

Lockheed Martin Space Systems Company

Aerospace Sector Research and Development Drivers

Brett Tobey
Chief Engineering Director
Civil Space Line of Business

John Henderson
Corporate Fellow – Propulsion

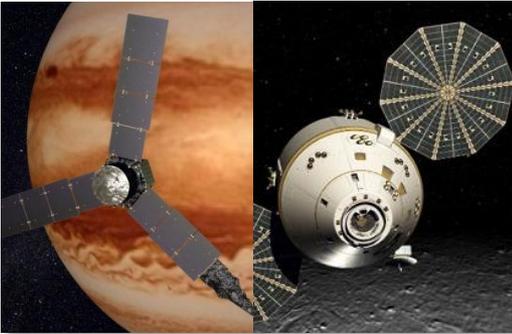
November 29, 2012



Space Propulsion

John Henderson

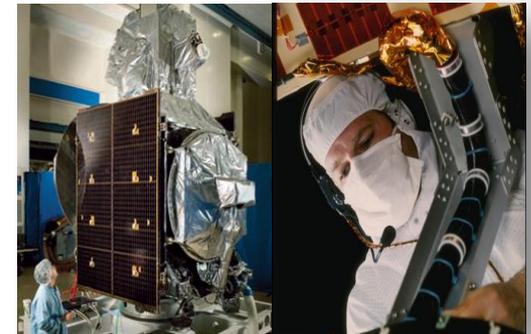
Space Systems Company's (SSC) Portfolio



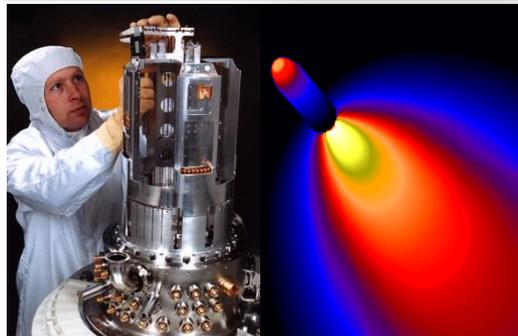
Civil Space



Military Space



Special Programs



Advanced Technology Center



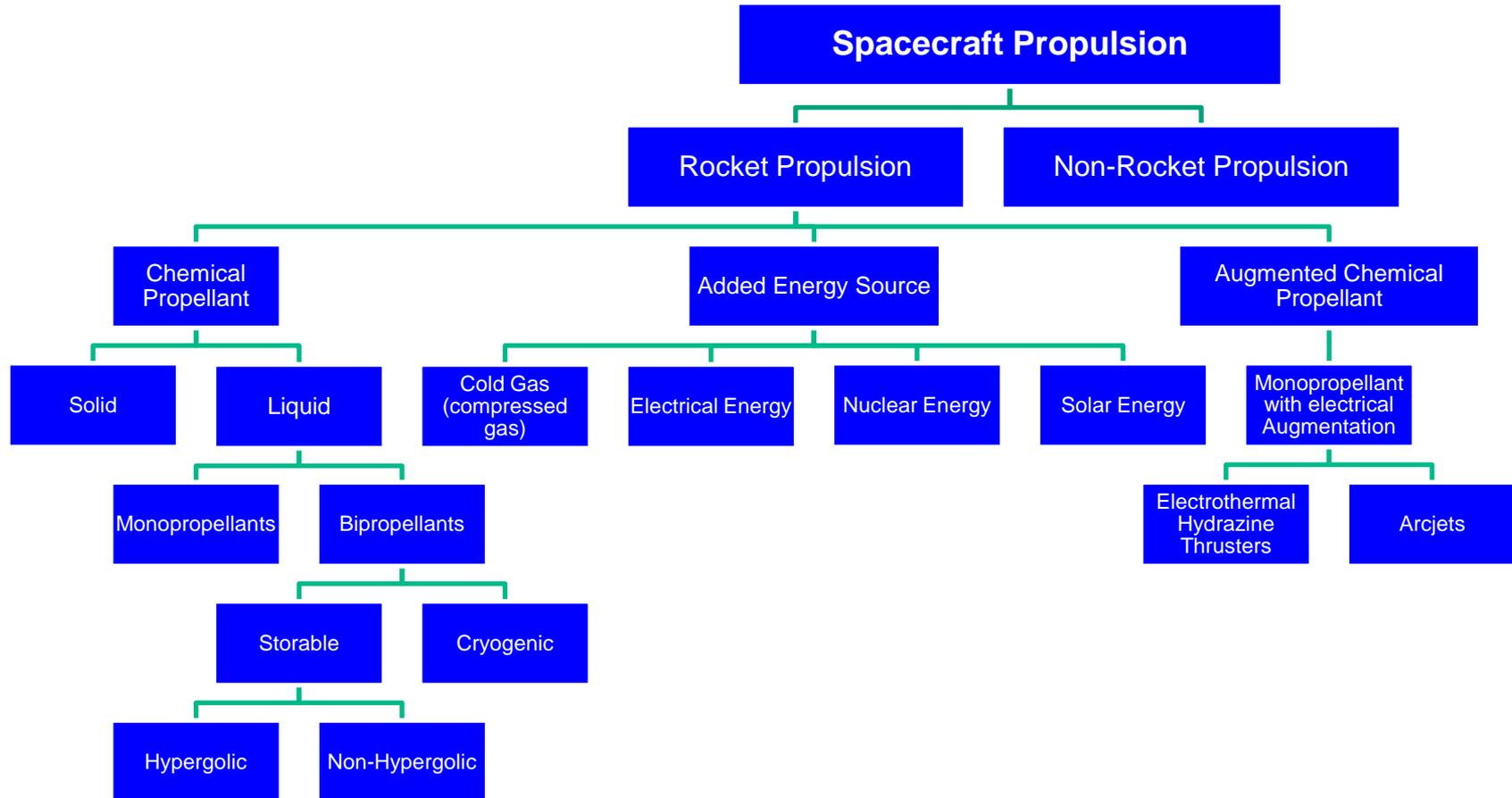
Commercial Ventures



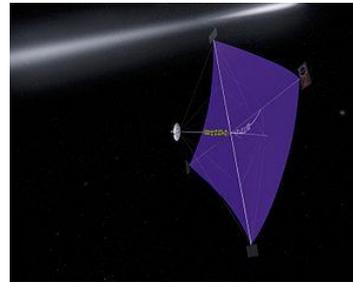
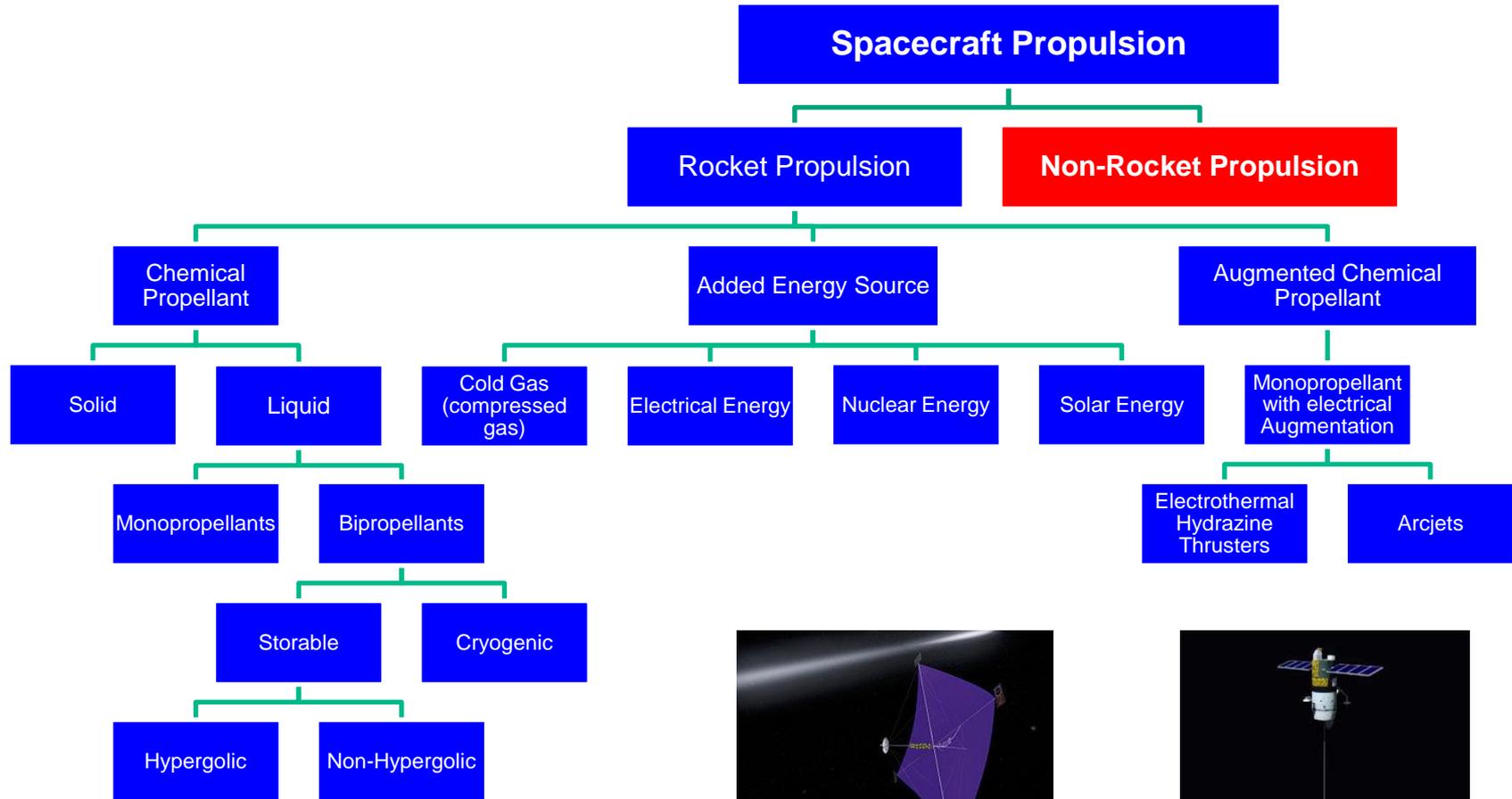
Strategic & Missile Defense

SSC's Space Portfolio Integrates a Vast Array of Technologies

Types of Spacecraft Propulsion



Types of Spacecraft Propulsion

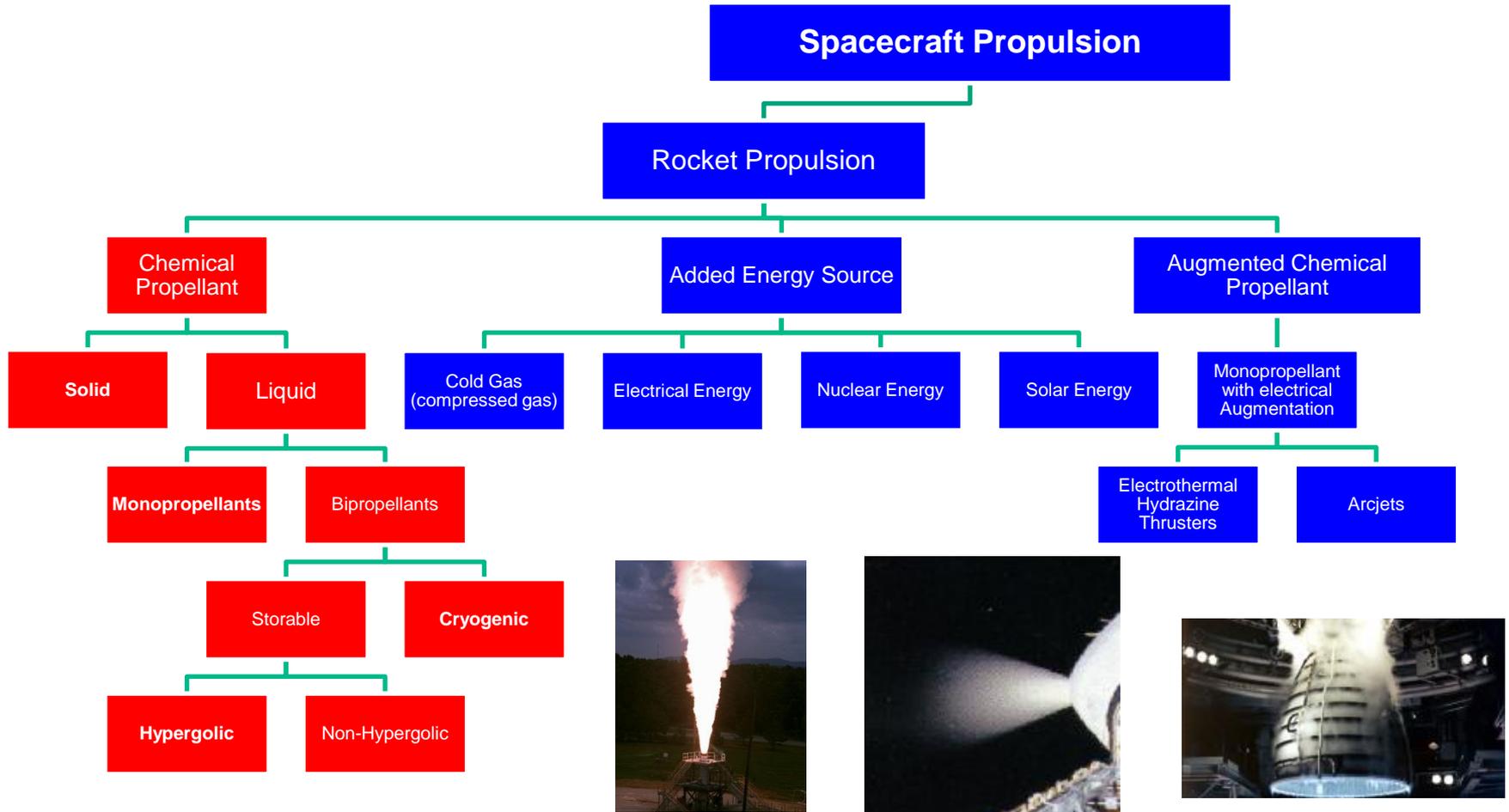


Solar Sails



Tethers

Types of Spacecraft Propulsion



Solid

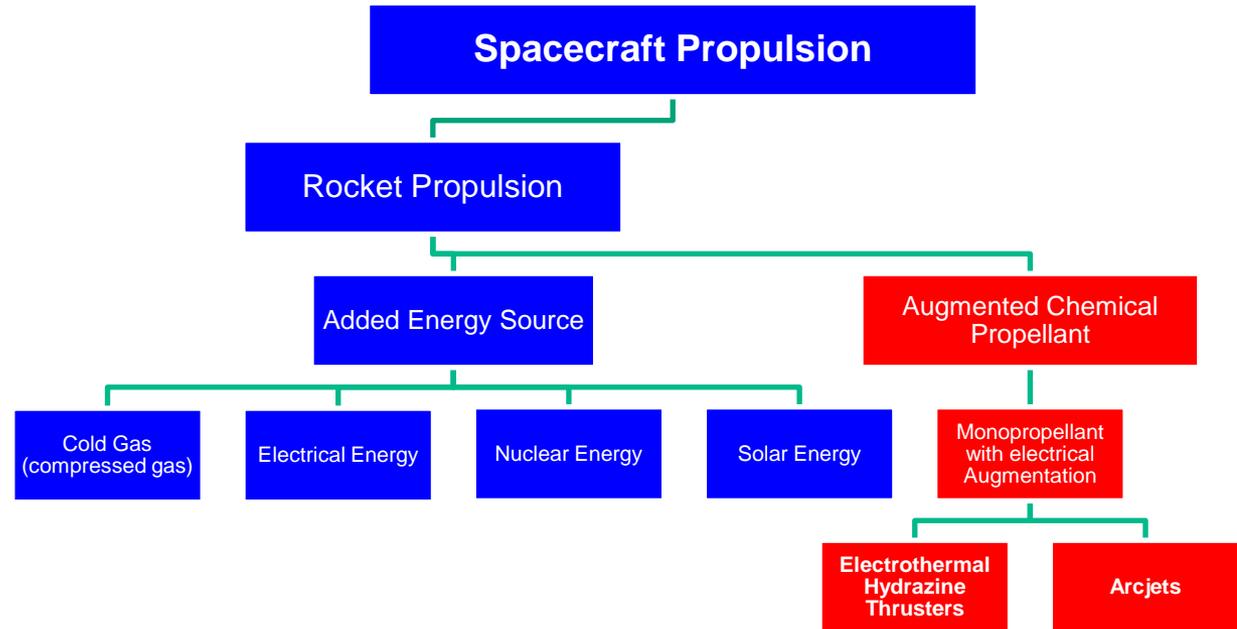


Hypergolic



Cryogenic

Types of Spacecraft Propulsion

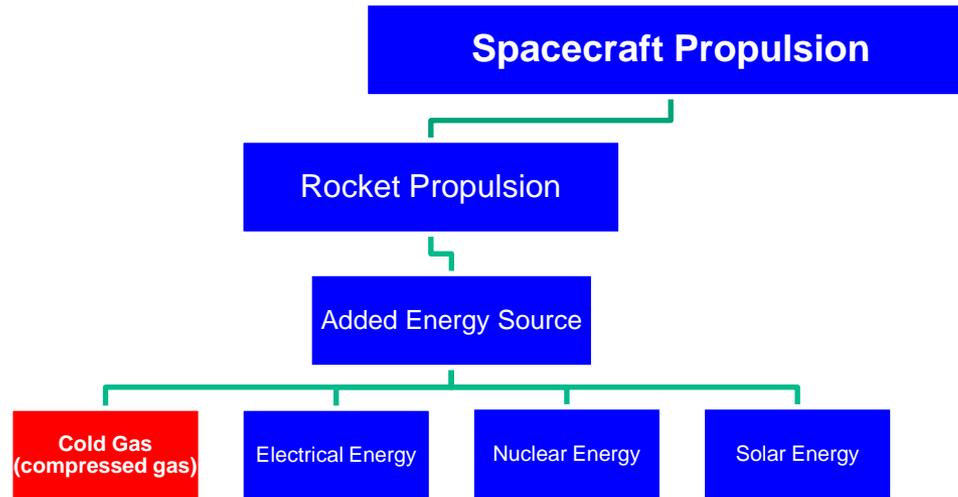


EHT



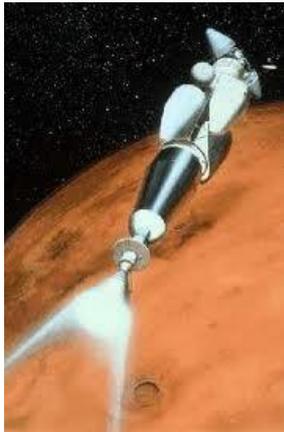
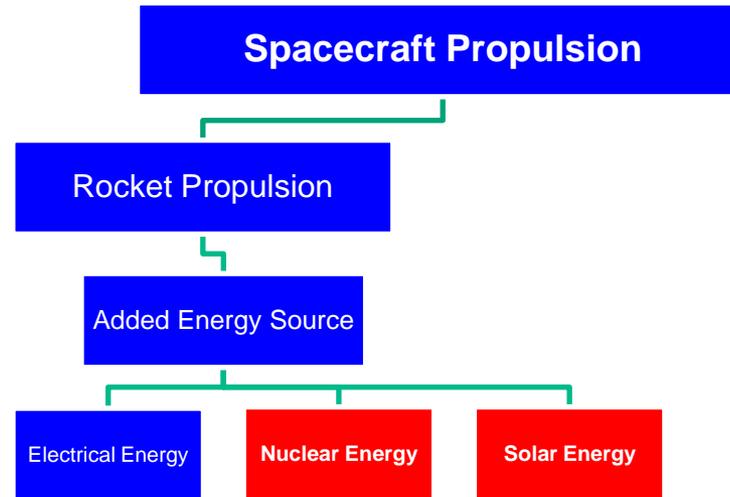
Arcjet

Types of Spacecraft Propulsion



Cold Gas Thruster System

Types of Spacecraft Propulsion

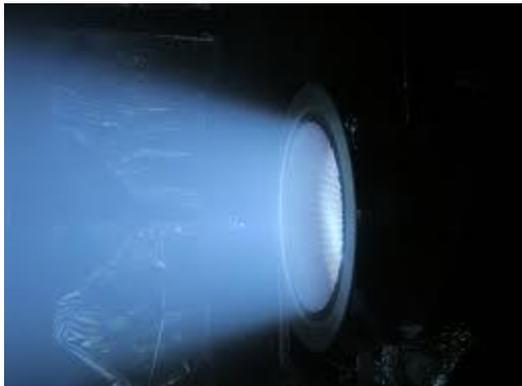
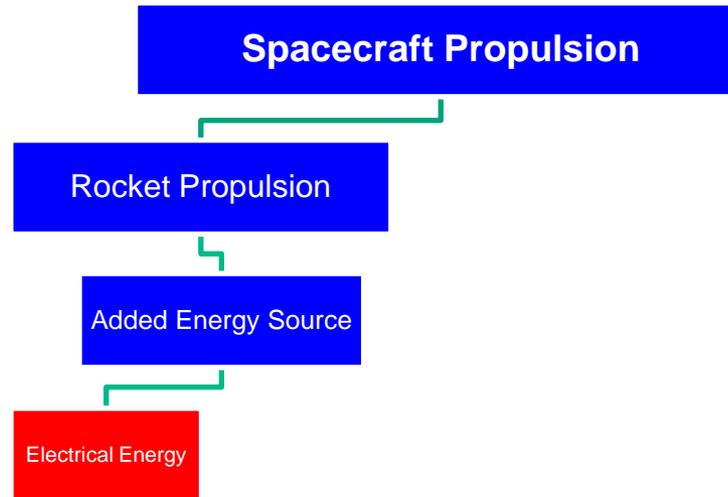


Nuclear Concept



Solar Thermal Concept

Types of Spacecraft Propulsion



Ion Thruster



Hall Effect Thruster



- ✓ Communication Platform Stationkeeping
- ✓ GEO Transfer Orbit Completion
- ✓ Exploration of the Asteroids
- All Electric Propulsion Platforms
- Electric Propulsion Cargo Vehicles
- Exploration of the Solar System

Limitations in thrust has discouraged the more widespread use of these systems



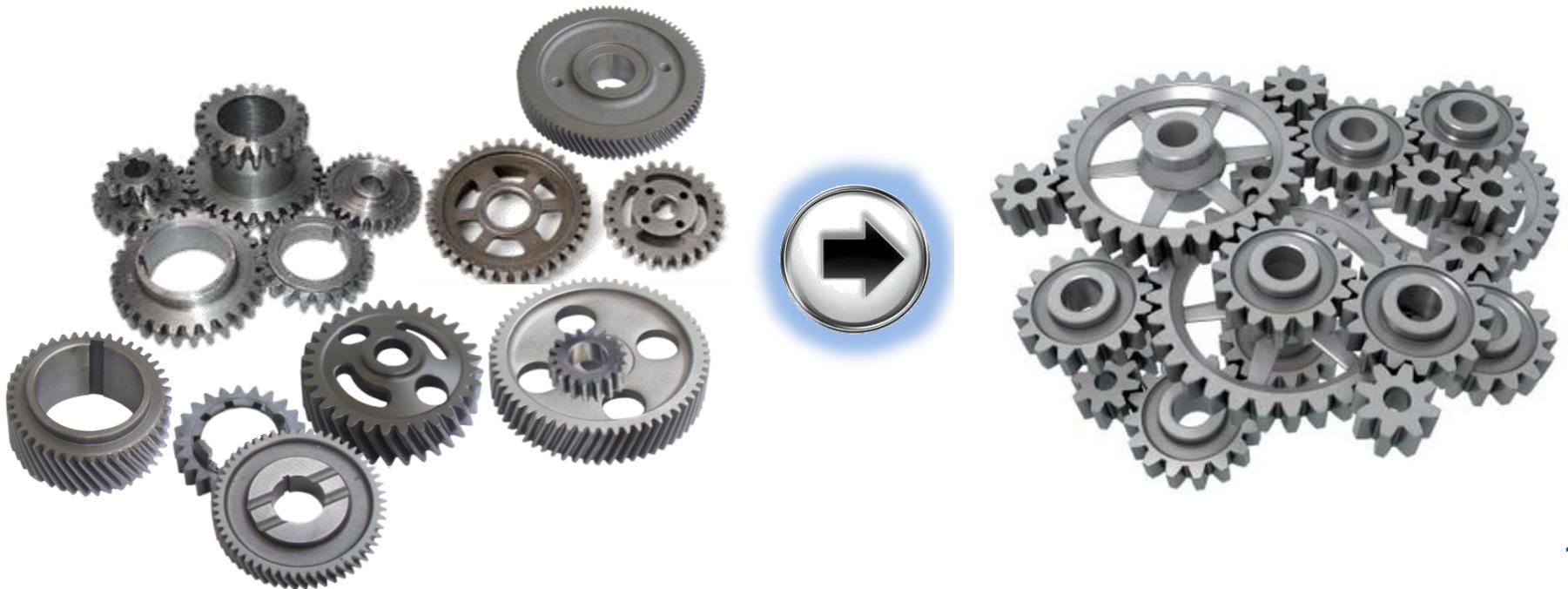
- High Power Generation
- High Power Conditioning and Control
- Thermal Control Technologies
- High Thruster/Specific Impulse Engines
- High Temperature Materials
- Engine Plume Control Technologies

Technology Rich Territory for Near Term Advances in EP



Model Based System Design Integration

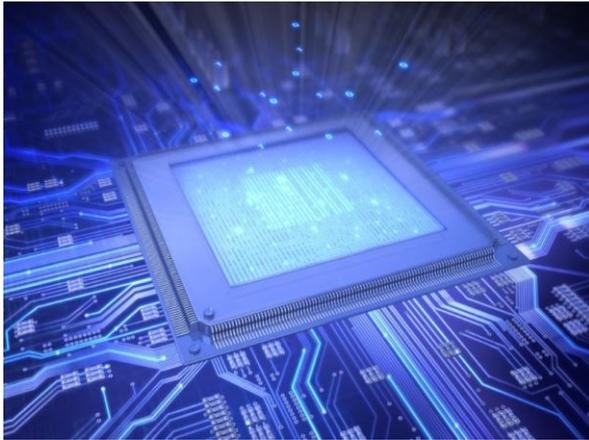
Brett Tobey



One of SSC's Key Engineering Challenges: Addressing Complexity and Delivering Affordability



Complexity ↑

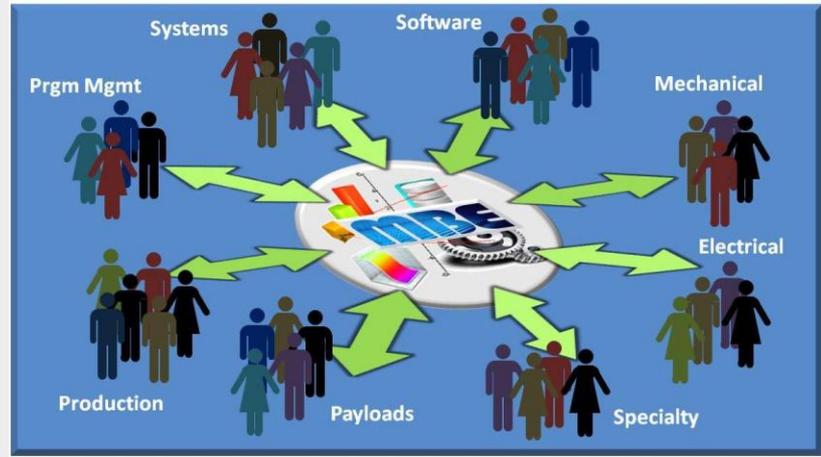
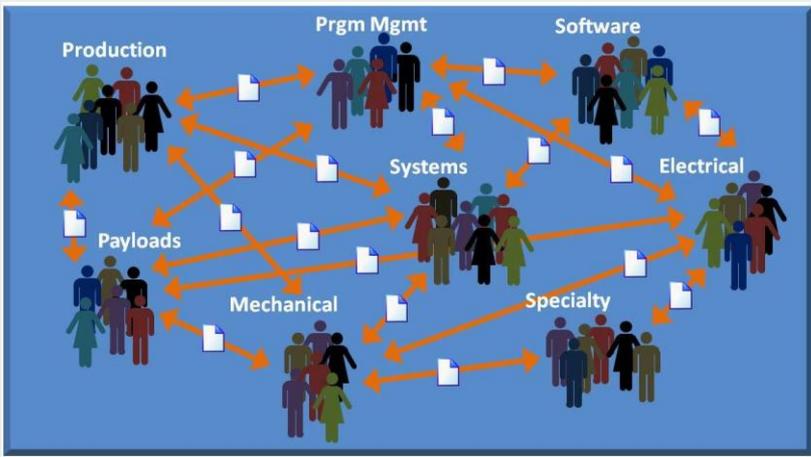


Technology Advances have Blurred the Line Between Hardware and Software through the use of devices like FPGAs

While complexity is on the rise, our customers are demanding more affordable products and solutions in less time.



Affordability ↑



Today: Document driven, loosely connected modeling and simulation efforts, labor intensive integration

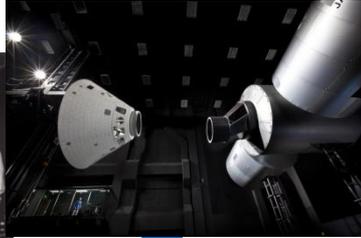


Future: Highly integrated data sets, tightly coupled modeling and simulation efforts, efficient system integration

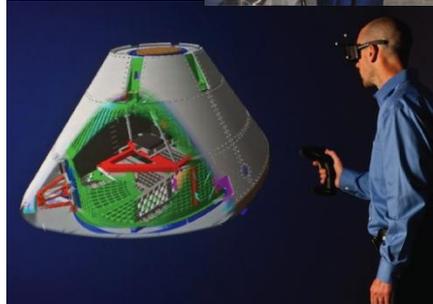
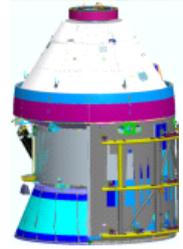




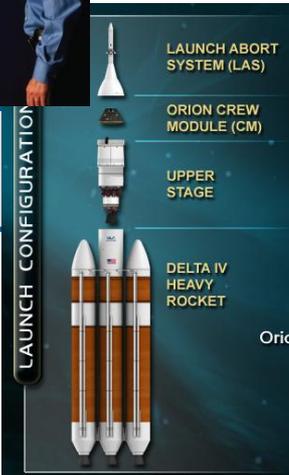
**Design
Collaboration**



**Virtual
Validation**



**Requirements
Management**



**Integrated
Production**



**Concept
Definition**



**Simulation Proven
Deployment**





Model Based Enterprise Spiral Development Strategy:



Elements:

MBE Capabilities to
Address Strategic
Enterprise Wide
Objectives

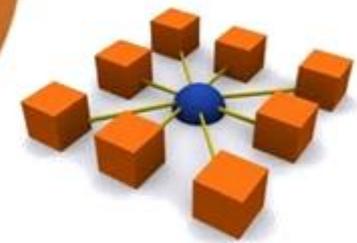
Implementation:

Ongoing MBE
Projects Focused
on Program Needs



Infrastructure:

Phased Capability
Insertion of MBE
Expertise, Processes,
Tools, and Training



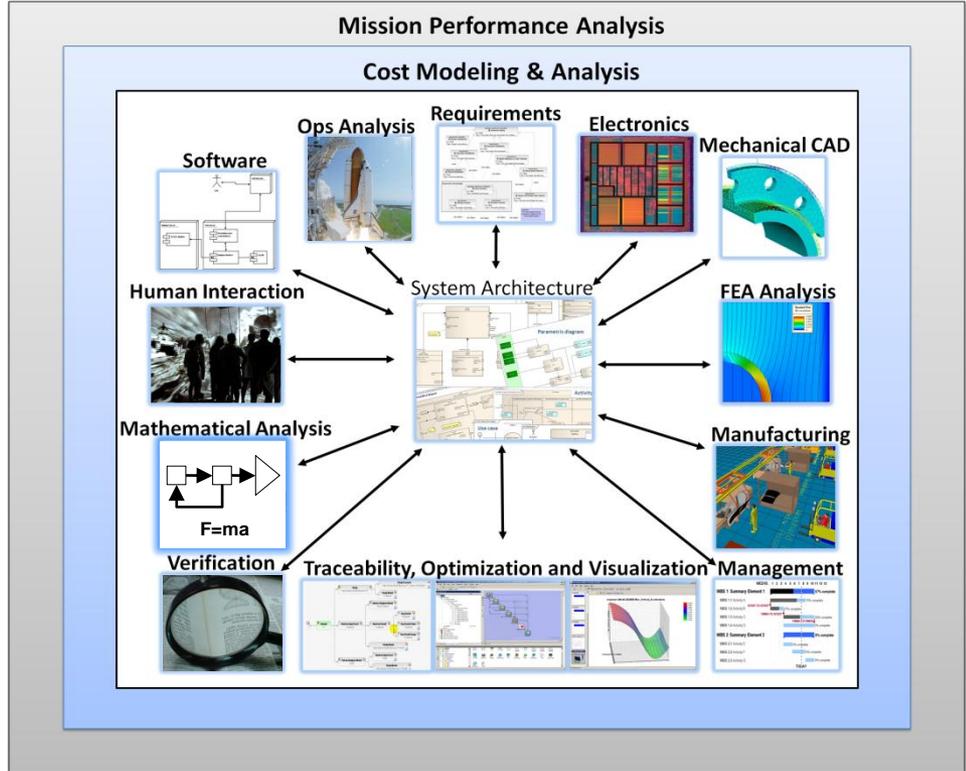


SysML: Enables a New Level of Mission Engineering and Design Integration



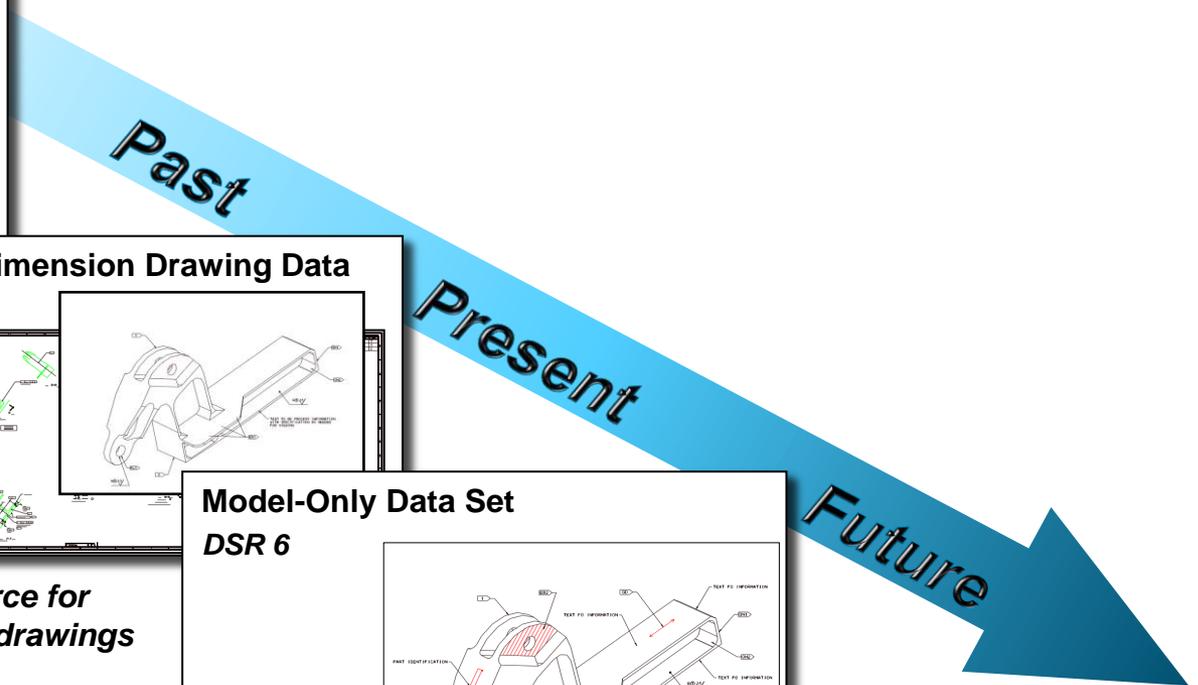
System Architecture Model (SAM) :

- A well defined SAM is the loom that weaves the many threads of digital information together.
- The SAM helps link requirements to logical and behavioral design.
- Requirements can be fed into increasingly detailed levels of domain specific modeling.
- By viewing the SAM as the hub of the digital tapestry, an integration pattern emerges enabling cross-domain connectivity with a minimal set of required integrations.

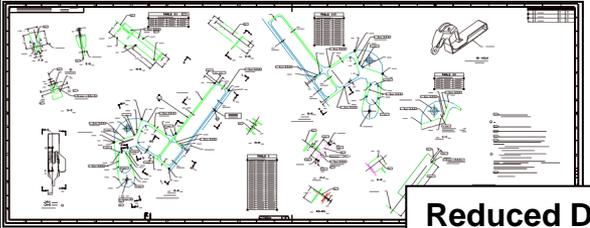




SSC's Mechanical CAD Future, 3D Model as Digital Record-of-Authority

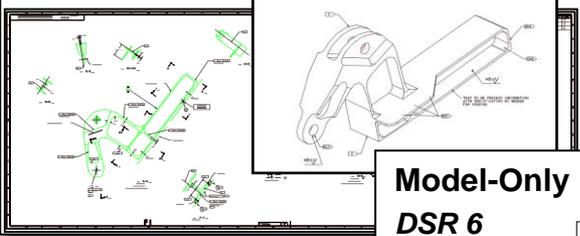


Fully Dimensioned Drawing
Data Set Rating (DSR) 1



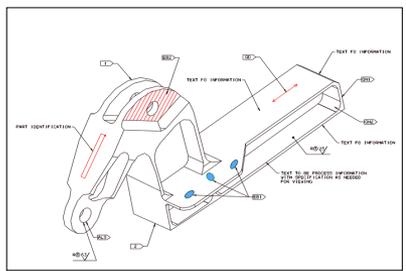
Drawings are sole source for design data

Reduced Dimension Drawing Data Set



Models are source for geometry data, drawings for all else

Model-Only Data Set
DSR 6



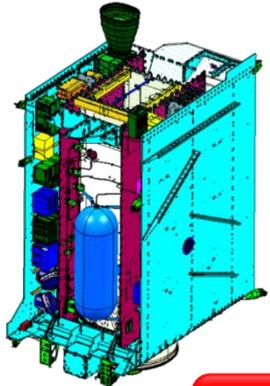
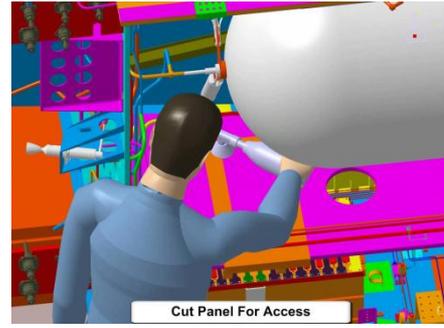
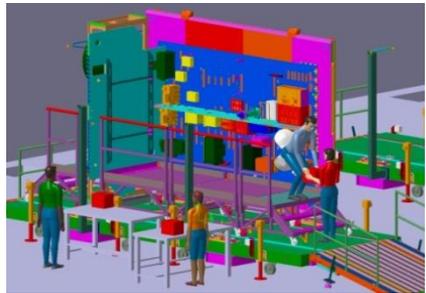
Models are sole source for design data



SSC's Future in Virtual Manufacturing, Virtual Creation before Physical Creation



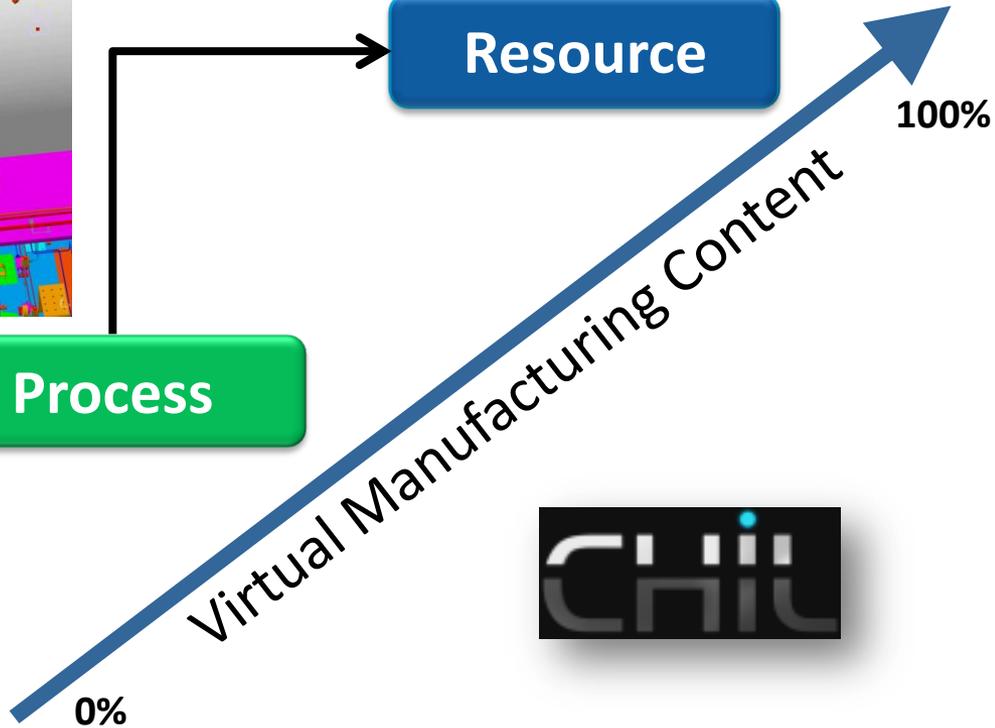
Visualization enables effective and early Engineering, Manufacturing, and Production collaboration



Product

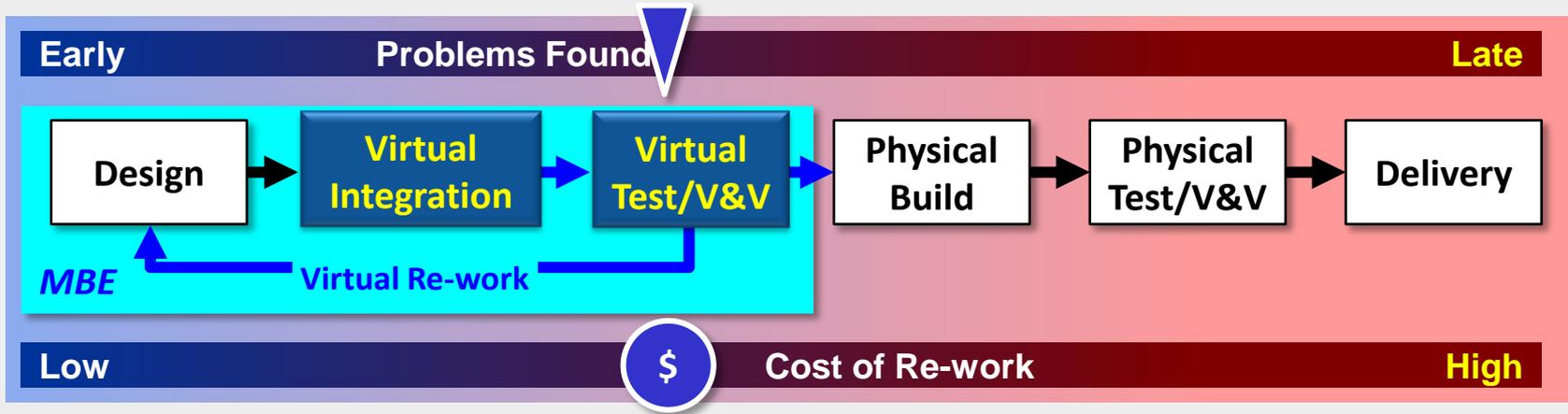
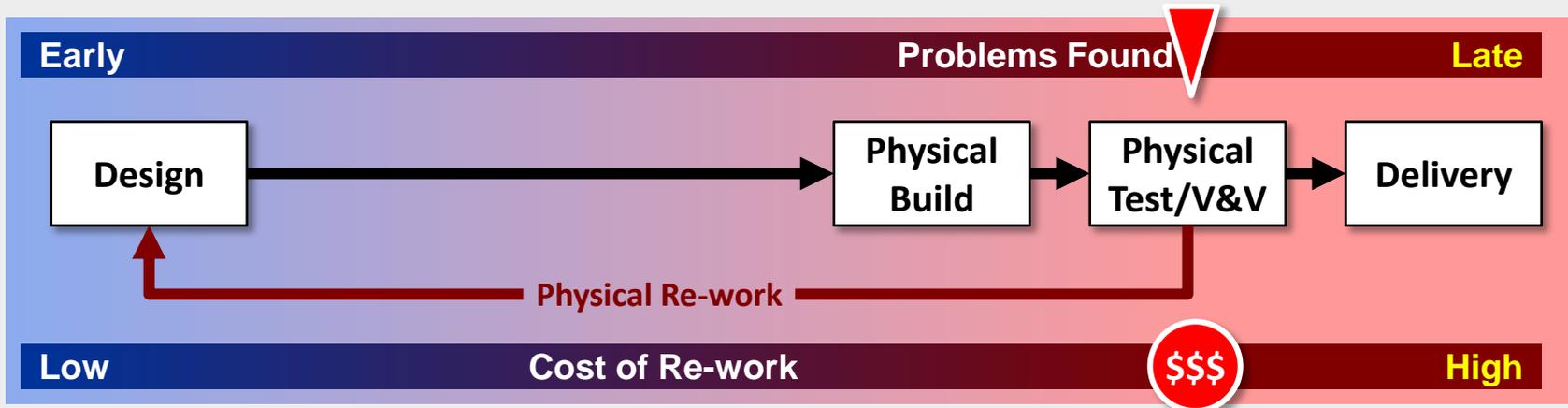
Process

Resource





Virtual Systems Integration & Test, Drive Out Engineering Errors Early





1) Apply Across Corporation



2) Engage With Customer



3) Systematically Deploy Capabilities

MBE V₁

2007

Auto Coding & Model Sharing



MBE V₂

2010

Virtual Manufacturing



MBE V₃

2012

Digital Tool Integration



MBE V₄

2013

Design Integration



MBE V₅

2014

Enterprise Collaboration



MBE V₆

2015

Architecture Commonality





