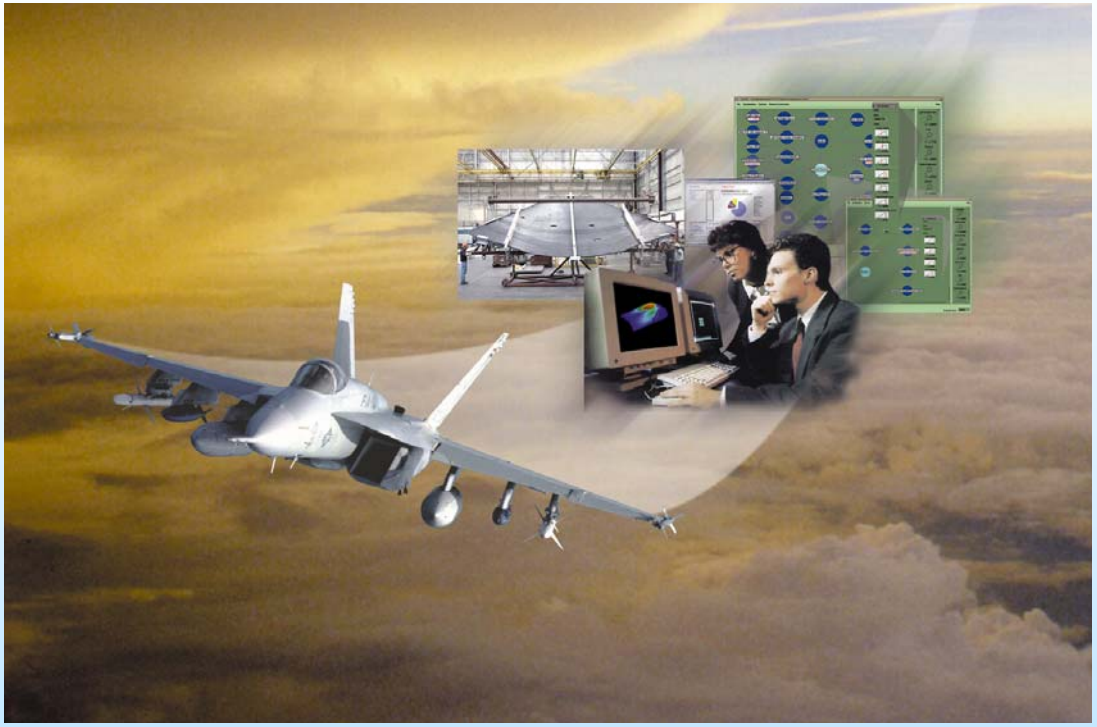
Lessons Learned from AIM-C



MEANS2 Bidders' Meeting

3 May 2004

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Accelerated Insertion of Materials – Composites (AIM-C)

Jointly accomplished by a Boeing Led Team and the U.S. Government under the guidance of the Office of Naval Aviation Systems Technology

Dr. Leo Christodoulou of DARPA/DSO **Dr. Raymond J. Meilunas, NAVAIR**

BOEING® Public Release Cases: BOE 061103-367, BOE 100703-440, BOE 030204-038

Where AIM started . . .

AIM-C Alignment Tool

The objective of the AIM-C Program is to provide concepts, an approach, and tools that can accelerate the insertion of composite materials into DoD systems.

AIM-C Accomplishes This Three Ways

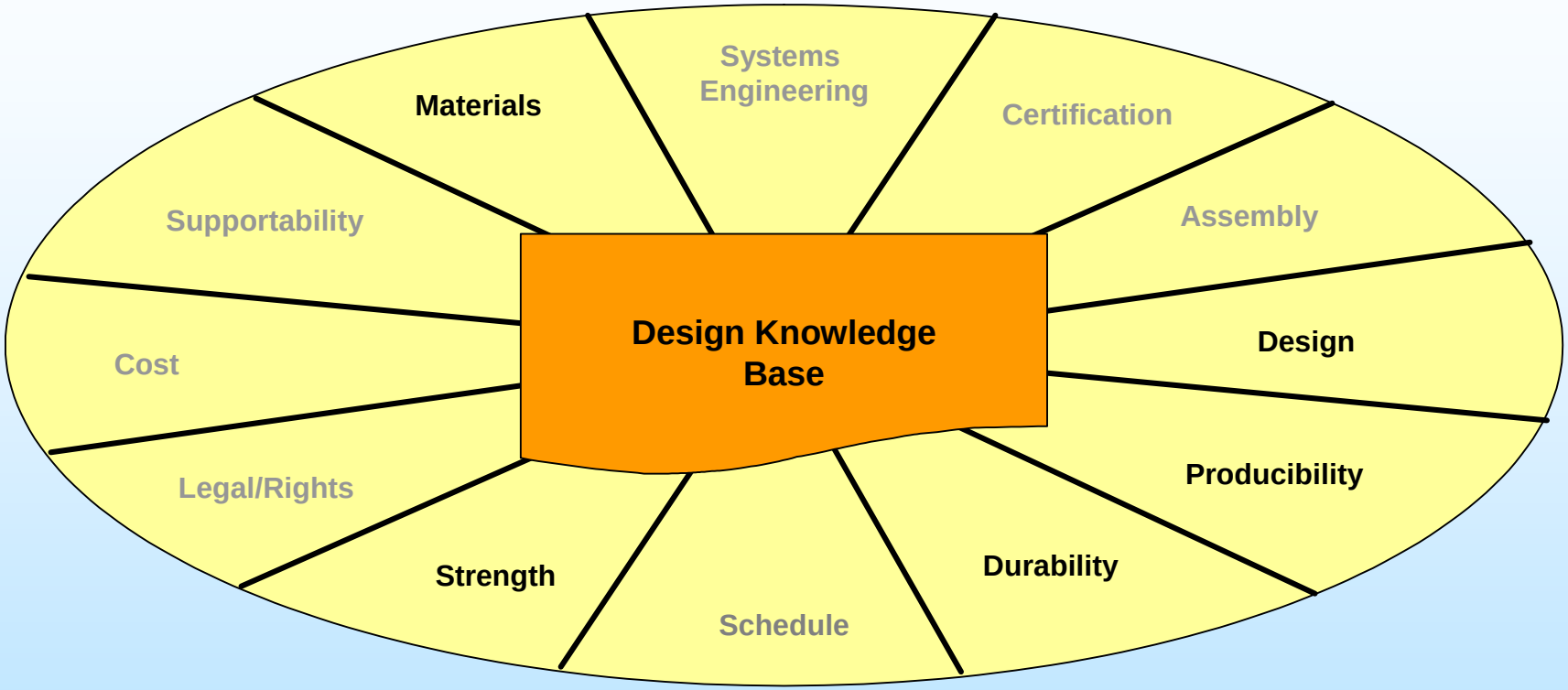
Methodology - ***Evaluates the historical roadblocks to effective implementation of composites and offers a process or protocol to eliminate these roadblocks and a strategy to expand the use of the systems and processes developed.***

Product Development - **Provides** ***a software tool that facilitates evaluation of composite materials for various applications.***

Demonstration/Validation - ***Provides a mechanism for acceptance by primary users of the system and validation by those responsible for certification of the applications in which the new materials may be used.***

Develop approach to establish a DKB for either a new material or an existing material in a new application.

Challenges Encountered . . .



Scale up
End of life properties
Unplanned rework
Transition of the knowledge base

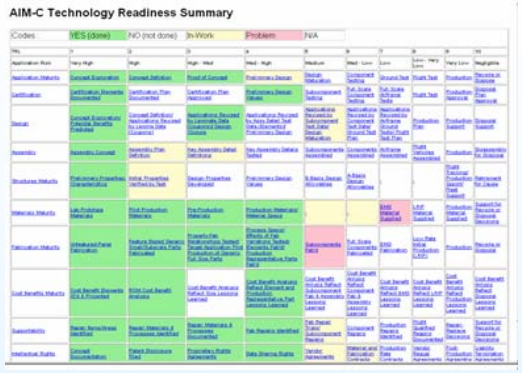
Accelerated Insertion of Materials Is Achieved in AIM-C Methodology by

- Focusing on Real Insertion Needs (Designer Knowledge Base)
- Approach for coordinated use of
  - Existing Knowledge
  - Validated Analysis tools
  - Focused Testing
- Application of Physics Based Material & Structural Analysis Methods
- Use of Integrated Engineering Processes & Simulations
- Uncertainty Analysis and Management
  - Early Feature Based Demonstration
  - Tracking of Variability and Error Propagation Across Scales
- Rework Avoidance
- Disciplined approach for pedigree management

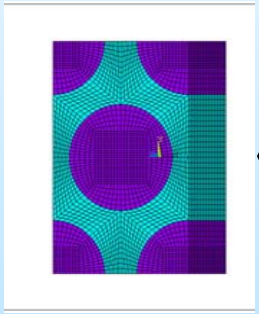
Orchestrated Knowledge Management to efficiently tie together the above elements to DKB

Accomplishments

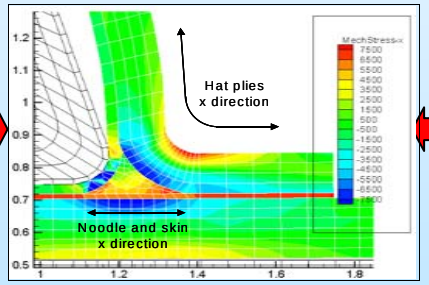
Web-Based System Delivery



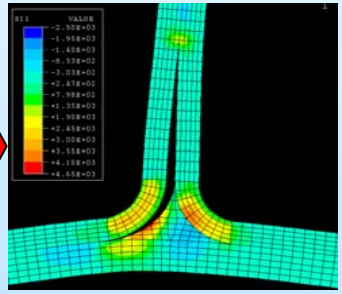
Process Guidance and Risk Reduction Status



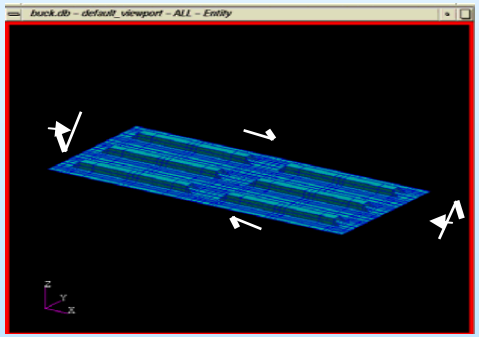
AIM-C Contains Analytical Models From Constituents



To Processing



To Effects of Defects

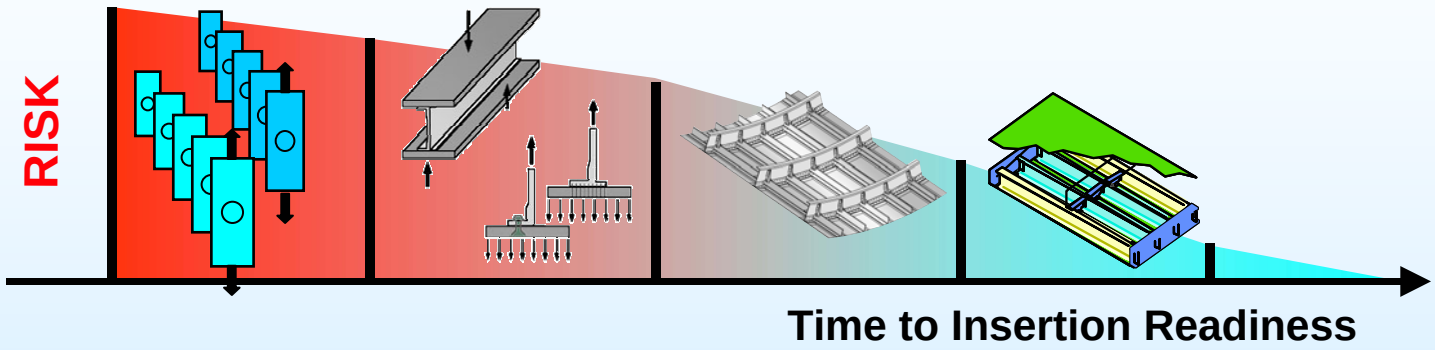


To Structural Requirements

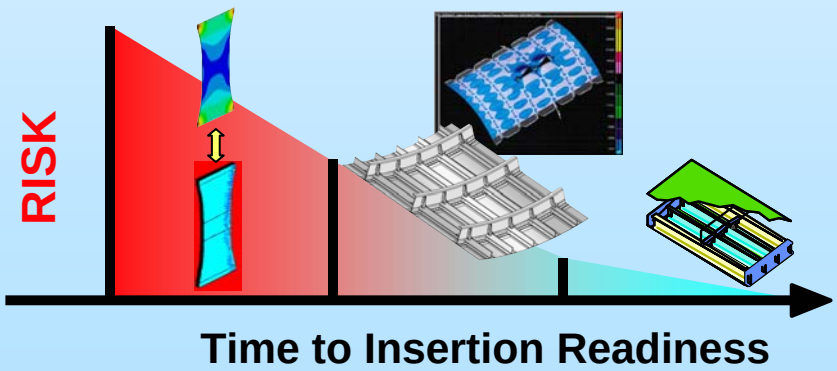
To Provide Analysis Supported by Test To Technology Readiness

Accomplishments

Traditional Test Supported by Analysis Approach



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



- **COMPRO in RDCS – 6 month Taguchi vs weekend full factorial**
- **Processing cycle matched on first process attempt vs 6 panels by empirical methodology**
- **SIFT Analysis within RDCS – 3 days vs 6 months**
- **Hat mandrel study – 6 months vs 3 years**
- **Hat stiffened panel – projected at 60% of 8 year baseline**

Uncertainty Analysis of Physics Based Model Predictions
The Major Steps to Reduce Design Risk
*Tools Available in a Convenient form in RDCS**

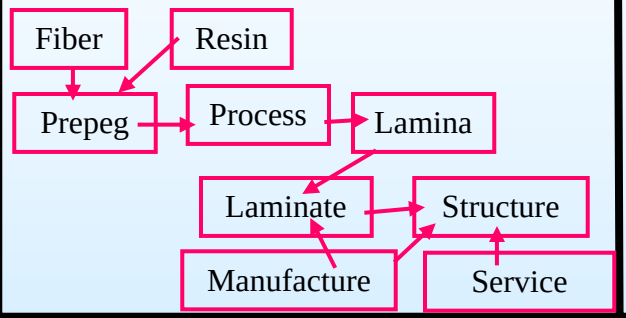
Step 1

Systematically identify potential uncertainty and Error Sources

- Inherent variations
- Their Statistics
- Lack of Knowledge
- Potential source of errors
- Potential Mistakes

Step 2

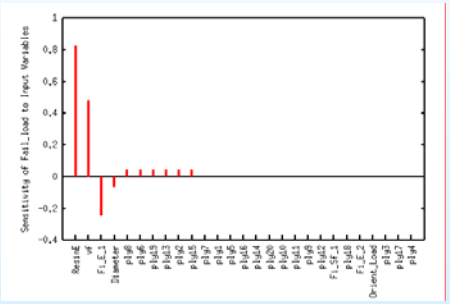
Construct linked models that will allow introducing uncertainty at the appropriate level, propagate uncertainties and capture correlations



Step 3

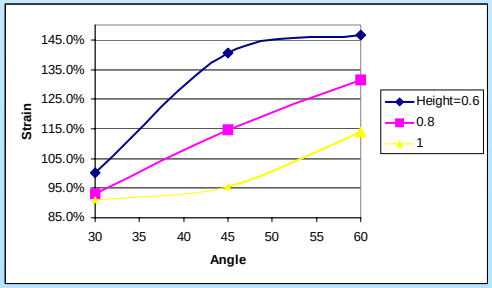
Determine which variables are important

Deterministic and probabilistic Sensitivity Analysis



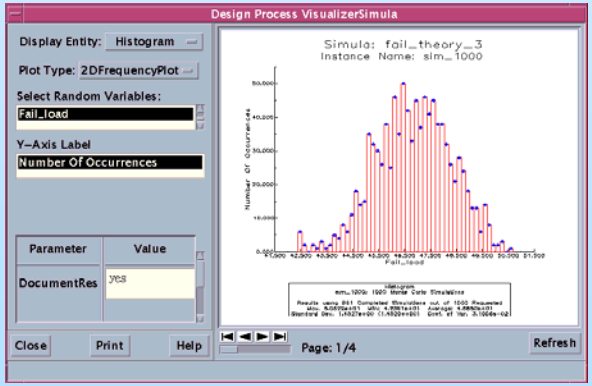
Step 4

Limit the impact of noise variables or lack of precise knowledge of variation on design



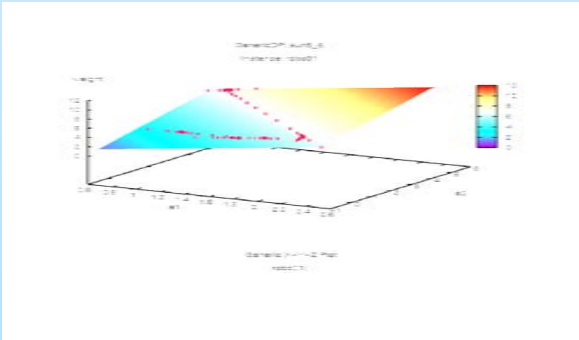
Step 5

Quantify the Response Variations



Step 6

Perform trade studies and optimization in the presence of uncertainty

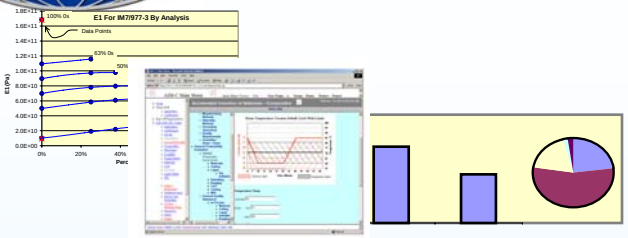


BOEING

* Robust Design Computational System

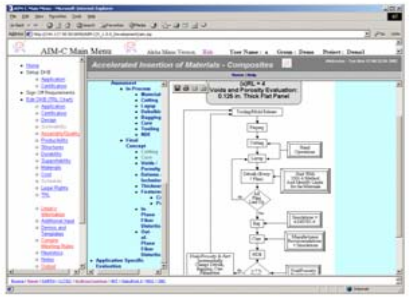
AIM Accelerated Insertion of Materials

AIM-C Significant Accomplishments

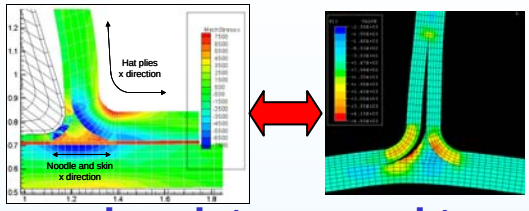


DKB Re-creation

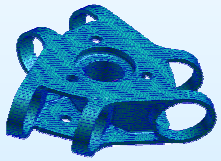
Encoded Heuristics

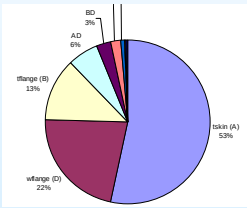


Producibility

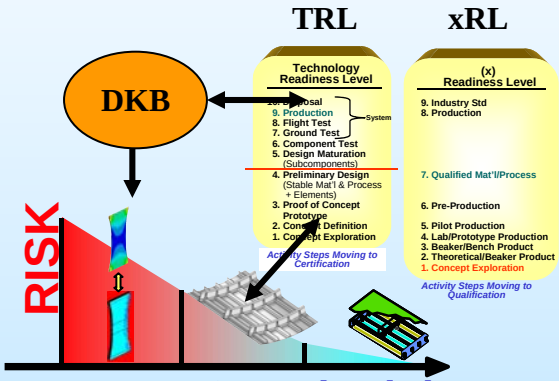


Processing data passed to Structural Analyses



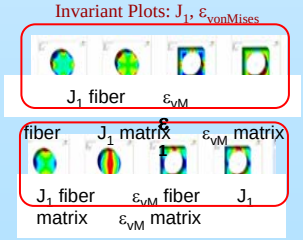


Design, ANOVA, Design Explorer, & Probabilistic Optimization RDCS Links

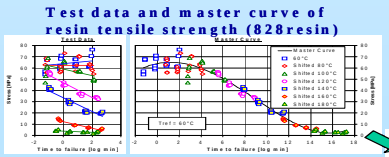


AIM-C Methodology Links Readiness Levels

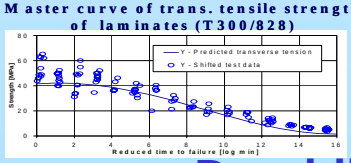
Physics Based 3D SIFT & Fracture Failure Theories

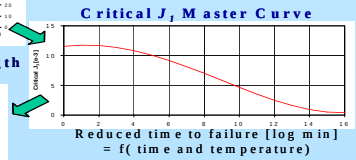


Structures

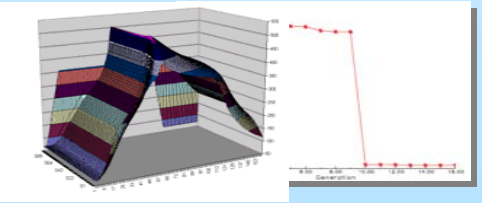


SIFT/Accelerated Testing





Durability



Materials & Processing

BOEING®

AIM Accelerated Insertion of Materials

We See AIM-C and MEANS As Complementary Programs

Computational Materials Development

MEANS

Basic research

Material Developer

Development

Design/processing alternatives

Design Guidelines

Specifications

Certification

Allowables

Cost/Weight Trades

AIM-C Phase 1 Focus - Interface of Insertion

Environmental Compliance

Life Cycle Support

Repair

Re-certification

Obsolescence

Disposal

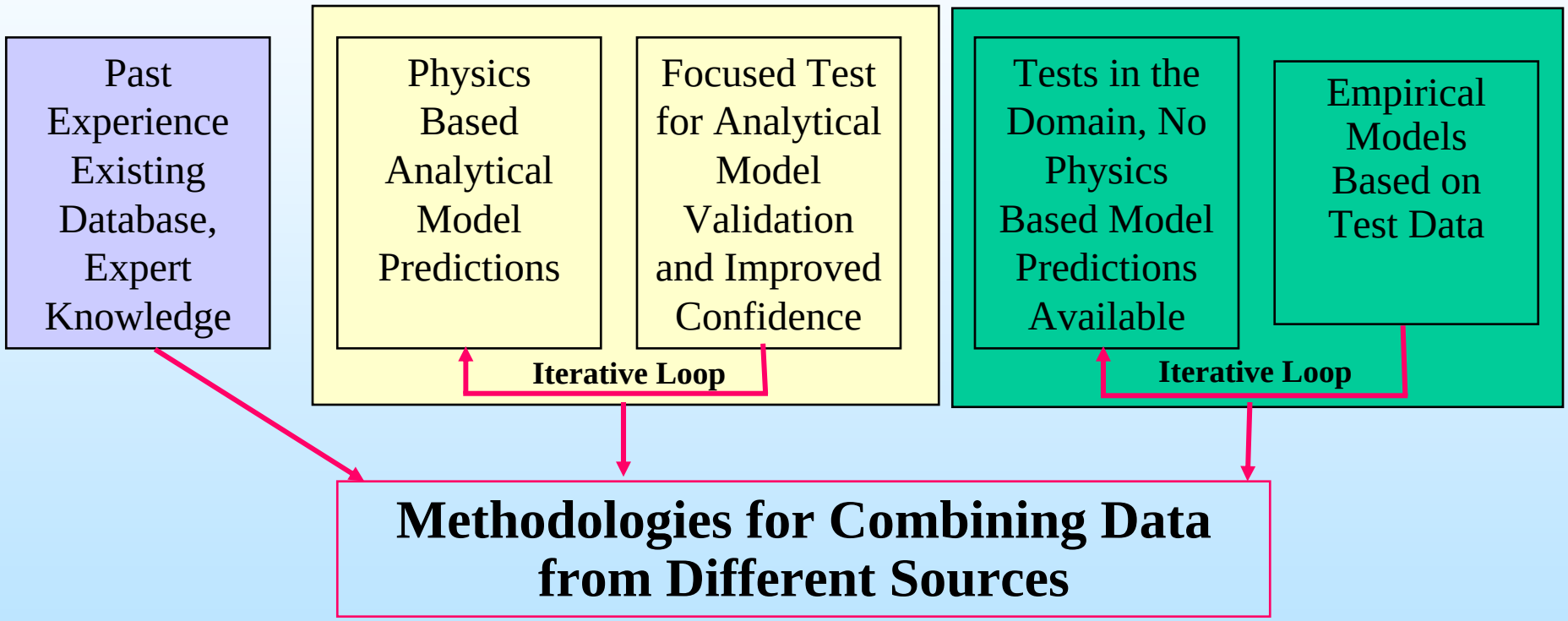
Operations and Support

Traditional material/application system maturity →

As methodologies mature, the "boundaries" will blend and materials design will be an integral part of the global design process.

Fruitful Areas to Pursue

Mathematical Approaches and Software Development



Verification and validation methodologies – along with the experiments and case studies to facilitate their acceptance

Fruitful Areas to Pursue

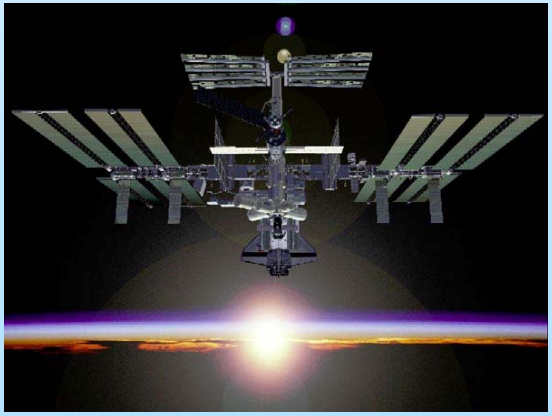
Life prediction models – based on (multiple, combined) degradation mechanisms and accounting for the as-built state, predict irreversible effects

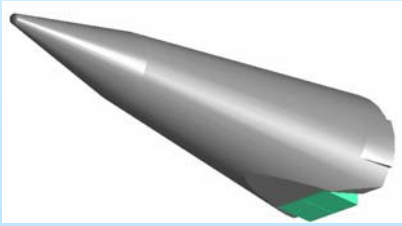
Physics-based design of PMC-metal interfaces for joints and hybrids

Test methods – standards, verification/validation approaches, appropriate length scale inputs for models, accelerated methods

Boeing Commitment to AIM Methodologies

AIM
Accelerated Insertion of Materials





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AIM
Accelerated Insertion of Materials