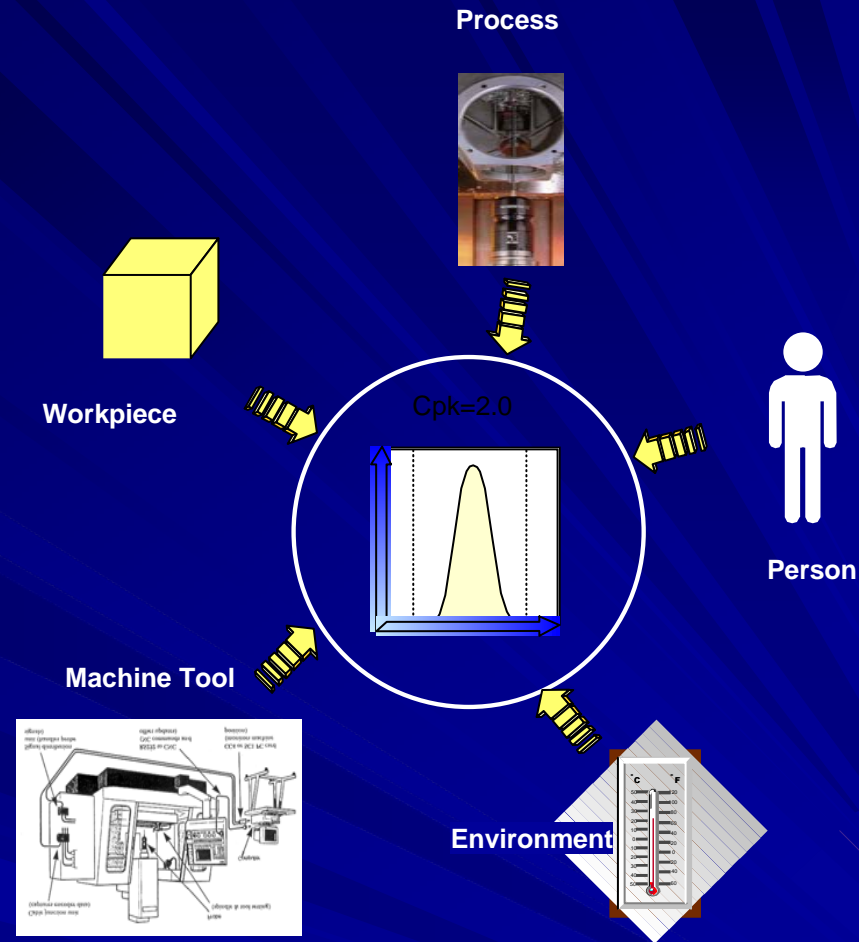


An Intelligent and Integrated Manufacturing System Can:

- **Sense and Respond to The Manufacturing Environment – Autonomously When Appropriate**
- **Determine Needed Information and Acquire It**
- **Control Manufacturing and Business Processes**
- **Detect and Correct Operational Deviations**
- **Continuously Learn to Mimic the Reality**
- **Generate and Manage All Manufacturing Information**
- **Provide Needed Information, in the Form Needed**

A Definition

An intelligent and integrated manufacturing system embraces a holistic view of the product life-cycle in a seamless continuous flow from requirements - to design – to production - through use and disposition. Needed information is available when, where, and in the form needed. All functions are controlled for assured performance at the level dictated for total value optimization.



The Current State

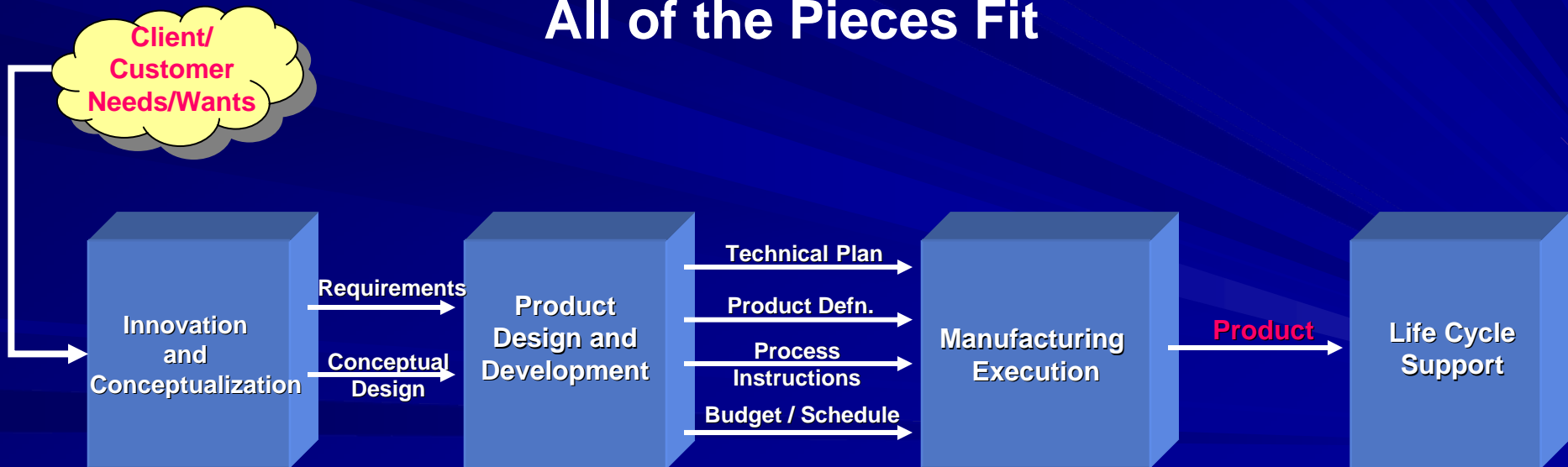
- Tremendous Improvement in the Toolsets
- Modeling and Simulation Still Ancillary to Mainstream Operation
- Interoperability is a Huge Challenge
- Manufacturing Control Systems Moving Toward Intelligent Control
- Manufacturing Equipment Designed for High Throughput
- Knowledge Integration in Design, Development, and Production Slowly Evolving

The Future

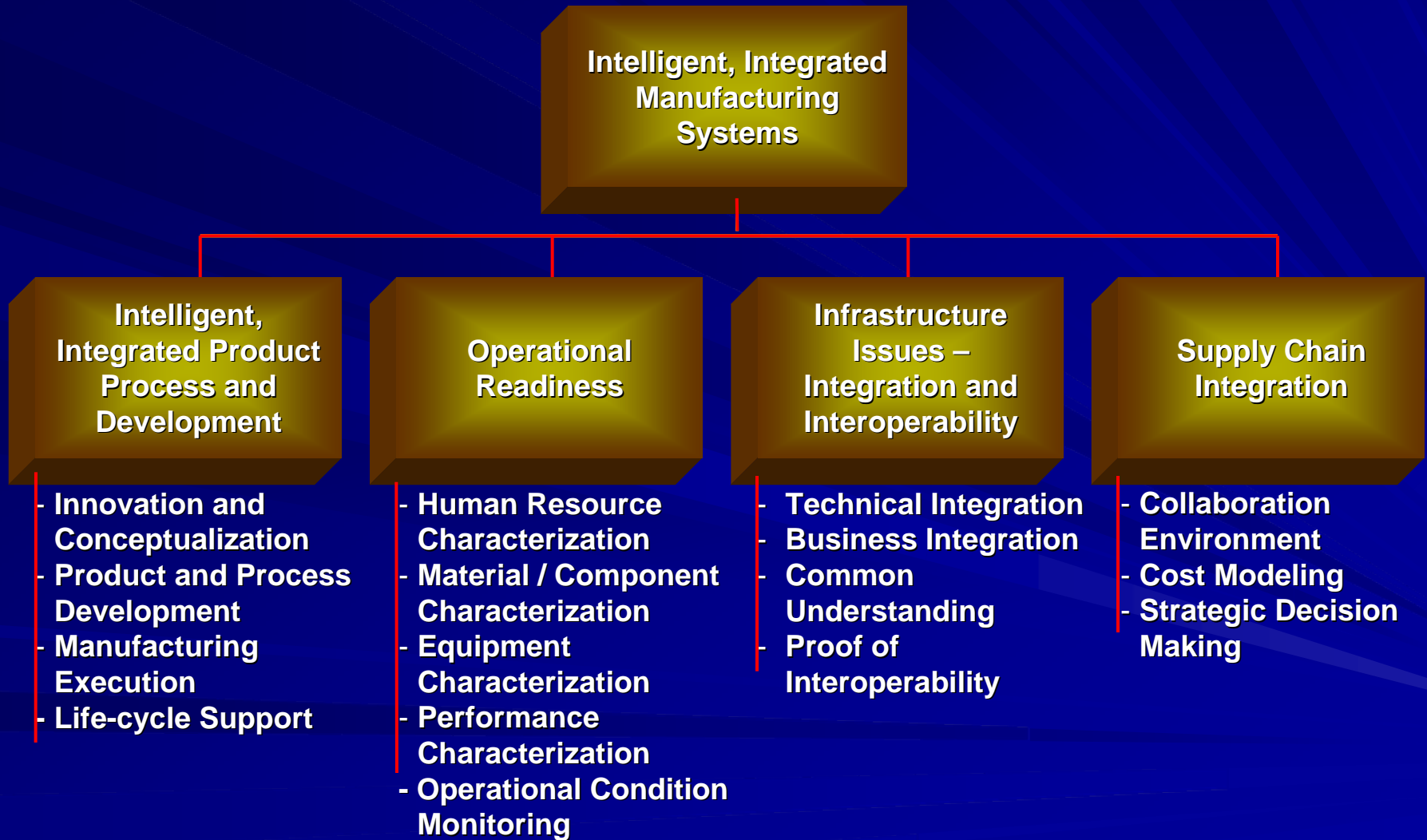
From Requirements – to Concepts – to Designs – to
Production – to Disposition

One System

All of the Pieces Fit



The IIMS Functional Model



Intelligent, Integrated Manufacturing Systems

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graph TD; A[Intelligent, Integrated Manufacturing Systems] --> B[Intelligent, Integrated Product Process and Development]; A --> C[ ]; A --> D[ ]; A --> E[ ]
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Intelligent, Integrated Product Process and Development

-Innovation and Conceptualization

-Product and Process Development

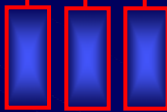
-Manufacturing Extension

-Life-cycle Support

Intelligent And Integrated Product And Process Development

Innovation And Conceptualization -Vision-

- Requirements Driven
- Considers all Options and Evaluates in Real Time
- Desktop Linkage to Modeling and Analysis Evaluation Systems
- Integrated Analysis for Optimization Across Attributes

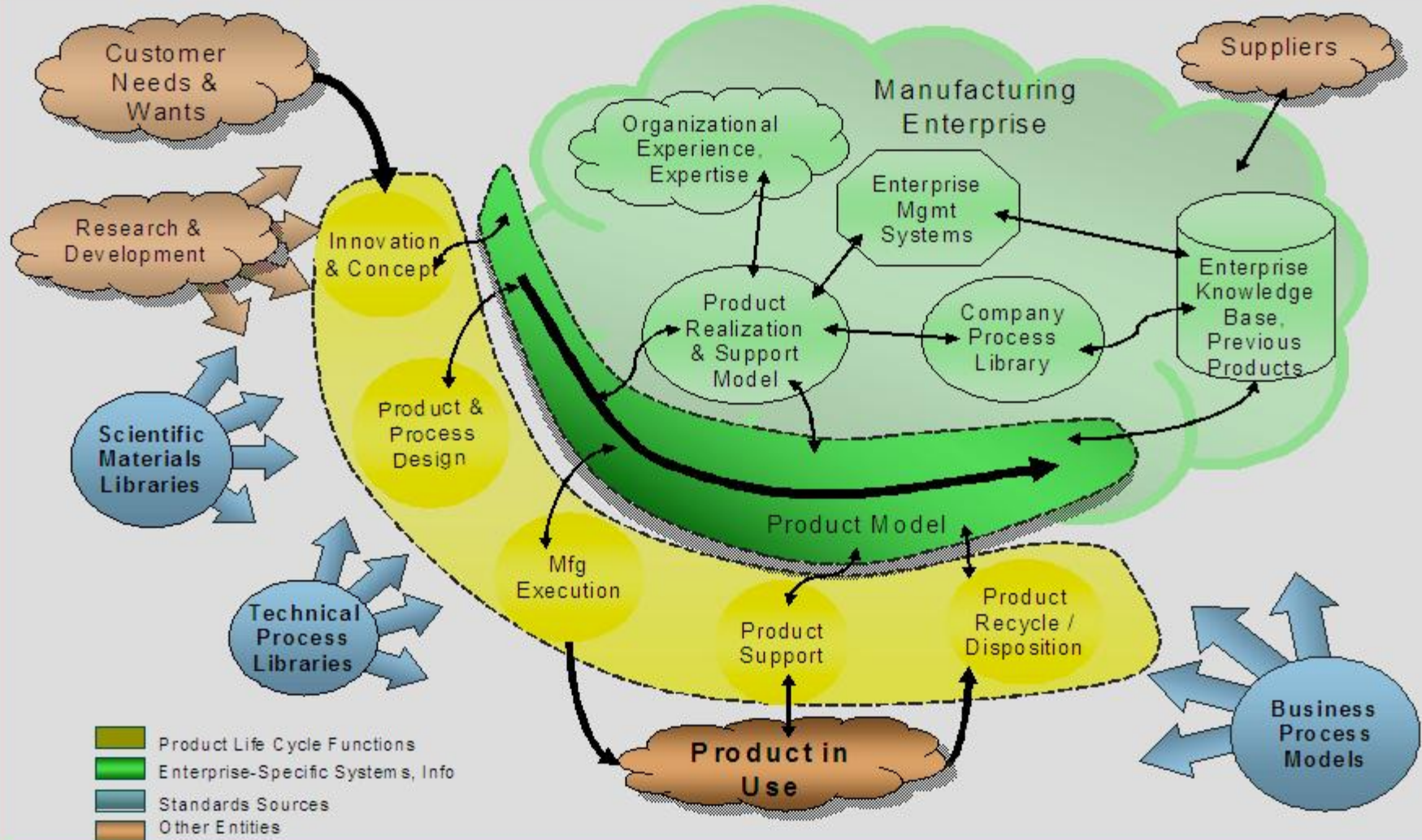


Product And Process Development -Vision-

- Design systems operate as virtual production systems, revealing all aspects of the production of the product.
- Product models defined in terms of functional requirements – traceable forward and backward.
- Knowledge-based design advisors assume a prominent role.
- Product definition forms a complete product model set – capable of driving all downstream applications.
- Product model will spawn other models. These ‘abstractions’ provide only precisely the information needed for each application.

- Innovation and Conceptualization
- Product and Process Development
- Manufacturing Extension
- Life-cycle Support

The Future Product Life-cycle



IIPPD

- Key Enablers-

- Flexible Representation of Complex Models
- Plug-and-Play Collaborative Modeling and Simulation Environment
- Intelligent Models
- Presentation by Levels of Abstraction

More Key Enablers

■ Smart Models

- Understand their information/interfaces needs and know how to satisfy them
- Self validating
- Plug and play interoperability

■ Visible Cost

- Accurate prediction and management of cost at every decision point

■ System of Systems View

- Components to systems, to system-of-systems capability
- Composable and decomposable models

Manufacturing Execution

-Vision-

An Intelligent and Integrated Manufacturing System Will:

- Interpret Requirements
- Produce All Needed Information for Operation and Control
- Execute a Process Optimized for the Total Enterprise Value

Manufacturing Execution



An IIMS Will Be:

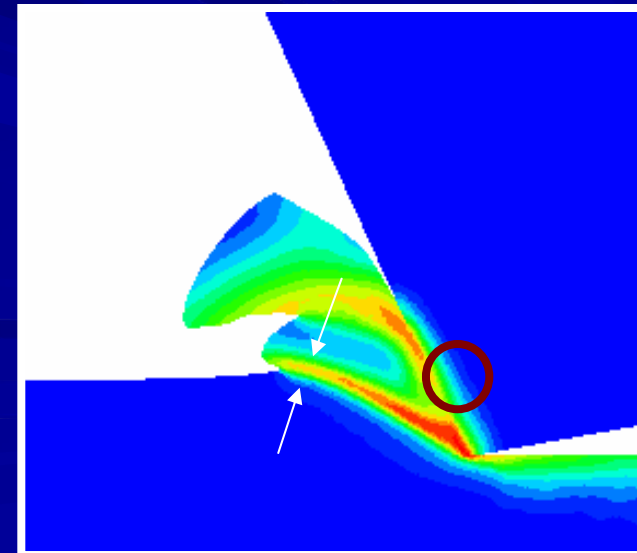
- Self-Configuring
- Self-Monitoring and Self-Diagnosing
- Self-Repairing
- Prognostic
- Executing Intelligent, Closed-Loop Processes

Always Operates within Control Boundaries

Manufacturing Execution

Models will drive the IIMS:

- Physics Based Process Models will Precisely Replicate Process Operations Including Response to Environmental Variations and Uncertainty
- Material, Equipment, and Resource Models will Support the Process Modeling Environment
- **The Integrated Process Model will become the Process Controller**
- Processes will be Programmed
– Not Equipment





Life-cycle Support

-Vision-

- **PLM Means Product Life-cycle and Not Just CAD Plus**
- Operations, Maintenance, and End-of-life Management Included in the Model Set
- Models Predict How a Product Reacts in its Environment
- Automated Analytical Tools Flag Lifecycle Issues and Offer Alternatives In the Design Process
- Monitoring Systems Provide Design Feedback to Identify Problem Areas
- Products Continually Adjust Operating Parameters to Maximize Lifetime Value
- Products Manage their End-of-life Actions – Fail Gracefully

Intelligent, Integrated Manufacturing Systems

Operational Readiness

- Human Resource Characterization
- Material / Component Characterization
- Equipment Characterization
- Performance Characterization
- Operational Condition Monitoring

Operational Readiness

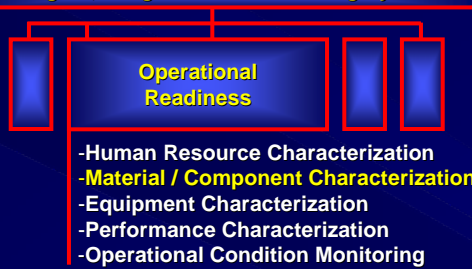


Operational Readiness

-Vision-

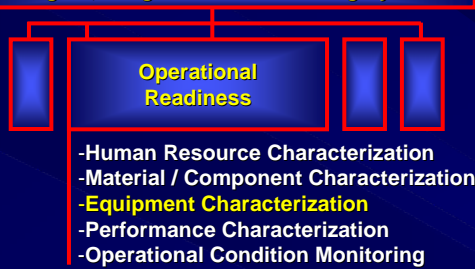
The IIMS:

- Knows Its Capabilities/Condition and Communicates this Information
- Autonomously Monitors and Optimizes Its Operations
- Responds to Changes at Point of Impact, with Results Automatically Reflected in Every Related System
- Assesses the Quality of Its Work/Output
- Learns and Improves Its Performance Over Time



Material / Component Characterization -Vision-

- Characterization of Materials to the Extent Needed to Assure the Best Product and Process Plans
 - Support material selection
 - Support best processing and assured quality
- Characterization of Components to Assure Their Role in the System – Not Just to Spec



Equipment Characterization

-Vision-

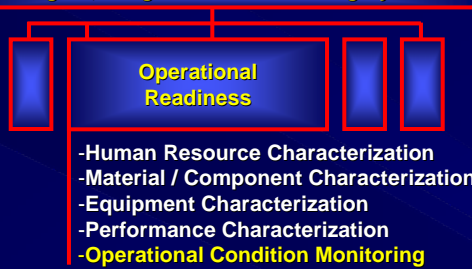
- Dynamically Maintained Performance Models
- Continuous Self-analysis with Response as Needed
- Adaptive Planning Based on Equipment Status
- Integrated with Enterprise Resources
- Multi-function Tools for Traditional and Non-traditional Processes



Performance Characterization

-Vision-

- Total Performance Capability is Available in Real-time
- Total Capability Models Combine Characterization of Enterprise Resources and Components
- Achieves First and Every Product Correct Without the Need for Evaluation



Operational Condition Monitoring

-Vision-

- 100% Uptime
- Self-diagnosis and Self-repair
- Immune Systems Engineering
- Plug-and-Play through Self-describing Interfaces
- Assurance of Present and Future Performance
- Real-time Operational Signatures
- Prognostic Models

Intelligent, Integrated Manufacturing Systems

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graph TD; A[Intelligent, Integrated Manufacturing Systems] --> B[ ]; B --> C[ ]; B --> D[Infrastructure Issues –Integration and Interoperability]; B --> E[ ]; D --> F[-Technical Integration]; D --> G[-Business Integration]; D --> H[-Common Understanding]; D --> I[-Proof of Interoperability];
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Infrastructure Issues –Integration and Interoperability

- Technical Integration
- Business Integration
- Common Understanding
- Proof of Interoperability

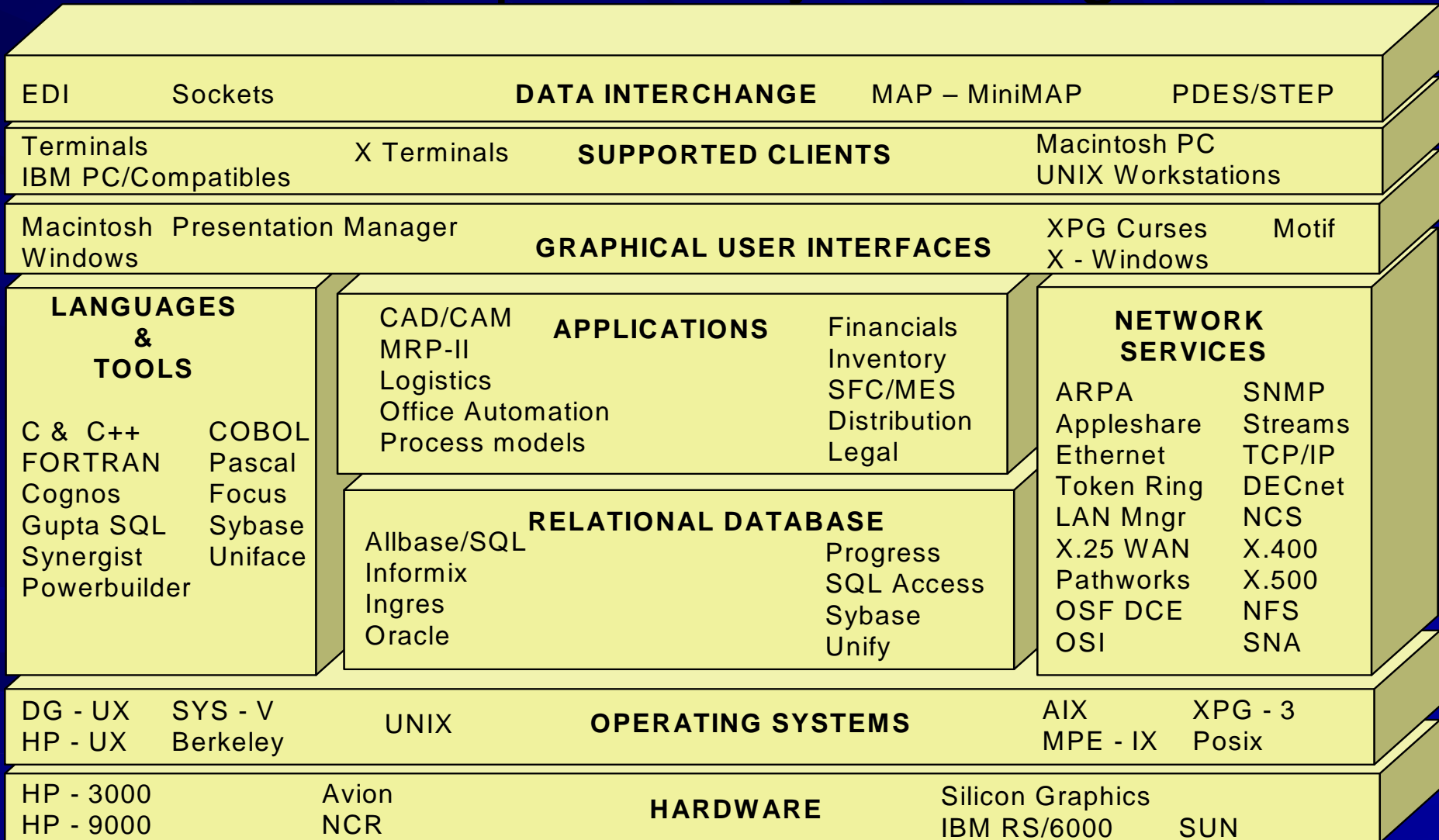
Infrastructure Issues –Integration and Interoperability

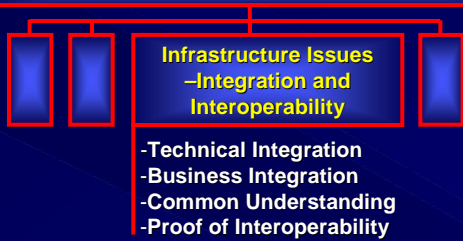
Intelligent, Integrated Manufacturing Systems

**Infrastructure Issues
-Integration and Interoperability**

- Technical Integration
- Business Integration
- Common Understanding
- Proof of Interoperability

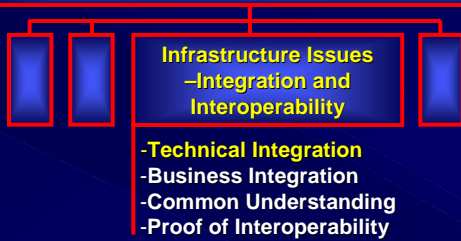
Interoperability Is Tough!





Infrastructure Issues – Integration and Interoperability -Vision-

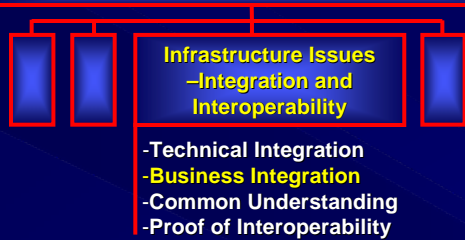
- Seamless Communications between all Applications
- Sending and Receiving Devices Speak the Same Language
- Devices will be Self Integrating
- Common Standards and Harmonized Standards Support Interoperability Needs



Technical Integration

- Vision -

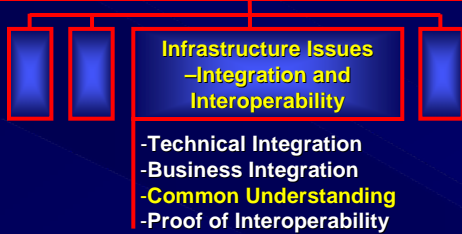
- PLM, ERP, MES (MOM) Grow and Overlap
- Modularized Toolsets
- Best-in-class Integration without Translation
- Integrated Models Support Integrated Operations



Business Integration

- Vision -

- Enterprise Resource Management Across the Supply Chain with Appropriate Horizontal and Vertical Penetration
- Common Business Agreements Implemented in Shared Business Systems
- Business Models used as Baseline for Operation
- Compatibility and Interoperability – Not Unification

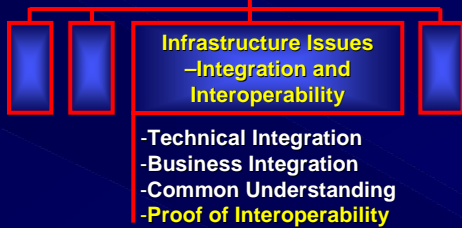


Common Understanding

- Vision -

The Integrated, Model Rich Environment Demands a Common Language.

- Semantic Understanding Across Tools and Applications
- Common Language for Manufacturing Ontologies will Enable:
 - Knowledge-based Advisors
 - Automated Planning
 - Learning Systems

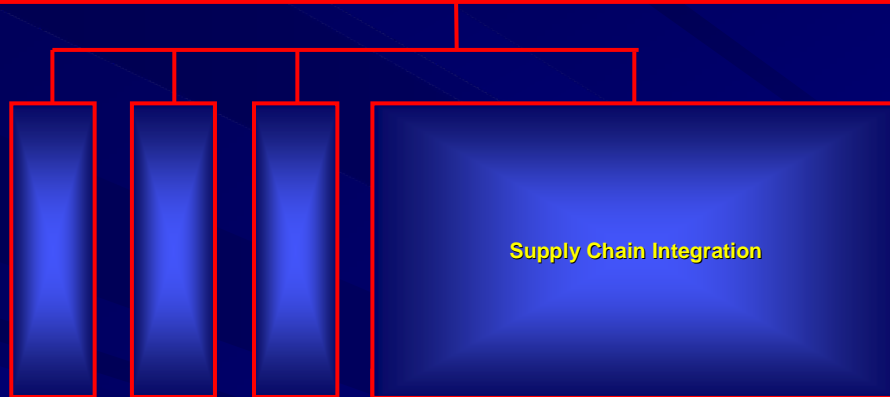


Proof of Interoperability

-Vision -

- A network of national interoperability testbeds verify interoperability against standards across companies, technology vendors, and industry sectors
- Proven, reliable communications and integration capability produce significant cost savings from
 1. Fewer costly communication errors
 2. More competitive companies able to successfully enter into dynamic virtual partnership interactions as opportunities arise.

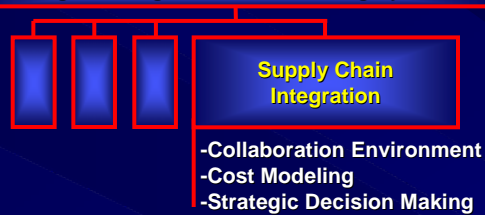
Intelligent, Integrated Manufacturing Systems



Supply Chain Integration

- Collaboration Environment
- Cost Modeling
- Strategic Decision Making

Supply Chain Integration



Supply Chain Integration

- Overall Vision -

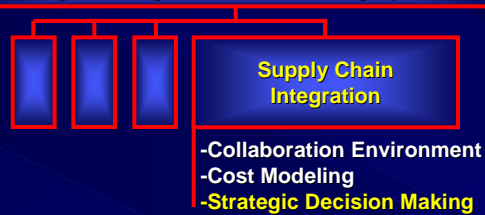
- Supply Chains Optimized for Total Value Performance
- Information Access Spread Across and Deep Into the Supply Chain
- **Secure Access to Abstracted Information**
- Plug-and-Play Interoperability of an Integrated Toolset
- **Net-centric meaning information, systems and organizations - harmonized**



Cost Modeling

- Vision -

- All Costs Readily Available for Every Product, Component, and Function
- Cost Models and Cost Data Integrate with Decision Support Tools
- Requirements-based Cost Models that Support the Product and Process Life-cycle
- Integration and interoperability of Various Cost Models
- Integration of Cost Modeling Methods
- Intelligent Cost Models that Understand the Enterprise and Supply Chain Members



Strategic Decision Making

- Vision -

- Highly Agile Supply Chains
- Business Planning Systems that are Interfaced with Comprehensive Supplier Models
- Discovery Systems that Populate Supplier Models Automatically
- Scalable Supply Chain Models and Frameworks
- Strategic “Cockpits” and “Dashboards” for Interactive Decision Making



- **We need your comments on the document.**
- **It is a living document seeking a living consensus**
- **IMTI desires to serve as a facilitator to bring the IIMS vision to realization**

Again, We Invite You to Participate in
the IIMS Forum III in Huntsville on June
10 and 11

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