

Accelerated Insertion of Materials - Composites

A New Way to Design Composite Structures

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for the
Innovative Design Workshop
Hampton, VA
March 2004

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What is AIM-C?

AIM-C is a methodology for accelerated insertion of materials into defense structures at reduced costs.

This methodology develops a design knowledge database that links what is known about a material system to what is needed in order to qualify its application to an application that meets certification requirements

It allows rapid identification of which applications are too risky and which are not.

It uses verified analysis methods, existing test data, and lessons learned from previous experience to minimize the amount of data required to insert new materials into a system with confidence



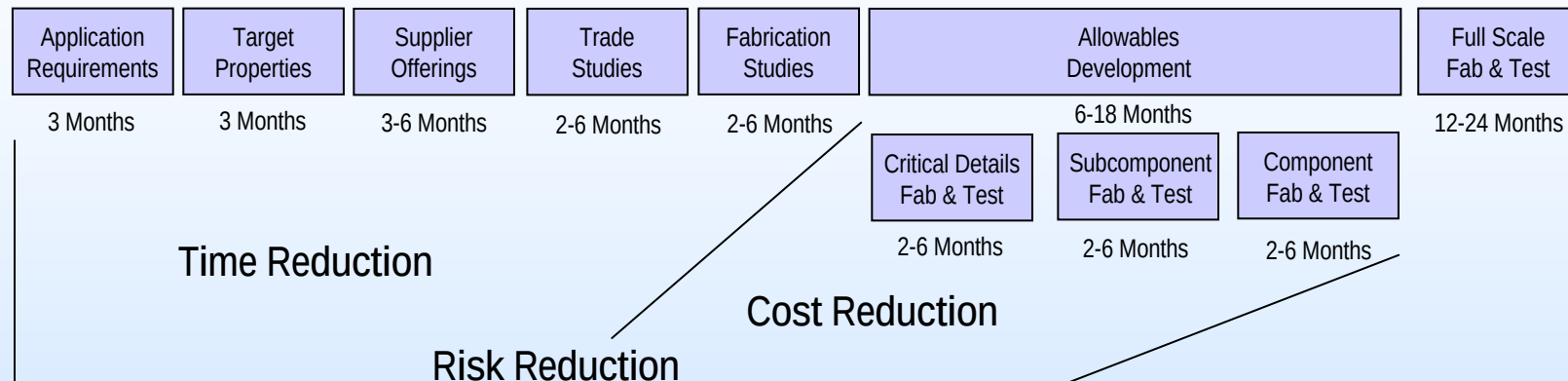
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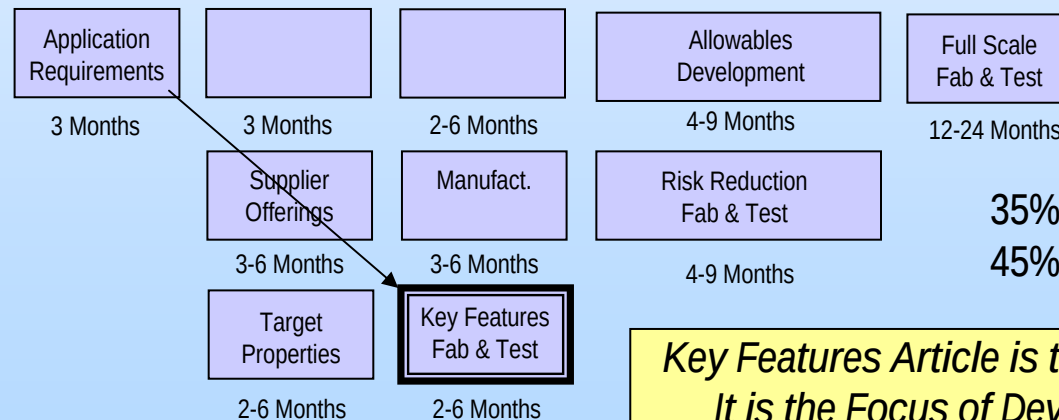


What Does AIM-C Do?

Replaces the Conventional, Sequential Building Block Approach to Insertion



With a Focused, IPT Approach to Insertion



35% Reduction in Total Time to Certification
45% Reduction in Time to Risk Reduction

*Key Features Article is the Key to Acceleration
It is the Focus of Development Activities
It Eliminates Rework
And It Focuses Certification Testing*



How Does AIM-C Accelerate Insertion?

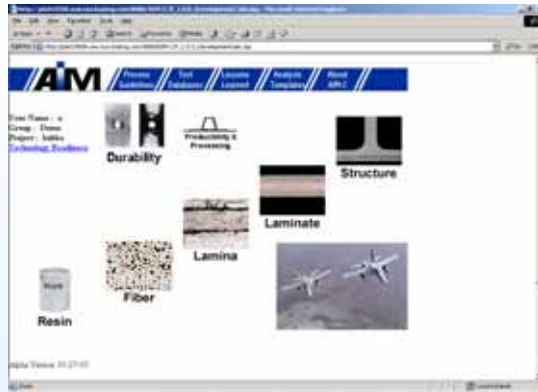
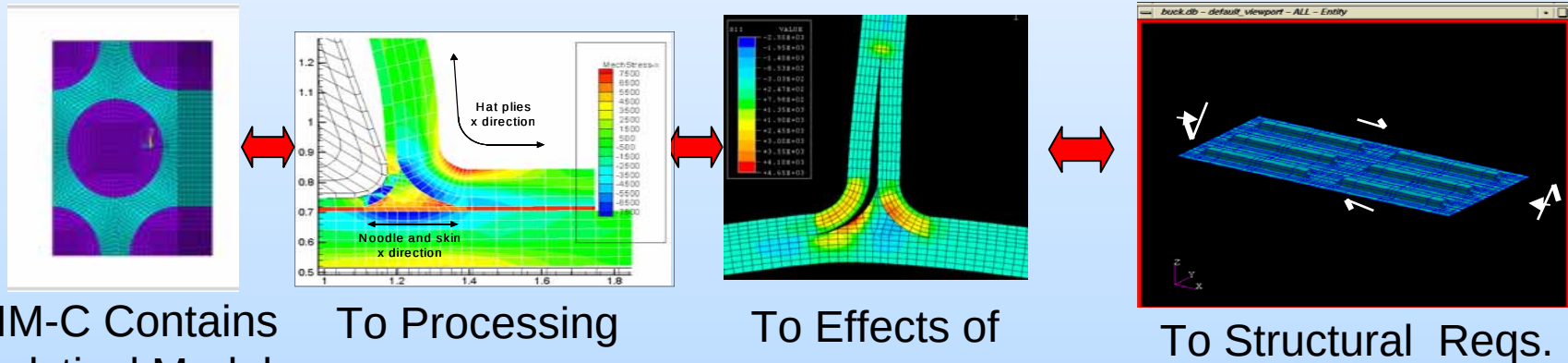
- Focuses on Real Insertion Needs (Designer Knowledge Base)
- Identifies the Necessary IPT and provides IPT with Readiness Level Status
- Coordinates Use of
 - Existing Knowledge
 - Validated Analysis tools
 - Focused Testing
- Provides Access to the Latest Physics Based Material & Structural Analysis Methods
- Uses Integrated Engineering Processes & Simulations
- Uses Uncertainty Analysis and Management
 - Focuses on Early Feature Based Readiness Demonstration
 - Tracks of Variability and Error Propagation During Scale Up

Provides Orchestrated Knowledge Management to efficiently tie these elements to the Design Knowledge Base



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AIM-C Contains Analytical Models From Constituents

To Processing

To Effects of Defects

To Structural Reqs.

To Provide Analysis Supported by Test To Technology Readiness

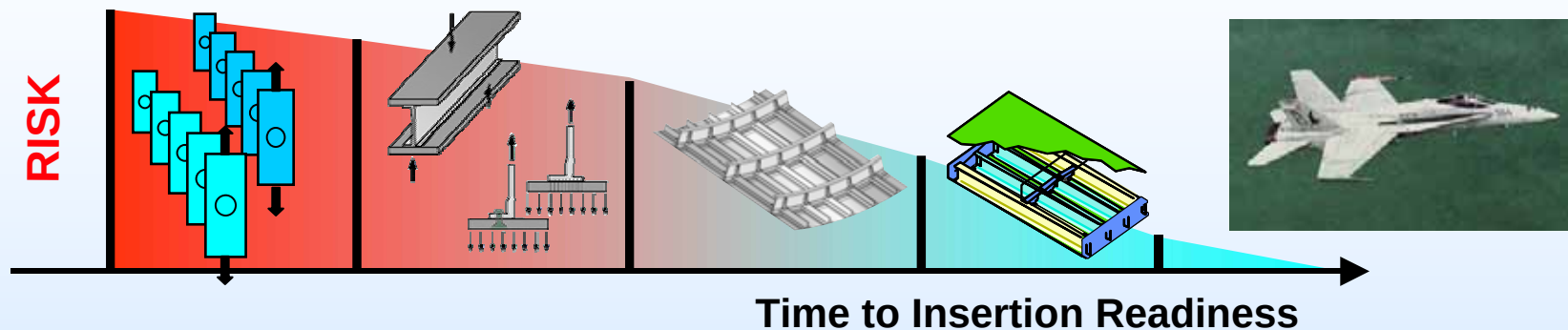


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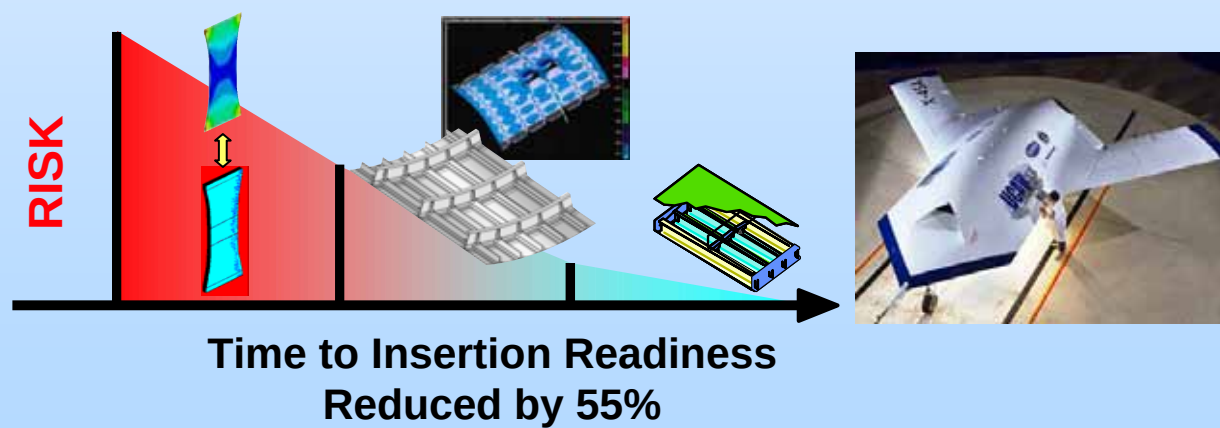


What's the Benefit of AIM-C?

Traditional Test Supported by Analysis Approach



AIM Provides an Analysis Approach Supported by Experience, Test and Demonstration

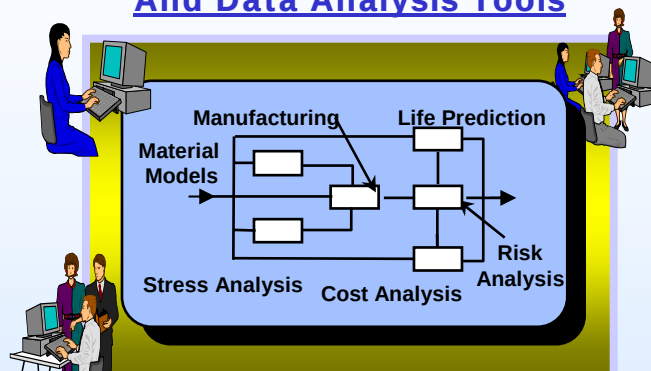


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The Approach

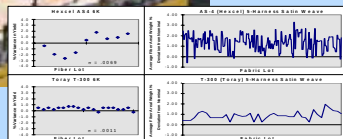
Integrated Modeling/Simulation And Data Analysis Tools



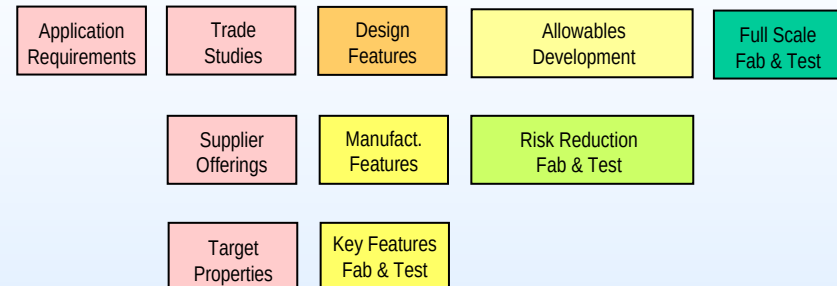
**Modular Architecture
Uncertainty Analysis**

Producibility Issues

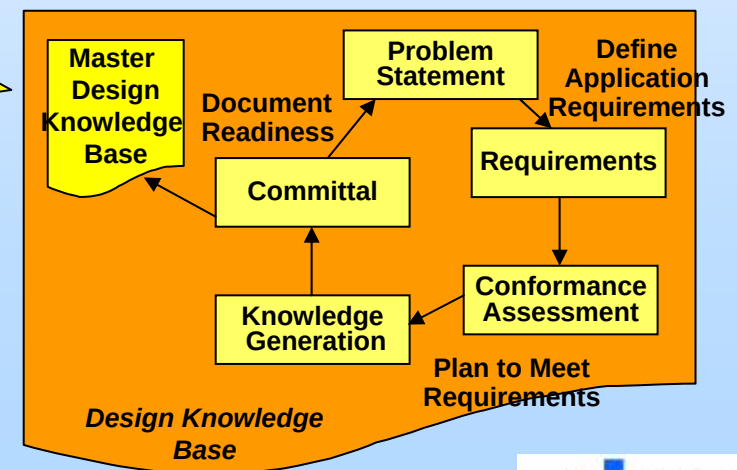
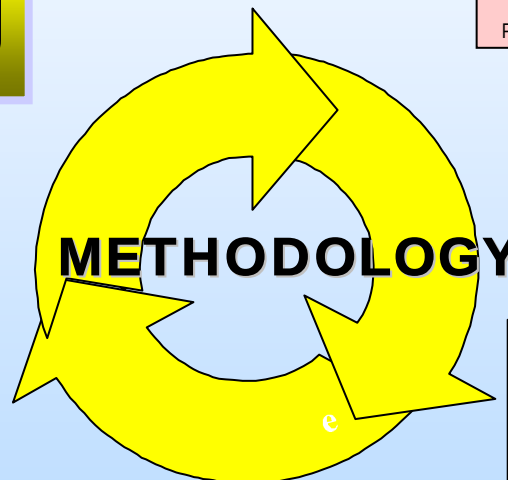
- Simulations
- Heuristics
- Lessons Learned



Optimized Building Block Approach



Technology Readiness Levels

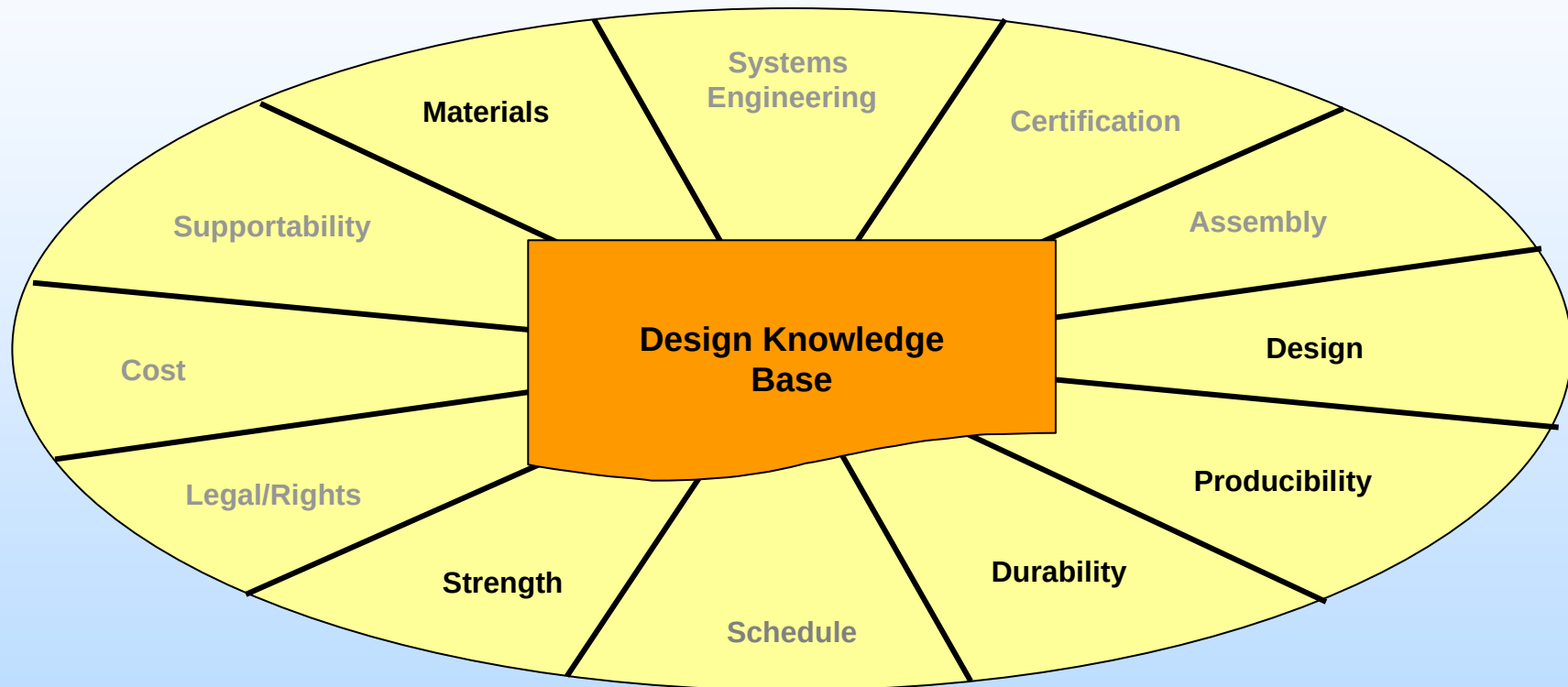


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The AIM-C Process Uses the IPT to Commit Data to the DKB



All functions contribute – All receive data from the DKB



AIM Allows the IPT to Track and Plan Progress Toward Successful Insertion

TRL	0	1	2	3	4	5	6	7	8	9	10
IPT Reviews	Technology Insertion Readiness	System Requirements Review	Material and Process Readiness	Key Features Design and Fabrication	Key Features Test / Conformance	Preliminary Design	Critical Design / Ground Test Readiness	Flight Test Readiness	Production Readiness	Operational Readiness	Technology Insertion Readiness
Application / Design											
Certification											
Assembly											
Structures / Durability											
Fabrication / Quality											
Materials & Processes											
Supportability											
Survivability											
Cost / Schedule											
Intellectual Property											



Technology Readiness Levels Differ in Focus

Technology Developers See TRLs Focused on That Development

Technology Readiness Levels													
Technology Development	1	2	3	4	5	6	7	8	9				
Application Development				1	2	3	4	5	6	7	8	9	10

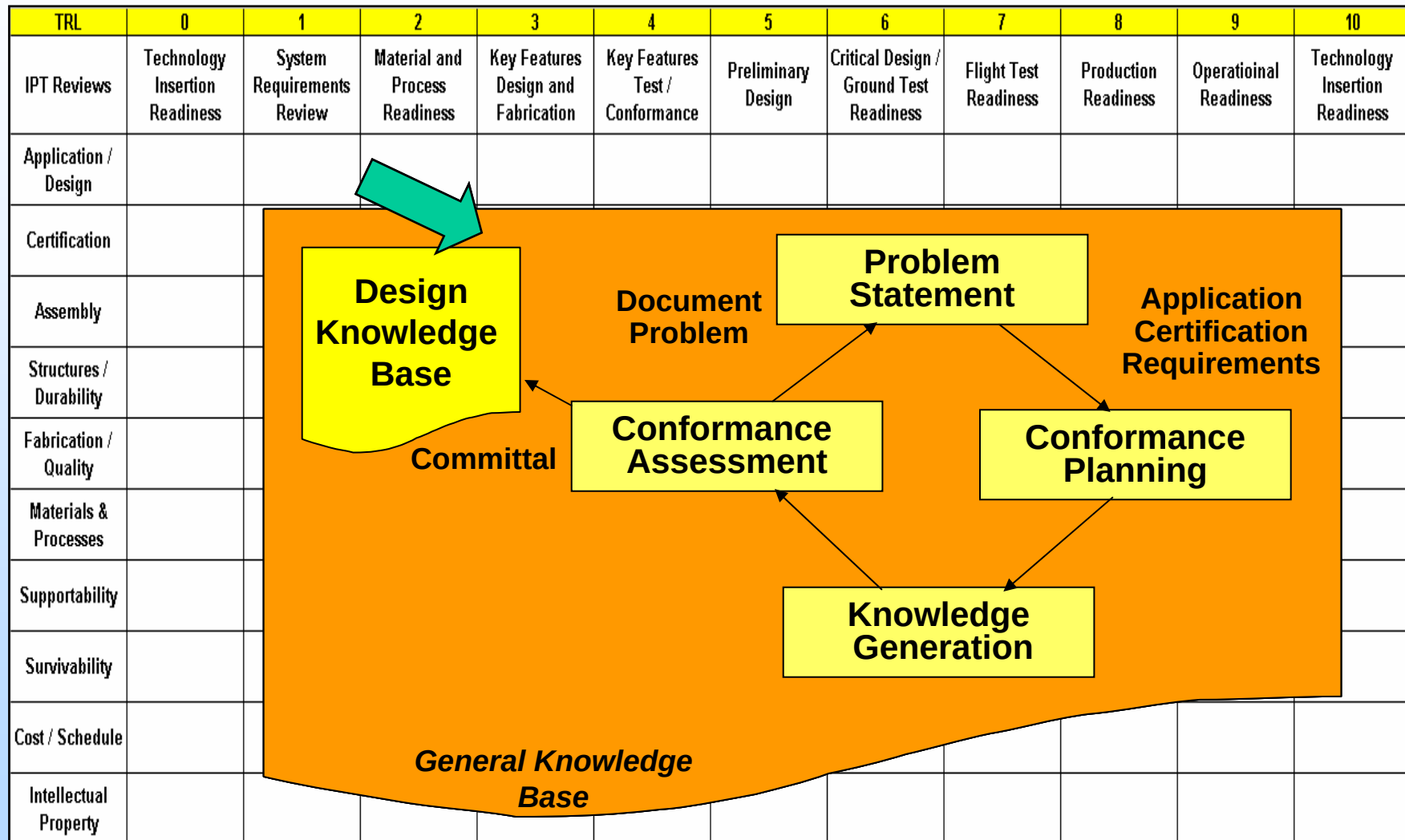
Application Developers See TRLs Focused on Insertion Into Their Products

Technology Readiness Levels													
Technology Development	0.25	0.50	0.75	1	2	3	4	5	6				
				One Team									
Application Development			0	1	2	3	4	5	6	7	8	9	10

AIM Developed TRLs Focused on Insertion but Linked Technology and Application Developers Into One Team

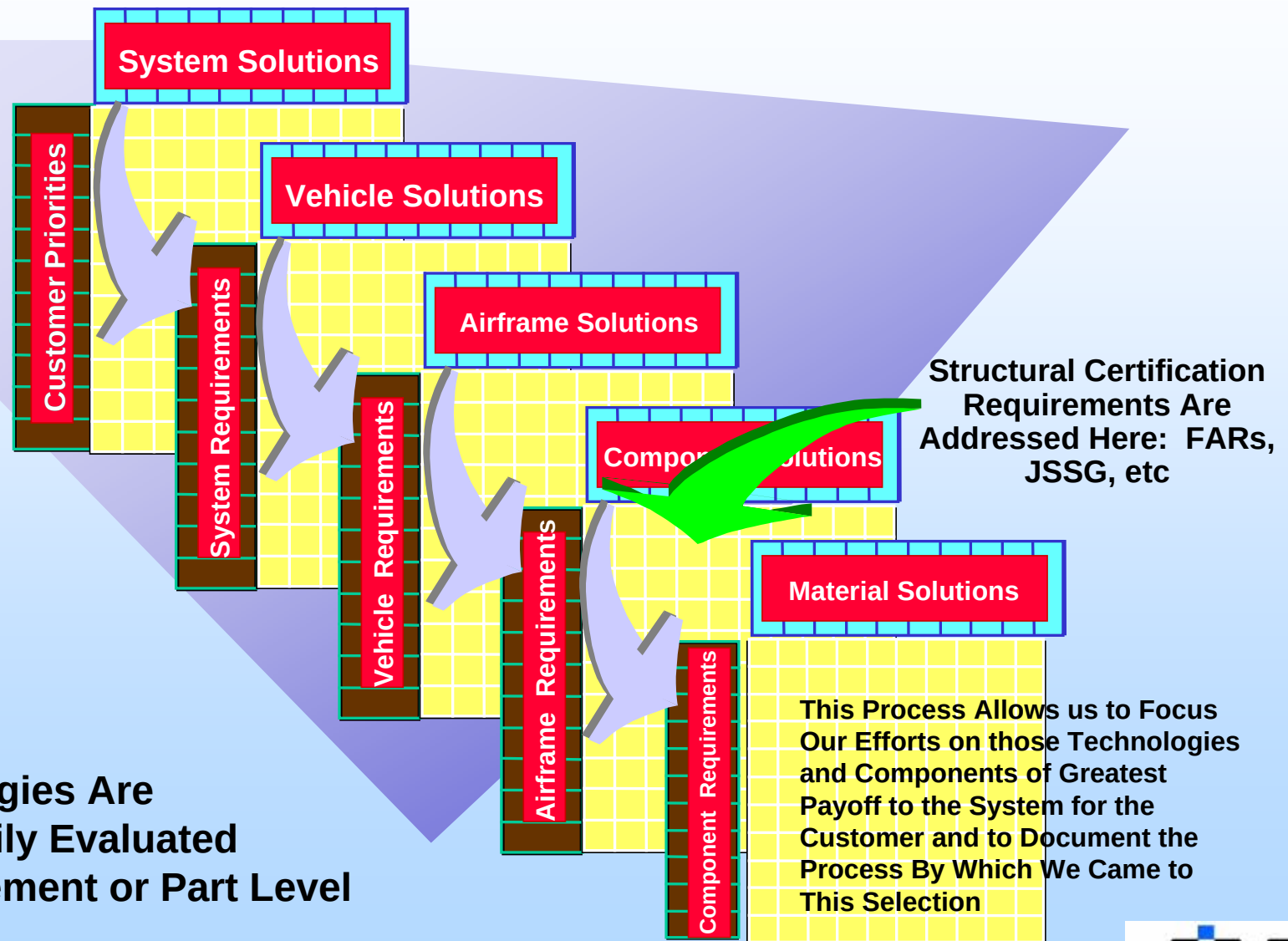


At Each Step Each Discipline Follows A Defined Process for Knowledge Committal





AIM-C Links Requirements from the System to the Technology / Material





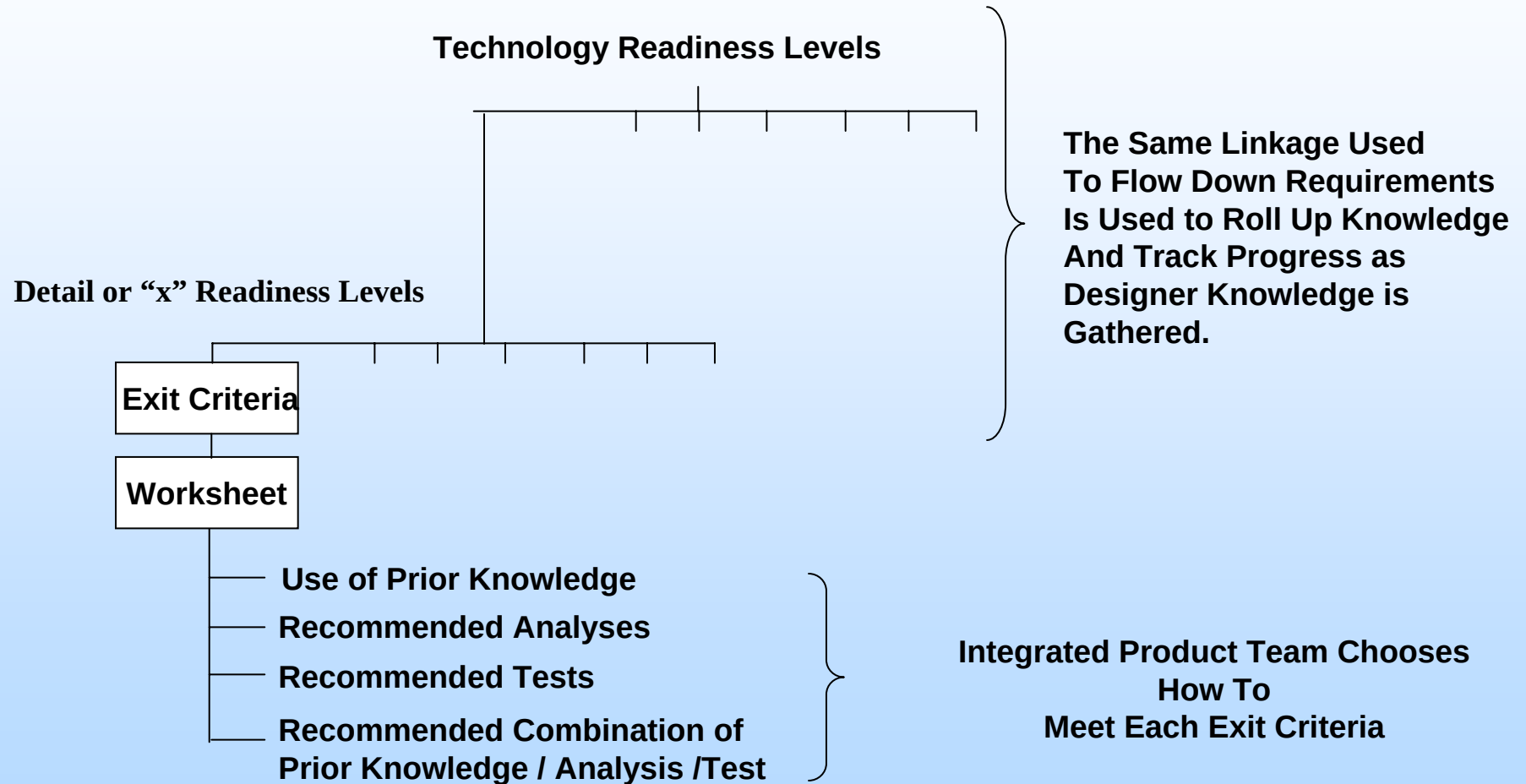
Conformance Planning

2.1		TEST TYPE/PROPERTIES - FIBER	0	1	2	3	4	5	6	7	8	9	10	
		Fiber Form and Type (Uni and Cloth, ie 5hs or plain or 8hs etc.)		x	x									
2.1.1	➤	Tensile Strength	x	x	x	x	x							Test-Analysis
2.1.2	➤	Tensile Modulus E11 (longitudinal)	x	x	x	x	x							Test-Analysis
2.1.3	➤	Tensile Strain to Failure	x	x	x	x	x							Test-Analysis
2.1.19		Compressive Strength				o								Analysis
2.1.20		Cost	x	x	x	x	x							Specified Value
2.1.21		T(g)		x										Test
2.1.22		wet T(g)		x										Test
2.1.23		Health and Safety		x										MSDS
2.1.10		CTE - Radial			o									Analysis
2.1.11		Filament Diameter	x		x		x							Test
2.1.12		Filament Count	x		x		x							Test
2.1.13		Transverse Bulk Modulus			o									Analysis
2.1.14		Youngs Modulus, E22 Transverse			o									Test
2.1.15		Shear Modulus, G12			o									Analysis
2.1.16		Shear Modulus, G23			o									Analysis
2.1.17		Poissons Ratio, 12			o									Analysis
2.1.18		Poissons Ratio, 23			o									Analysis
2.1.4	➤	Yield (MUL)	x	x	x	x	x							Analysis
2.1.5	➤	Density	x	x	x	x	x							Test
2.1.6		Heat Capacity (Cp)			x									Test
2.1.7		Thermal Conductivity Longitudinal			x-o									Analysis
2.1.8		Thermal Conductivity Transverse			x-o									Analysis

AIM-C Helps the IPT Plan Its Maturation Process



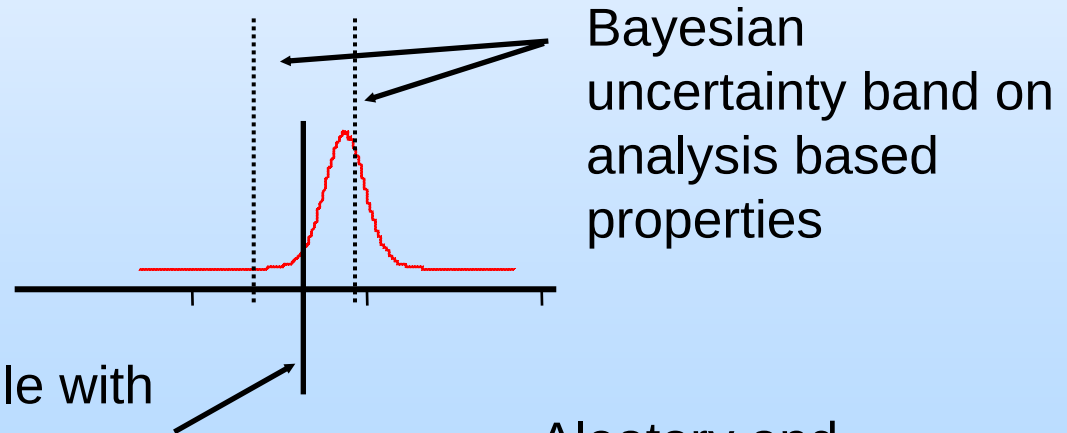
Knowledge Gathering





Conformance Assessment Data from Knowledge, Analysis, and Test – Design Values with Uncertainty

- Existing Data with replicates => can estimate design values (quantities and confidence bands)
- RDCS allows simulation of physical data with sources of randomness including batch effects (aleatory or random uncertainty) => can simulate design values.
- Combined data: design values with uncertainty bands



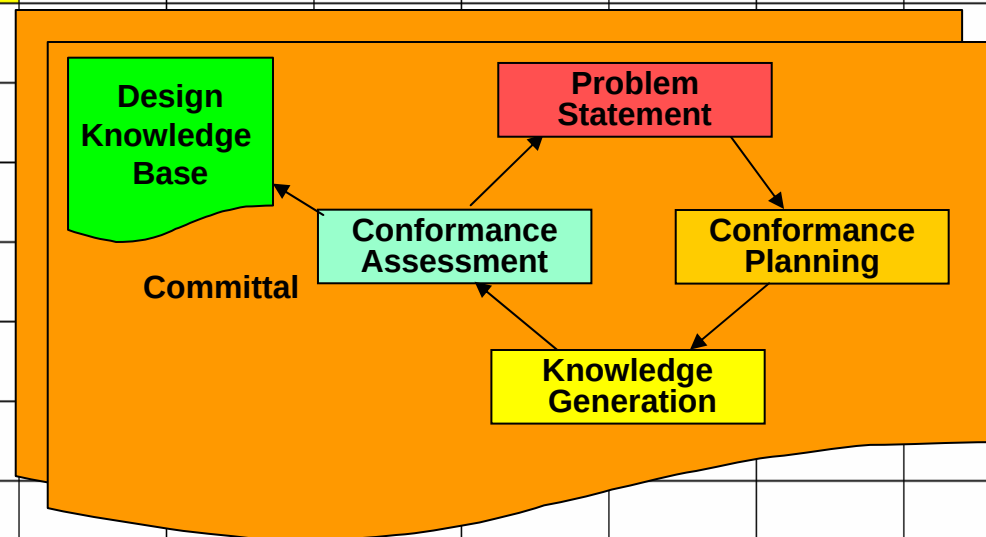
Property estimate = quantile with confidence band. This is the “aleatory”/measured content

Aleatory and Bayesian are kept separate



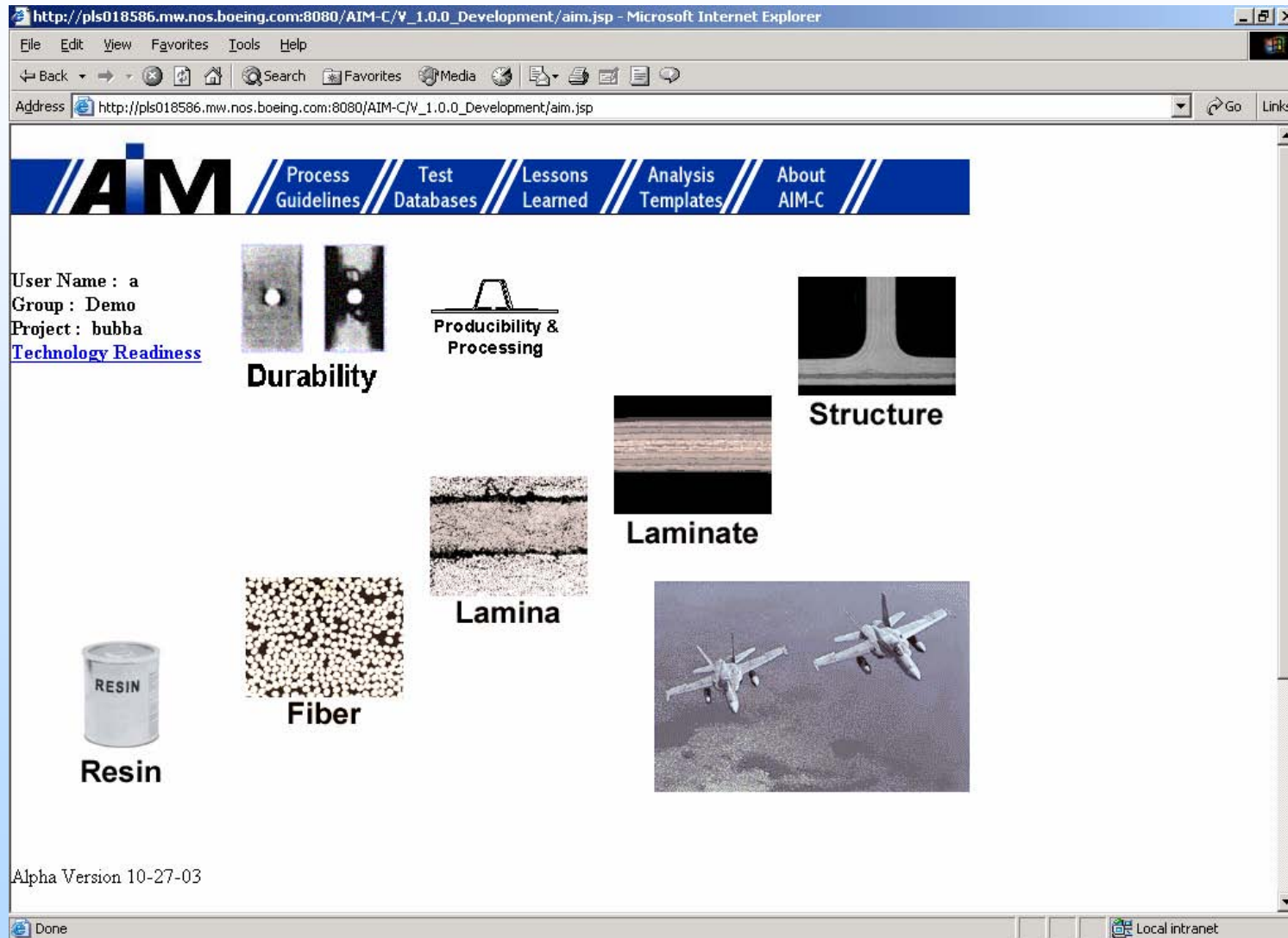
AIM Allows the IPT to Track Progress

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Intellectual Property											



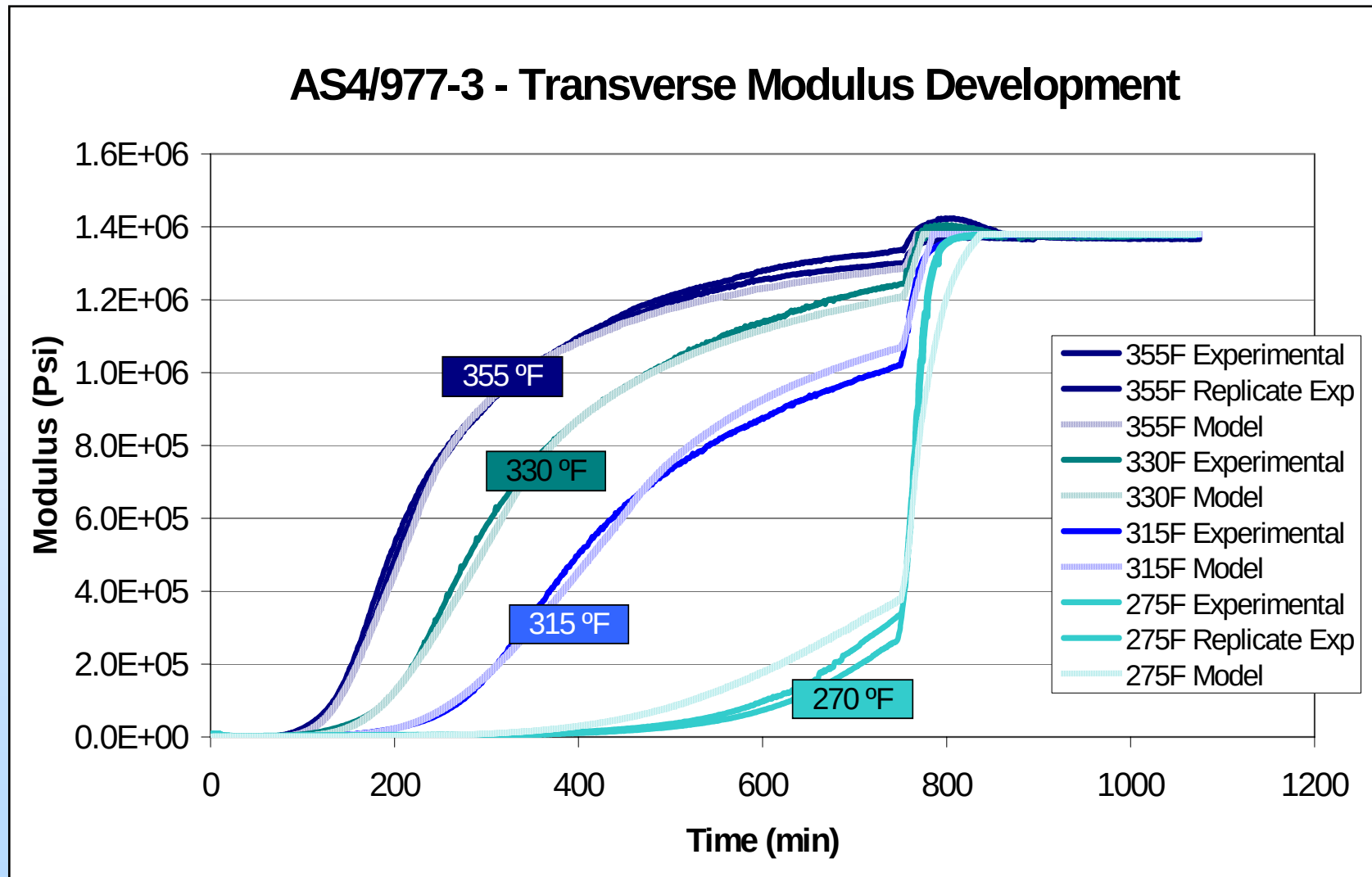


AIM Has Assembled a Web-Based System to Help the IPT Apply the Process





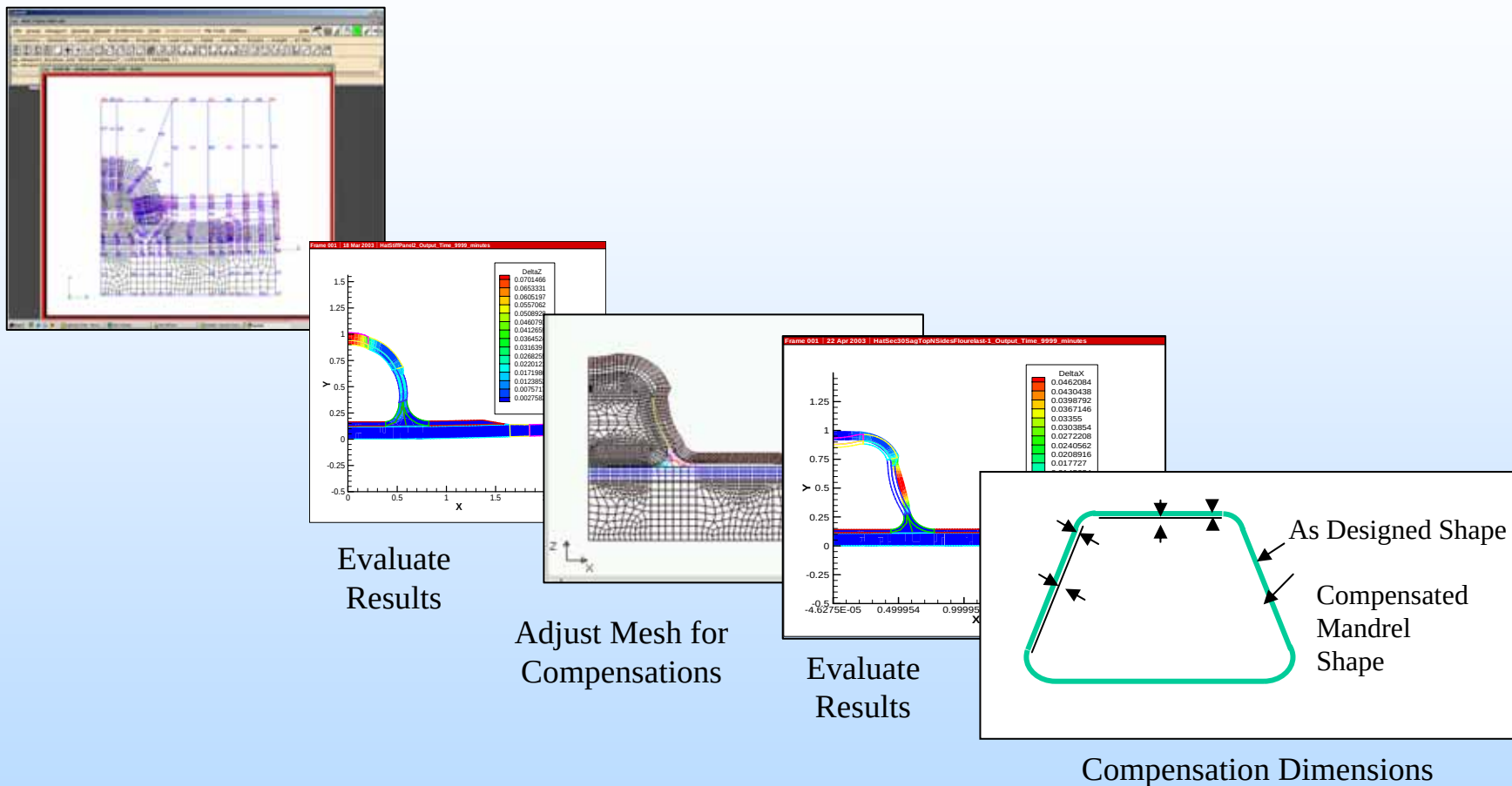
How Do Materials Engineers Use AIM-C?



AIM-C Helps Monitor Conformance to Requirements



How Does Manufacturing Use AIM-C?

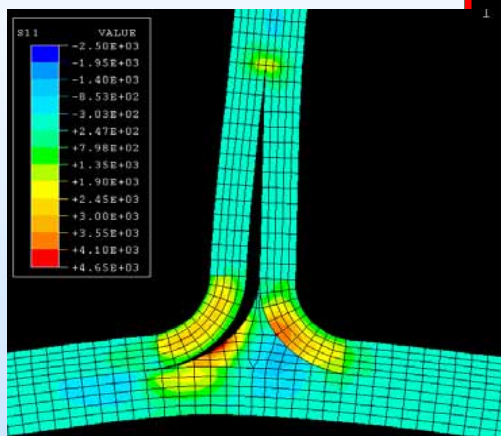


AIM-C Helps Identify Analysis Tools to Guide Fabrication

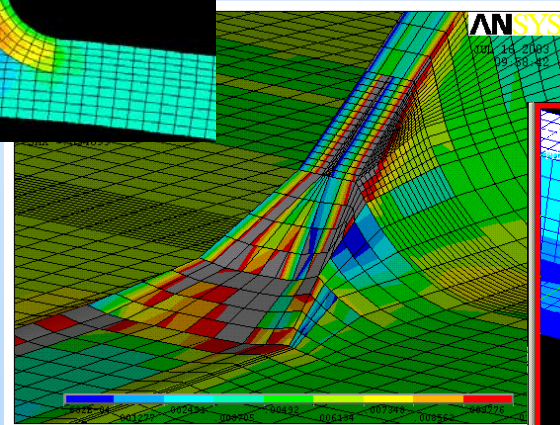


How Do Structures Engineers Use AIM-C?

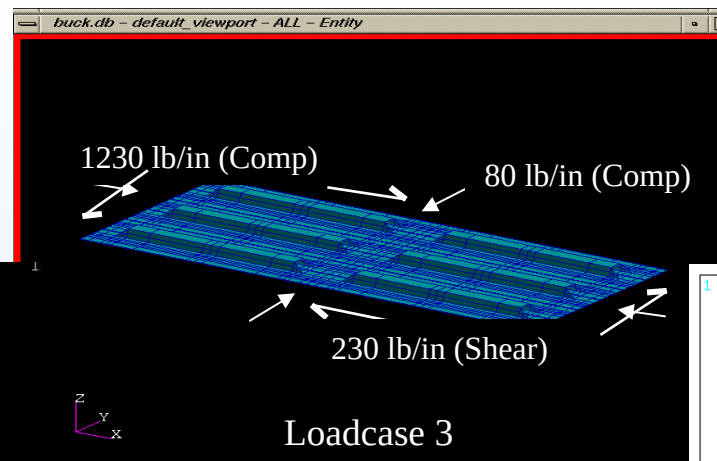
Fed Back to FEM
For Verify Satisfaction
Of Requirements



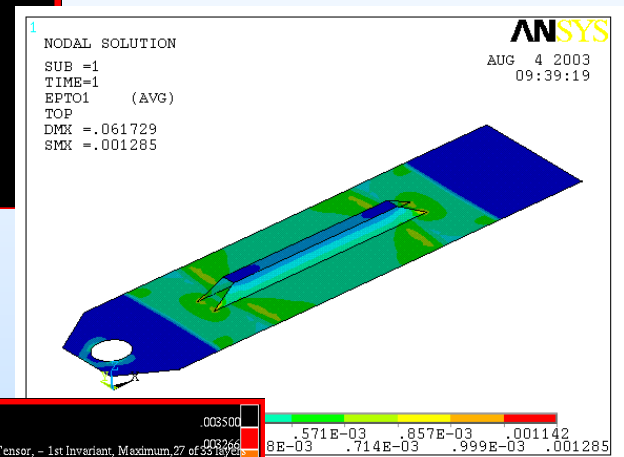
Details to
Effects of
Defects



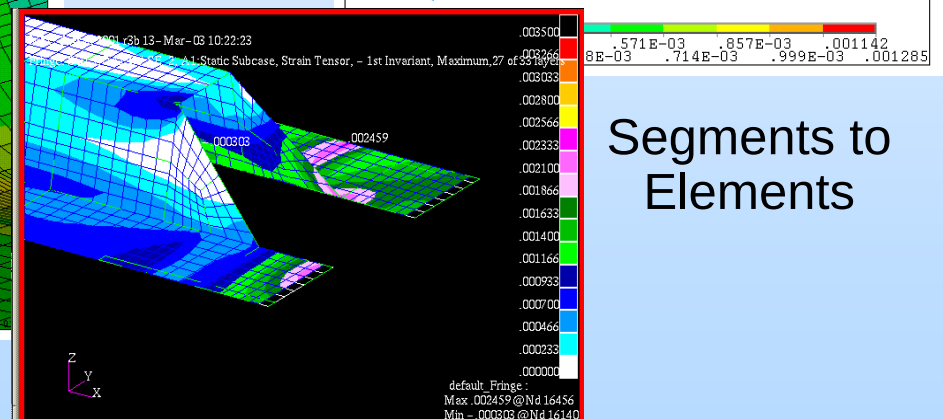
Elements to
Details



From Full FEM
to Segments



Segments to
Elements



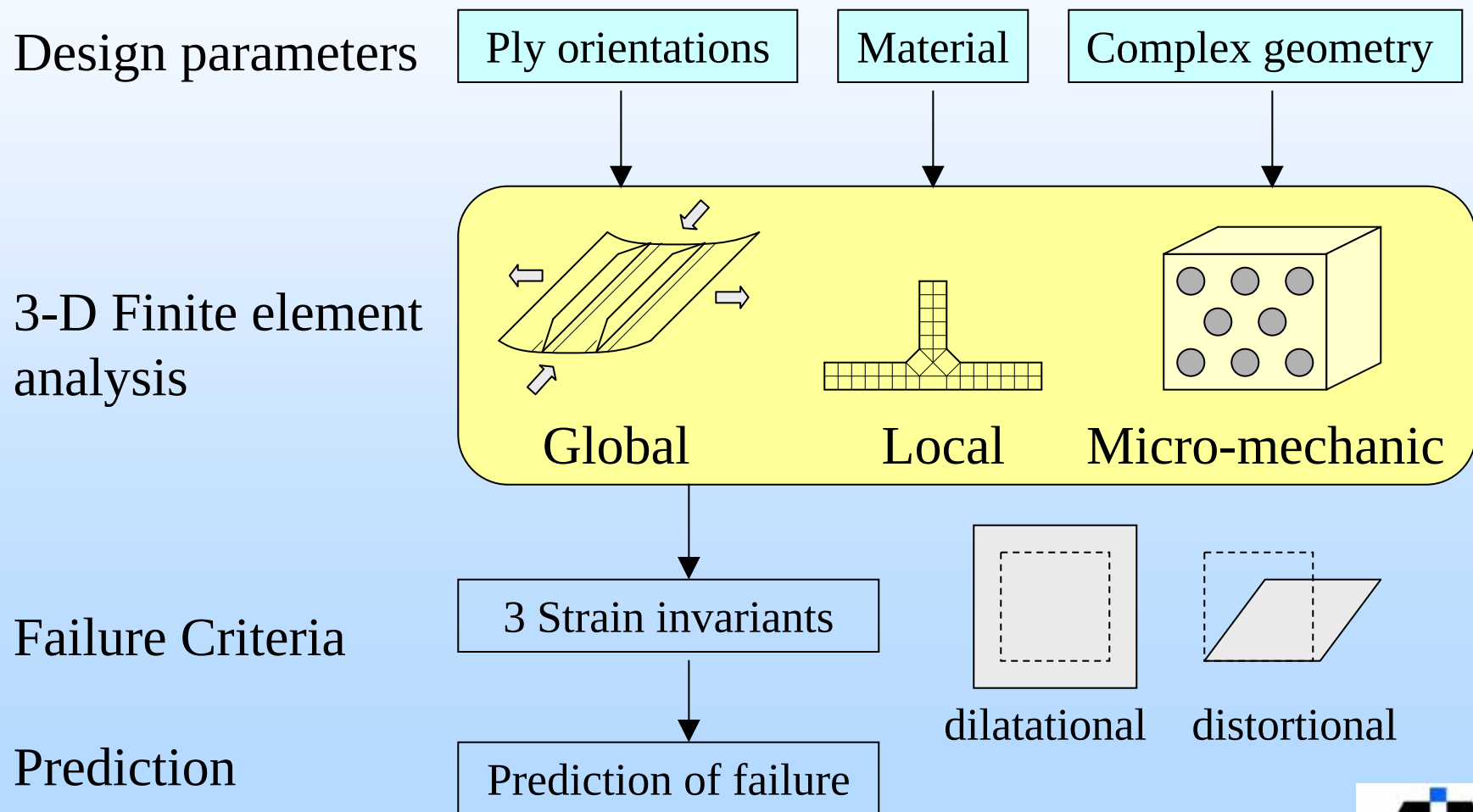
AIM-C Helps Plan the Maturation Process
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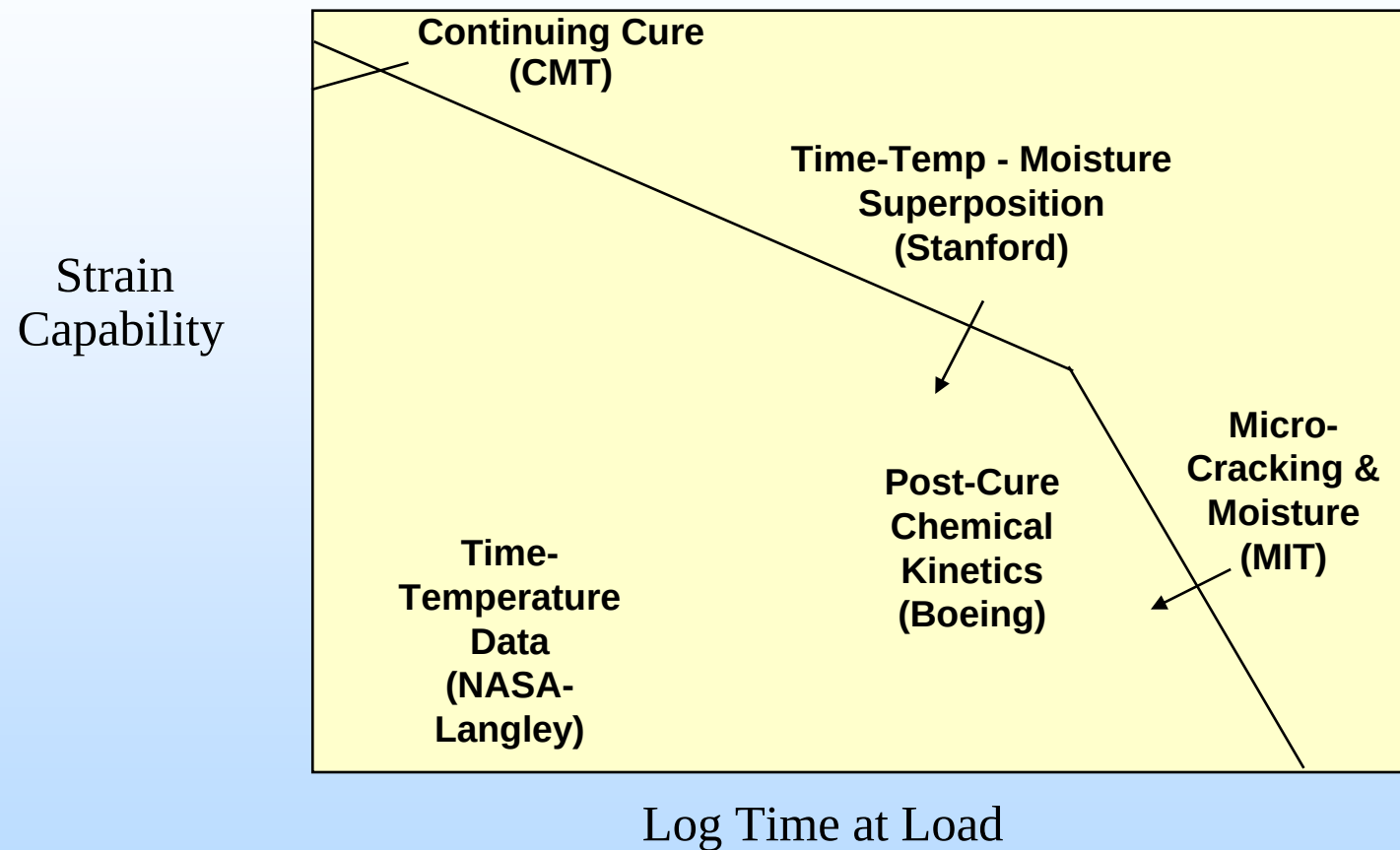
How Does AIM-C Assess Strength?

Detailed 3D FEA of complex structures
combined with simple strain-based failure criterion
(SIFT)





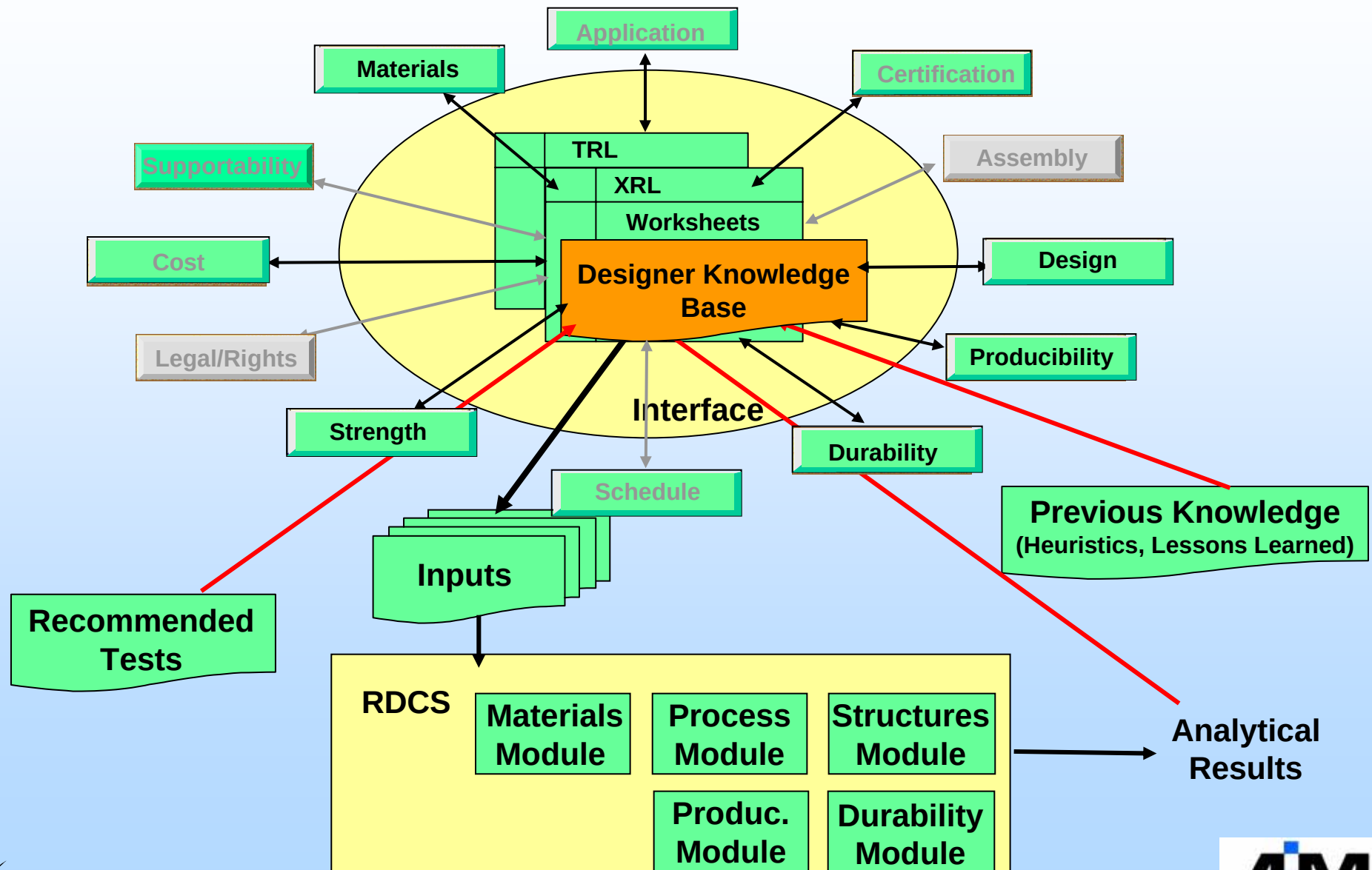
How Does AIM-C Assess Durability?



This Module Predicts the Effects of Four Competing Failure Modes –
Time, Temperature, Environment and Chemical Degradation



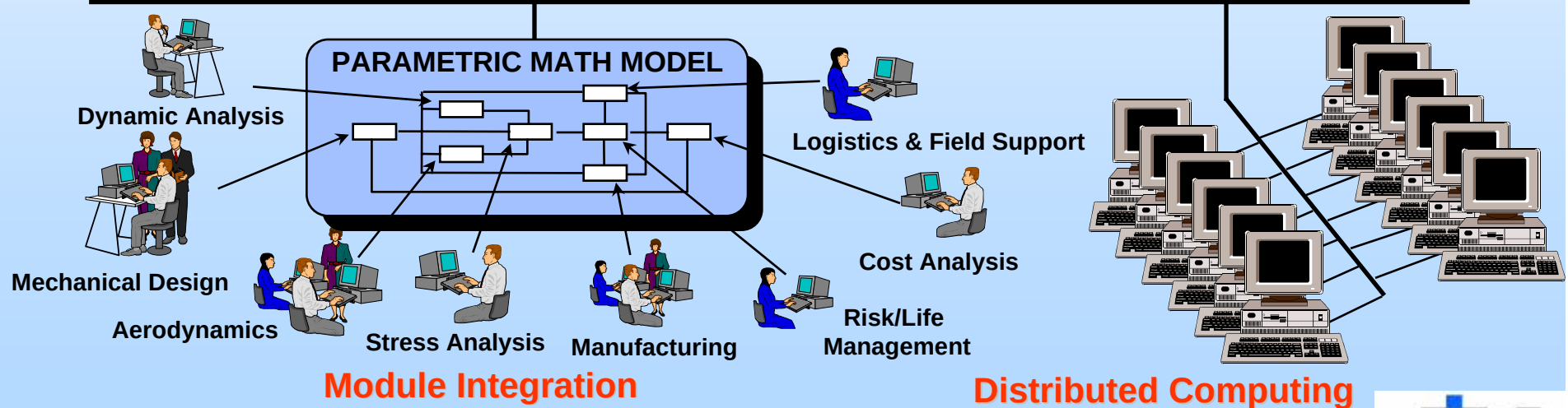
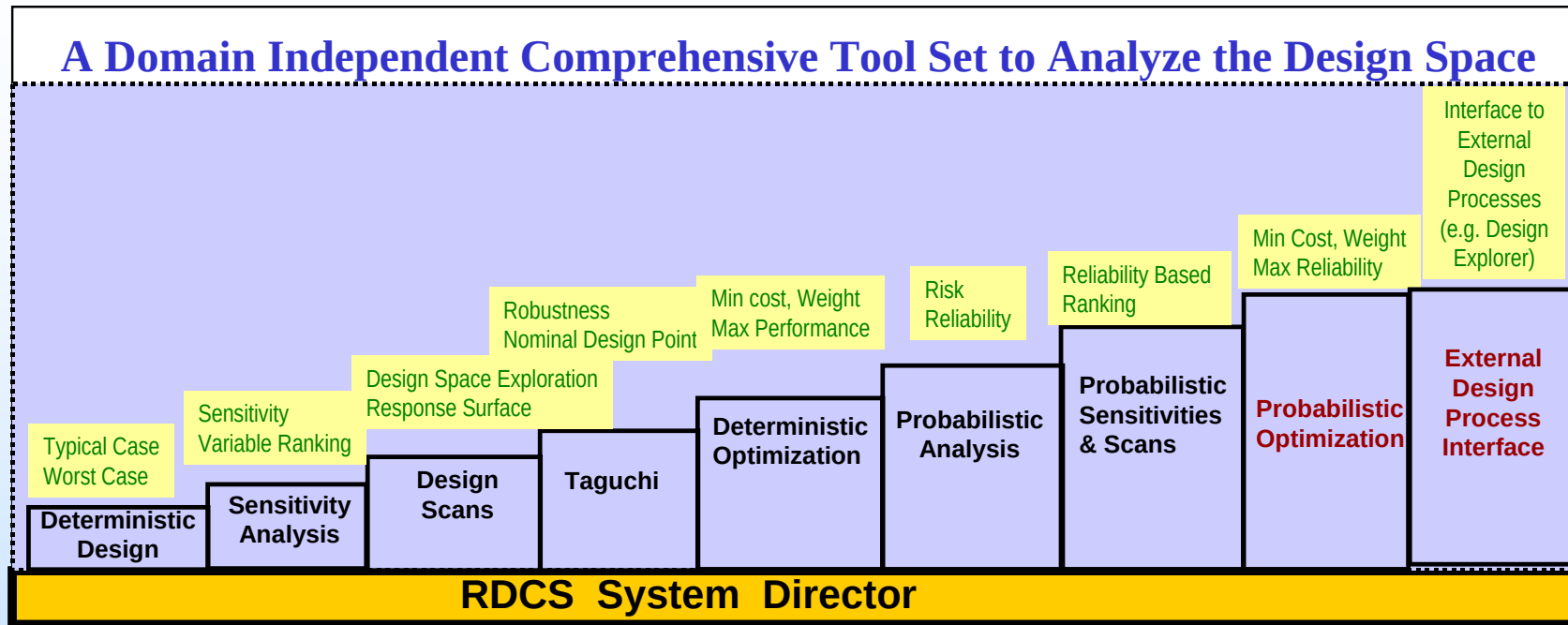
The AIM-C System Uses These Tools to Produce a DKB That Meets Certification Requirements





Robust Design Computational System

Wide Variety of Error Propagation and Uncertainty Analysis Tools



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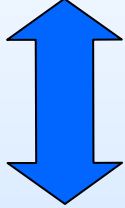




AIM-C Three Step Validation Approach

Step 1

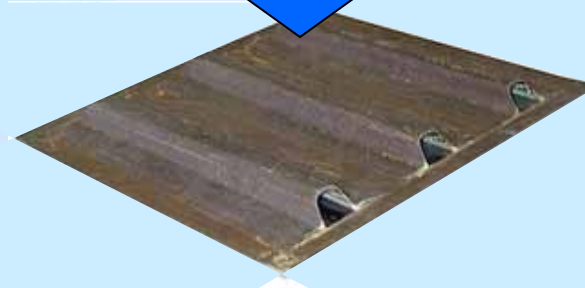
Individual
Module and System
Validation



Existing Data

Step 2

Demonstrations and System
Validation of Improvements



System Demonstration and
Tests of Compelling Demo
Validate Projected
Means and Scatter

Step 3

Blind
Validation



Known
Design
Requirements

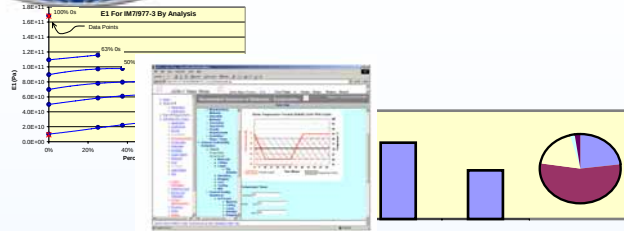


NGC IPT Uses AIM-C

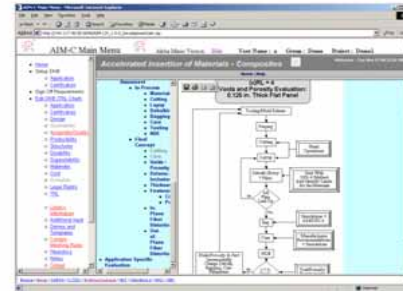
Validates Technical Results, Time Reductions, Cost Reductions



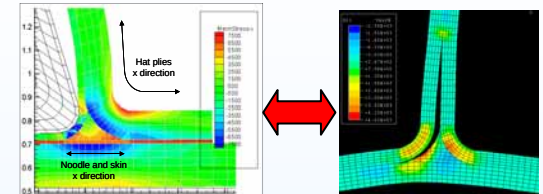
Encoded Heuristics



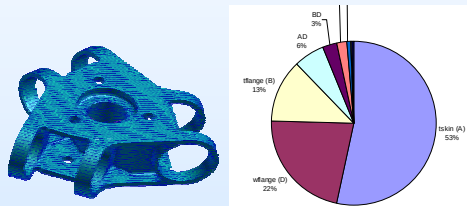
DKB Re-creation



Producibility

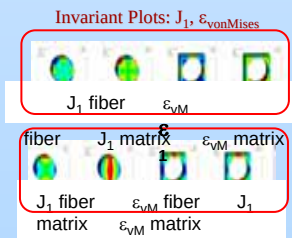


Processing data passed to Structural Analyses



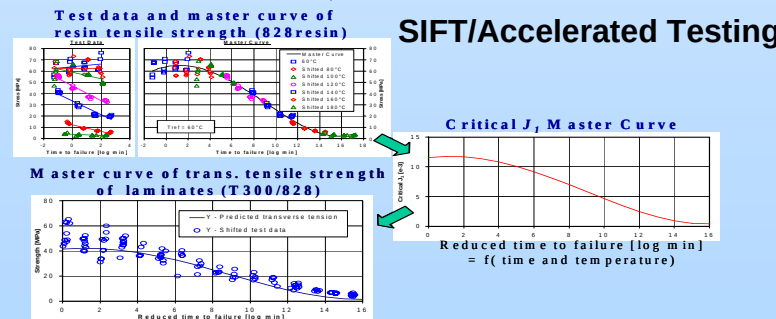
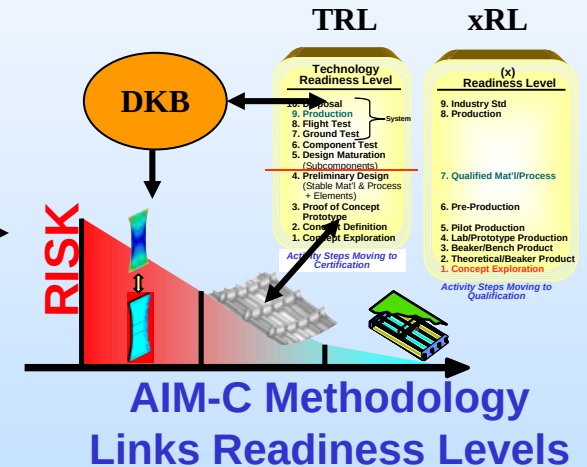
Design, ANOVA, Design Explorer, & Probabilistic Optimization RDCS Links

Physics Based 3D SIFT & Fracture Failure Theories

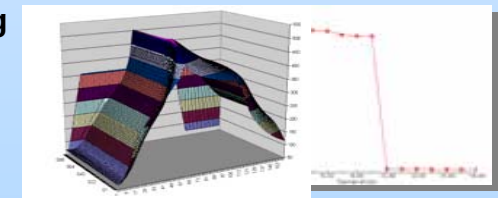


Structures

AIM-C Significant Accomplishments



Durability



Materials & Processing



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Where is AIM Being Used?



Materials Selection for X-45



Composite Flap for F/A-18 E/F



Transparencies for 7E7



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