

National Aeronautics and Space Administration



Cutting More Than Metal: Breaking the Development Cycle

AIAA Propulsion and Energy Forum 2014
July 28-30, 2014



marshall

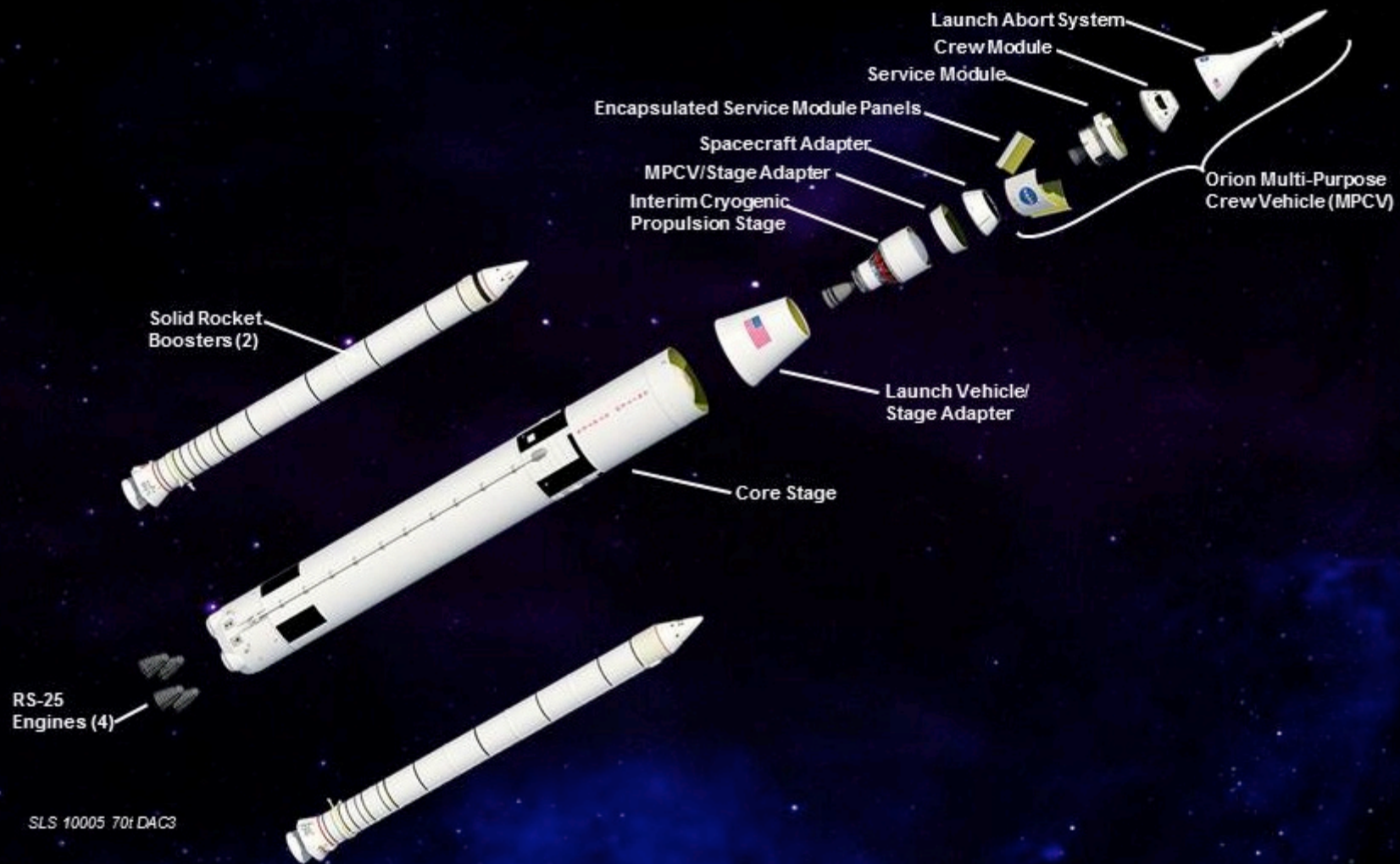


Christopher Singer,
Director of Engineering
Jay Onken,
Deputy Chief Engineer, Space Launch System

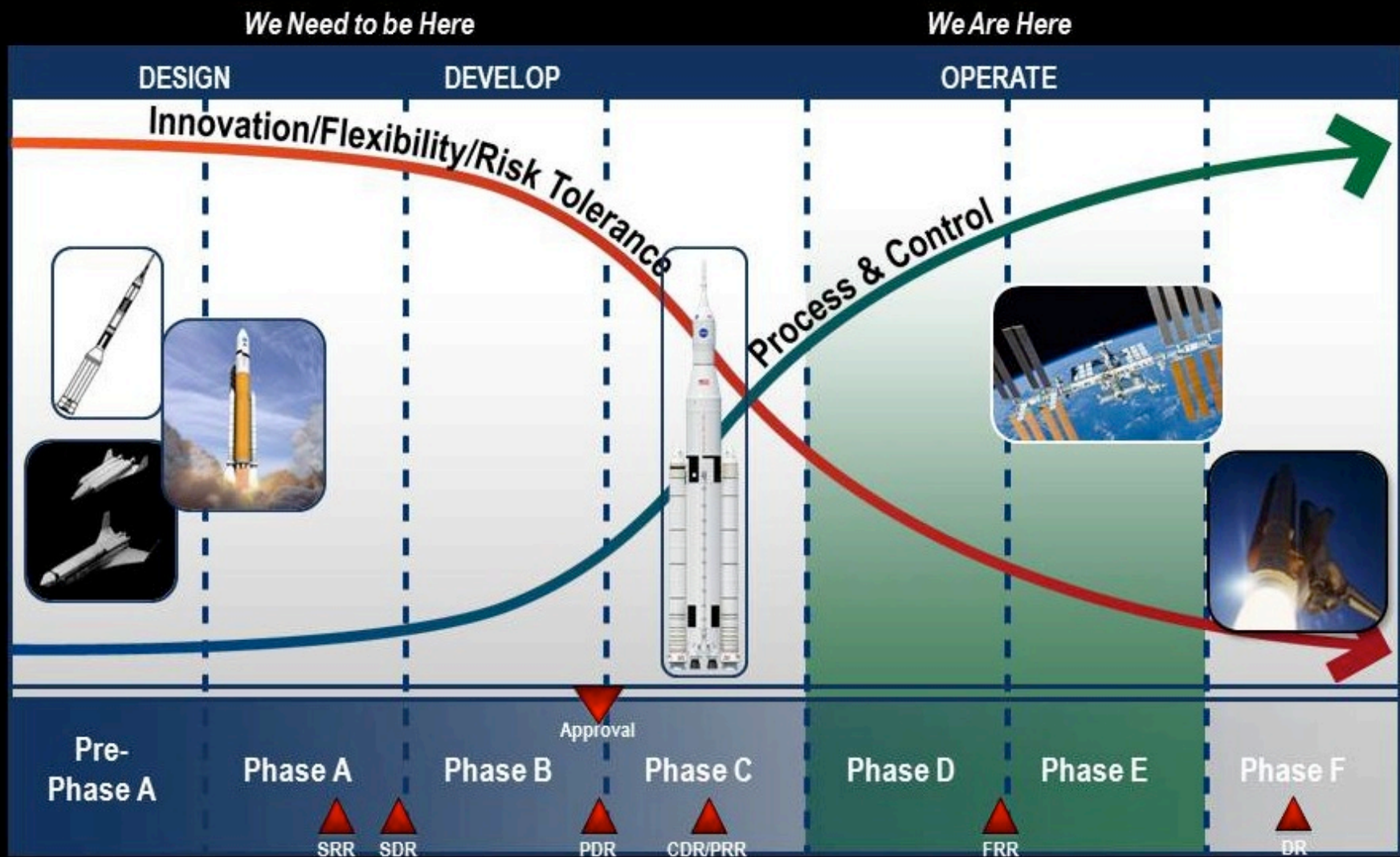
Learning from the Past, Not Living by it



Capability for a New Era of Space Exploration

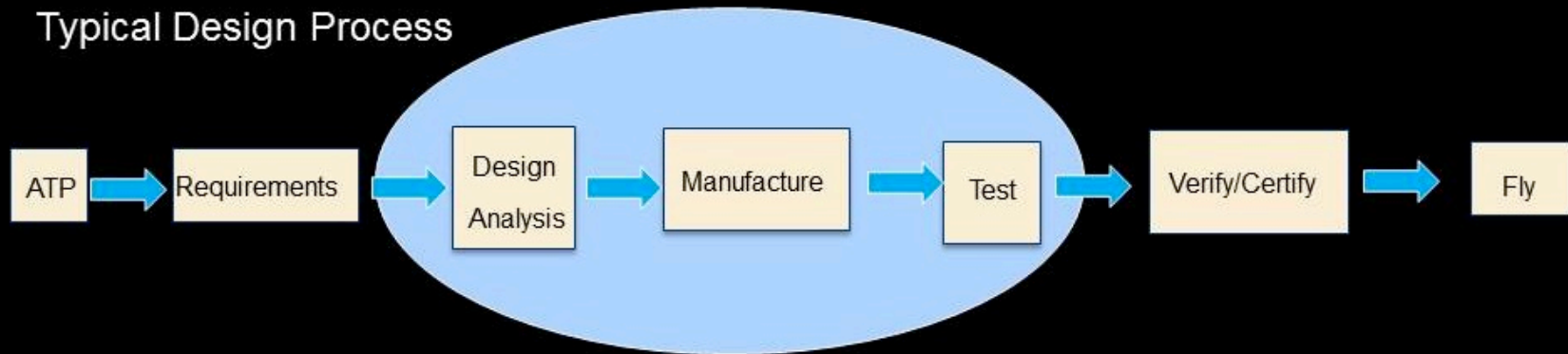


Development Culture vs. Operational Culture

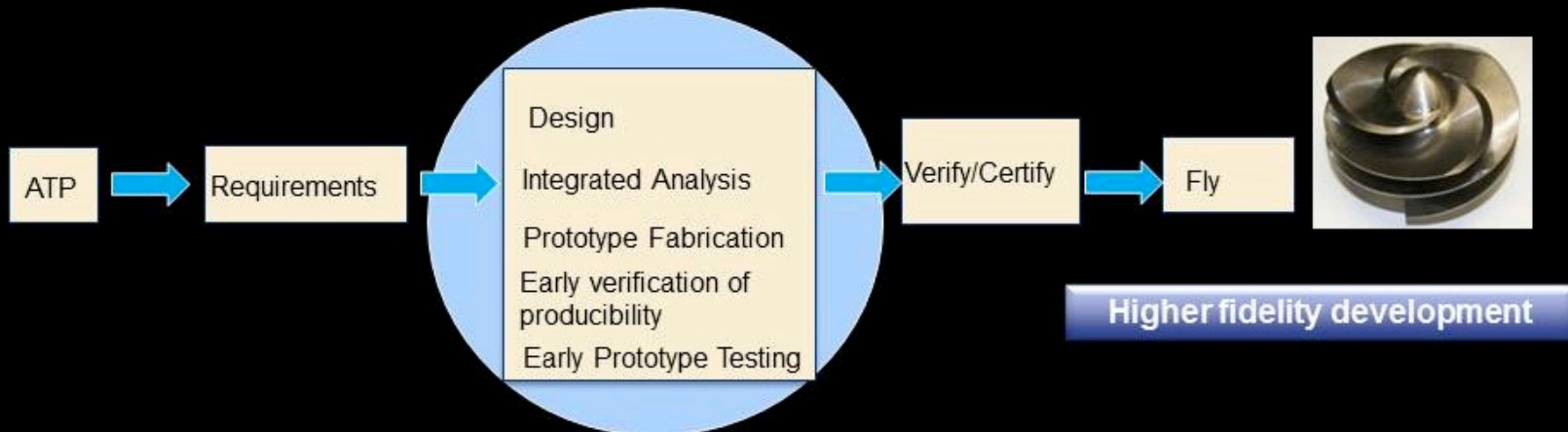


Changing the Design Process

Typical Design Process



Evolved Design Process, Enabled by New Technologies



Additive Manufacturing



3-D printed rocket injector for hot fire test

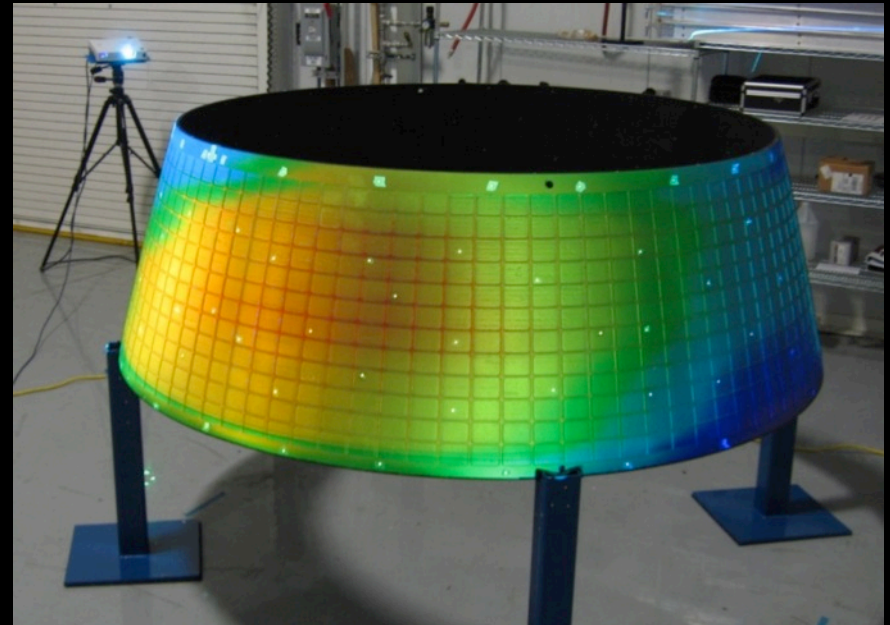


SLM Exhaust Port Cover for J-2X
(inset and position on engine)

Structured Light Scanning

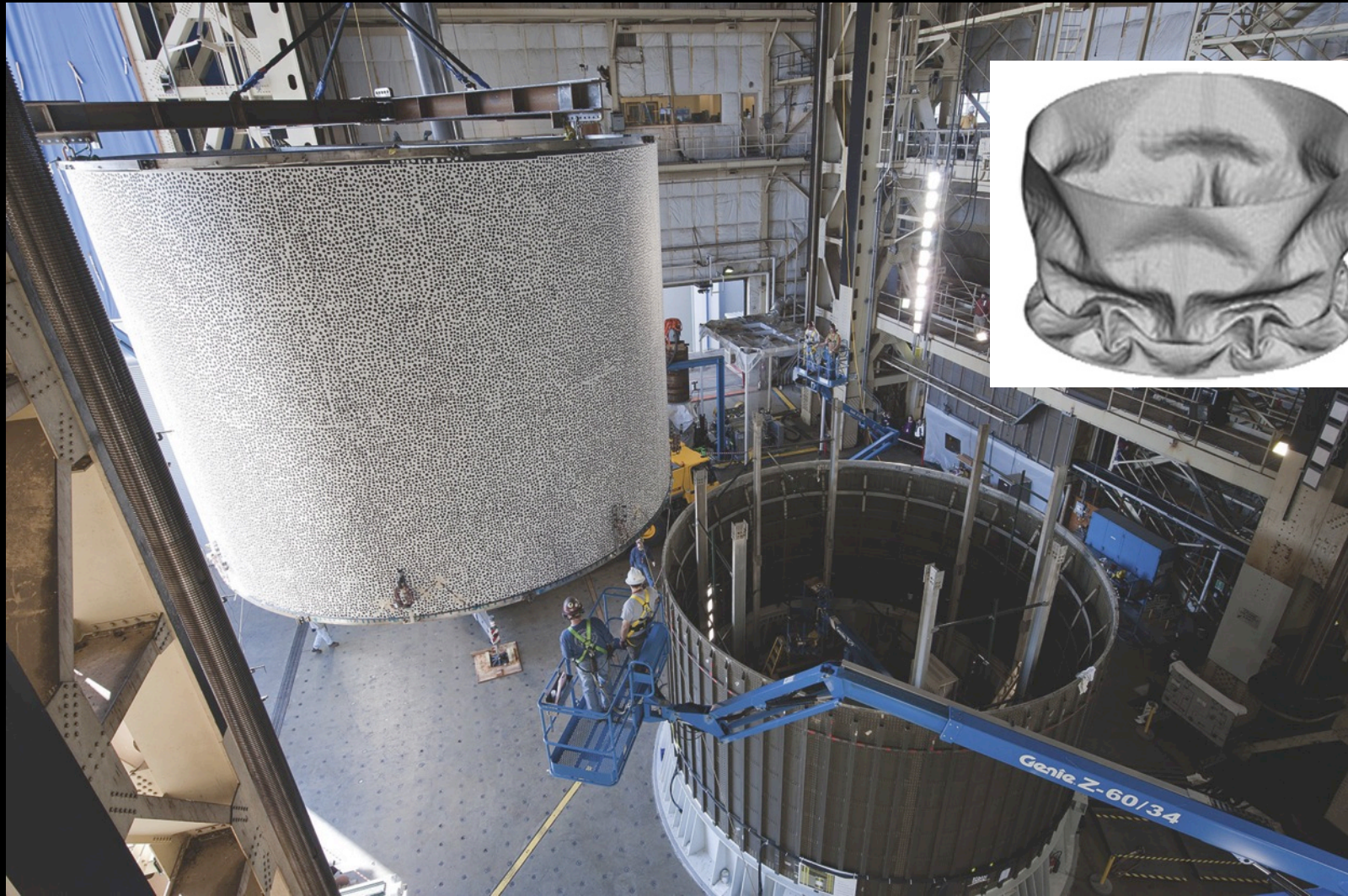


Training and implementing technique with industry.

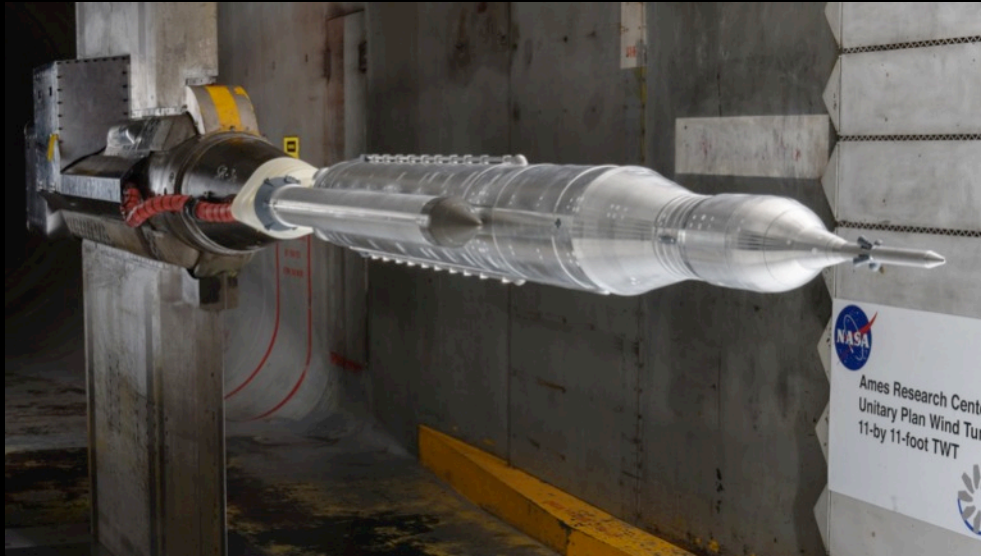


J-2X nozzle extension showing deformity data projected onto part.

Shell Buckling Knockdown Factor Testing



Wind Tunnel, Adaptive Algorithm Testing



3-D printed rocket injector for hot fire test

F/A-18 tests for SLS flight control



Hardware in the Loop Testing



Workers set up SLS avionics in SITF

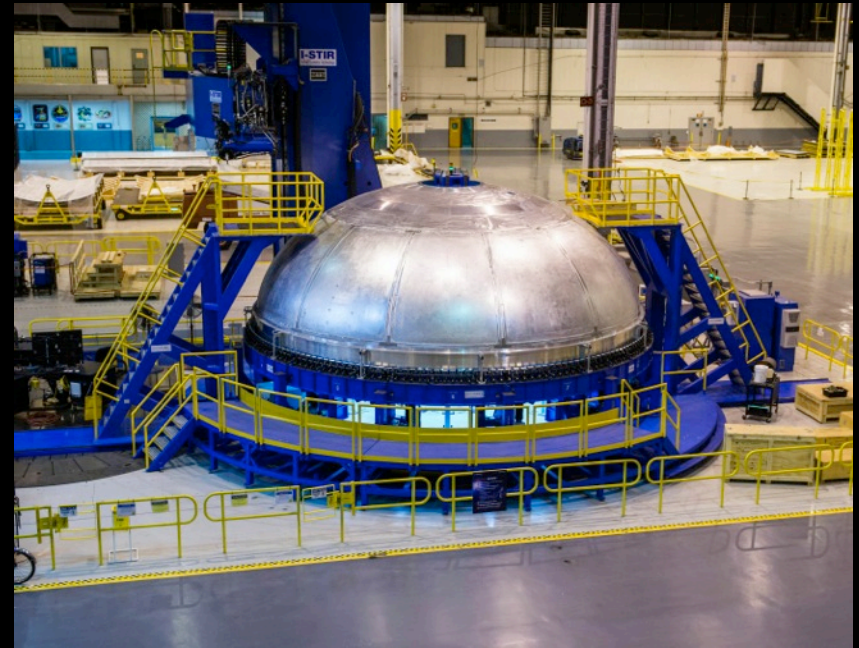


Test engineer runs avionics flight simulation in SITF.

Core Stage Manufacturing

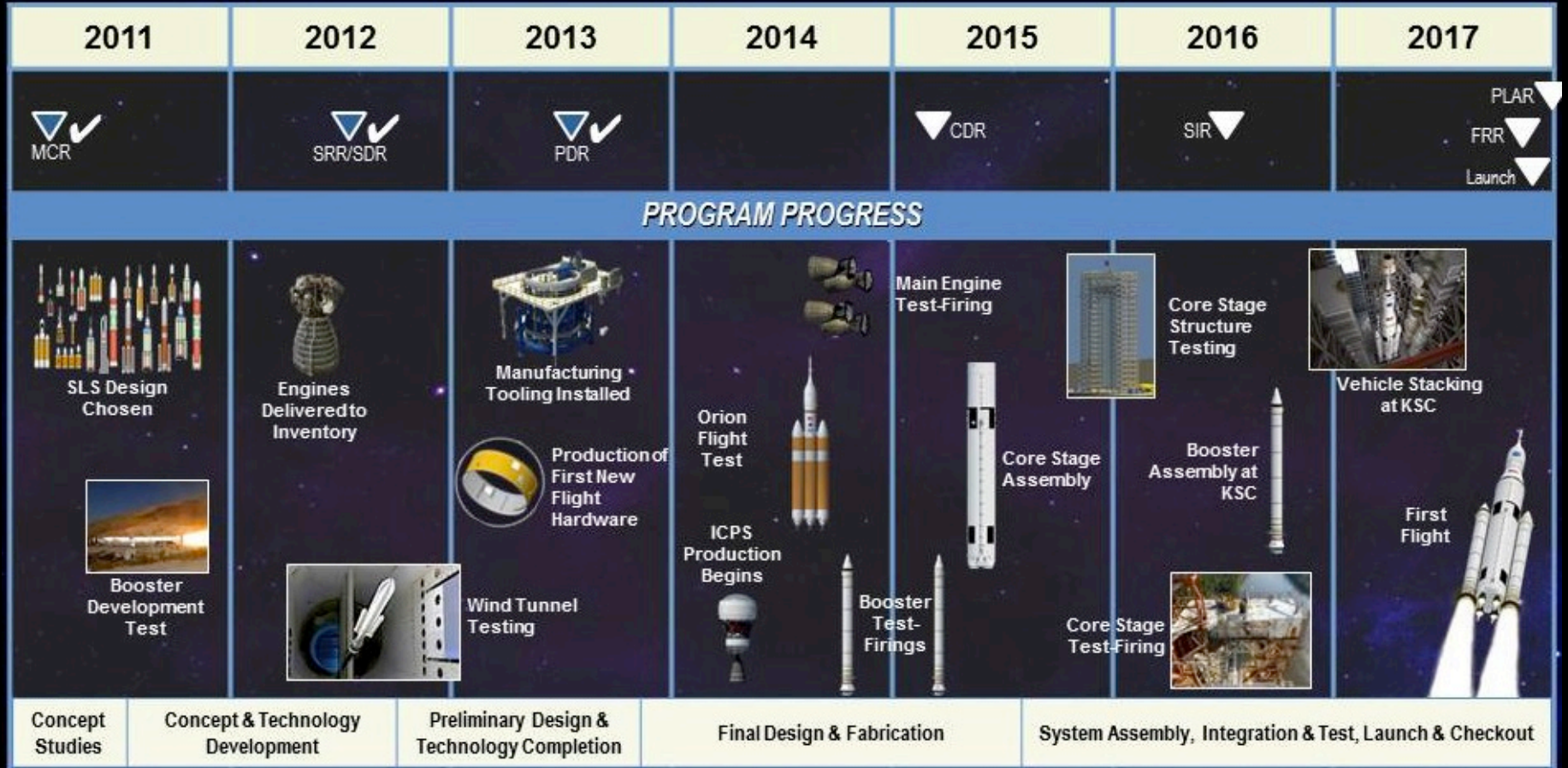


First Core Stage confidence barrel section at MAF



First Core Stage confidence dome section at MAF

Path to First Flight



Results



Questions?



www.nasa.gov/marshall

Explorers Heart: Courage, Passion, Curiosity



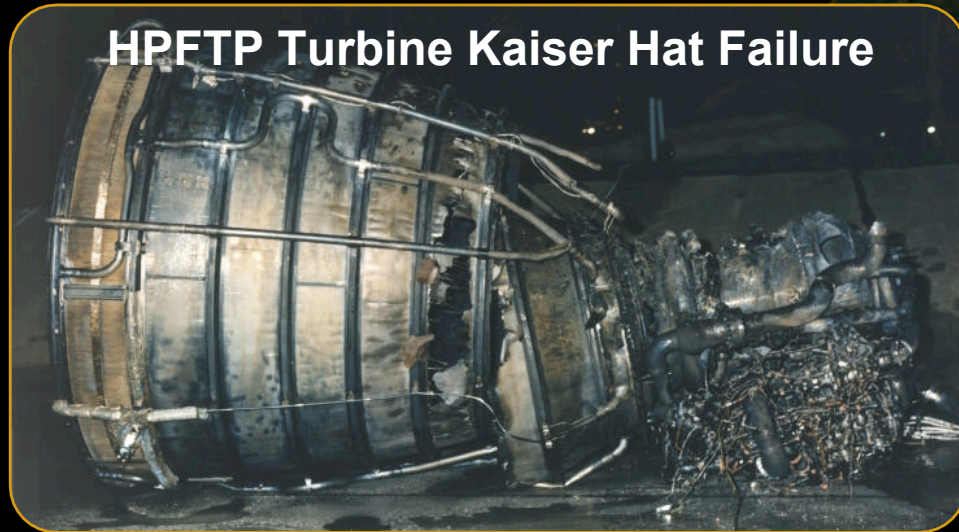
Tragedy triggers our opposing desire to control uncertainty

New Technologies Will Never Entirely Replace Testing

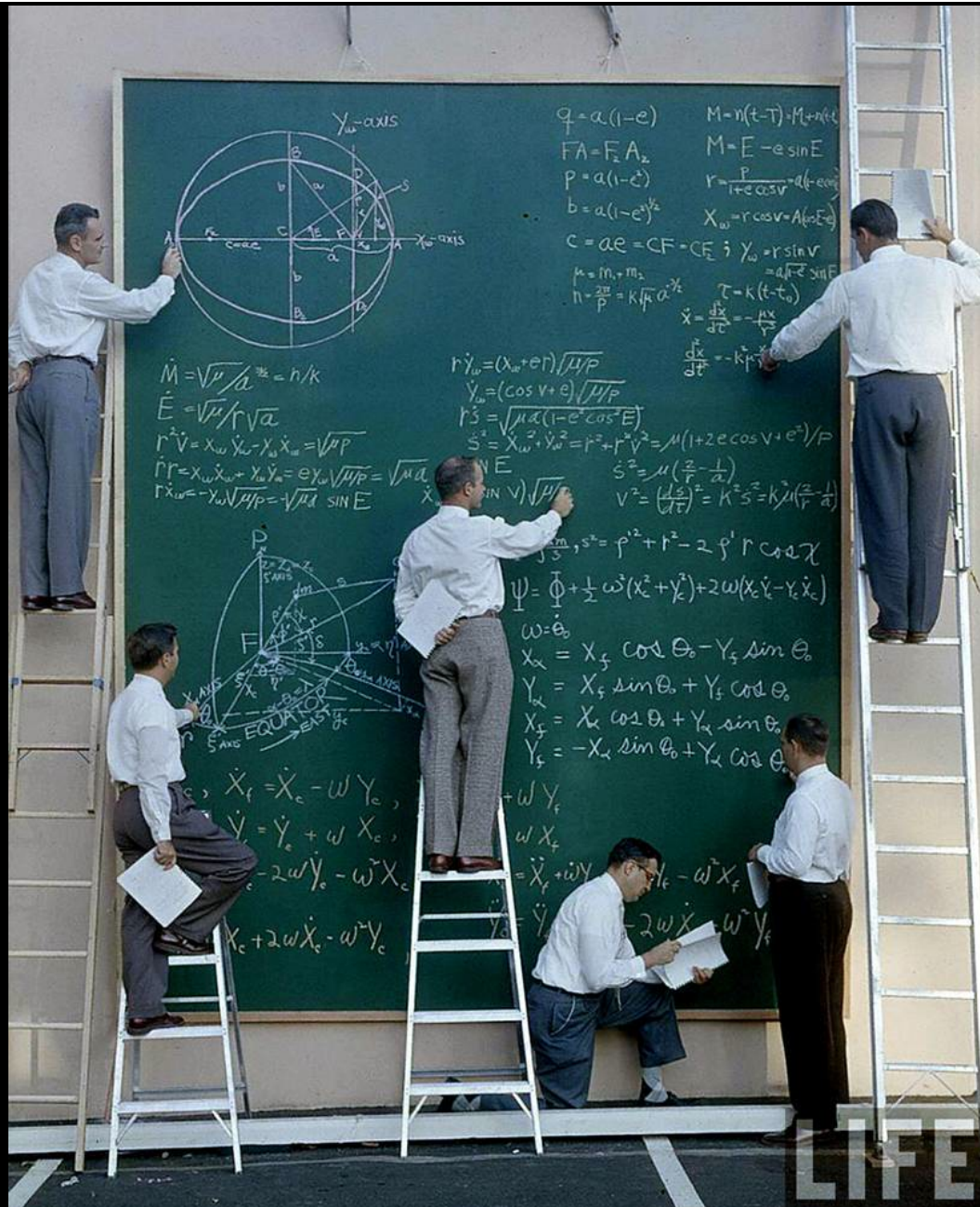
A-3 Test Stand in Background,
Engine and Photographers in
Foreground



HPFTP Turbine Kaiser Hat Failure



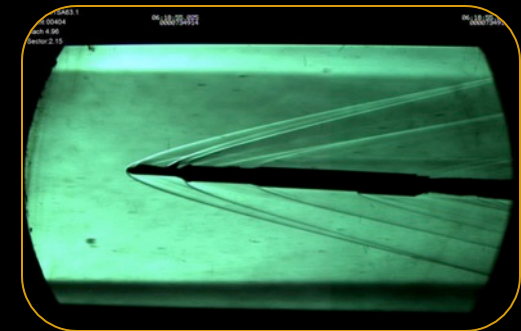
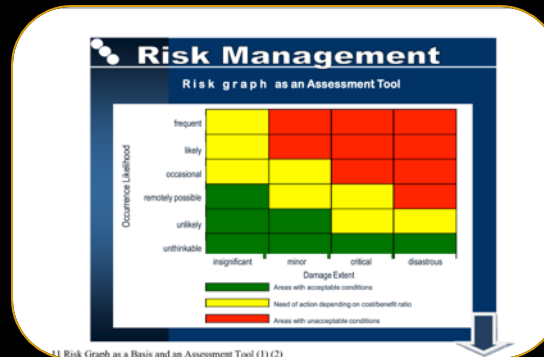
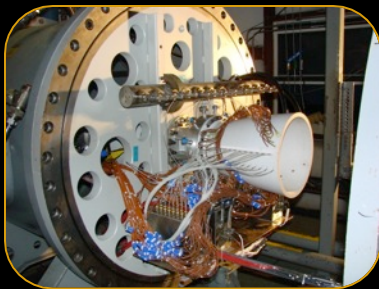
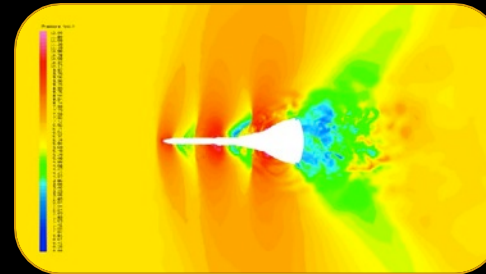
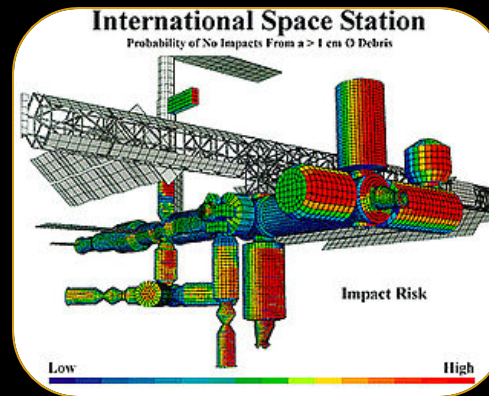
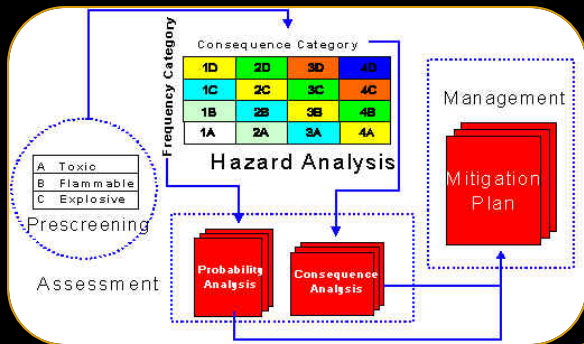
SSME 2013 In the Spillway
Downstream of the Flame Detector
Immediately After Test 901-364



NASA Before PowerPoint

The physics are the same. How we communicate has changed.

Tools and Techniques to Manage Risk



11 Risk Graph as a Basis and an Assessment Tool (11.12)

NASA Programs are Tied to Administration Cycles



Direction and Redirection Come Every 4 to 8 Years

Inspiration for Generations

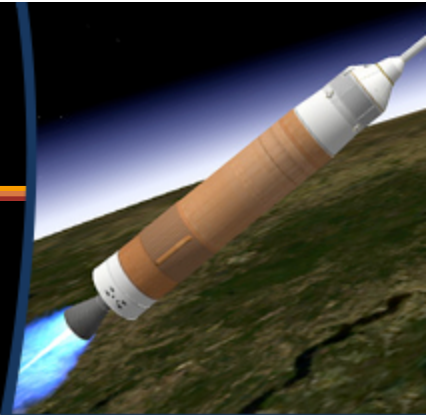


Ares Development Team Observations

We made incredible progress despite many obstacles

- Growing constraints, hurdles, and attitudes in an attempt to finish something ... anything
 - Decisions take too long and are unsupported
 - “Death” by meetings and PowerPoint
 - Proliferation of Ineffective Working Groups,: All voices are equal and no one is in charge
 - One-chance development philosophy (no block upgrade or early testing strategy)
 - Technical is disconnected from Cost & Schedule (Engineering vs. Project);
 - Subsystem stovepipes (everybody for themselves)
 - Pounding issues flat

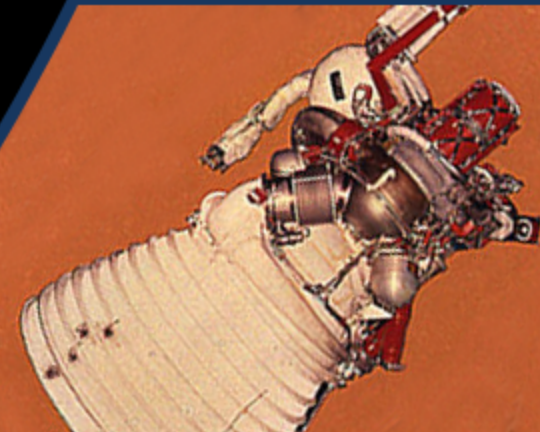
Uncertainty Can Help Feed Innovation



J-2X Operation



J-2X Development



J-2X Design

3D models are carried through all phases of the product life cycle.

More Automation

Past

Present

Future

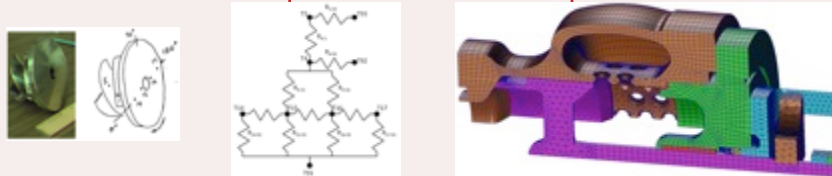
What is changing?

Design



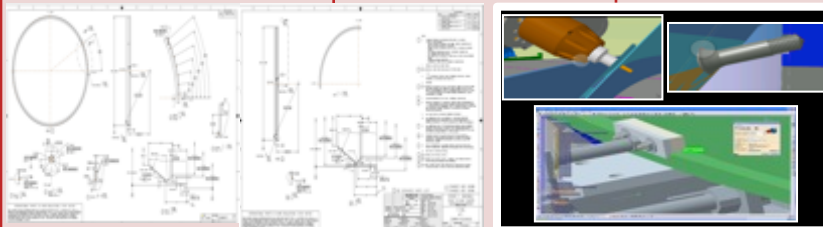
Design is becoming more integrated with manufacturing, shortening the product life cycle and reducing overall cost. Minimizes re-design, re-work.

Analysis



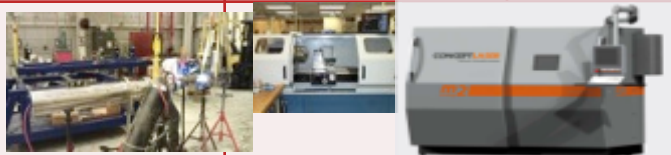
Computers are getting faster, memory is getting cheaper, leading to higher resolution analytical models. Analytical models are becoming more fully integrated.

Producibility, Modeling and Simulations



The transition from paper drawings to 3D design models and associated modeling and simulations have enabled advanced producibility analysis with great savings. We are also working towards using annotated models in place of drawings.

Manufacturing



Transitioning from manual processes to full automation, CNC milling, additive processes.

Inspection and Test

Label#	ActualX	ActualY	ActualZ	I
C_DEVICEPOS001				
M_PLANE001	0.3453	-0.0139	0	0
M_CIRCLE001_I	0	0	0	0
M_LINE001	8.6373	0.7553	0	0
C_COORDSYS001	0	0	0	0
C_ALIGNMENT001				
M_POINT001	53.7252	37.2856	6.728	0
M_POINT002	53.2972	-9.3056	6.205	0
M_POINT003	63.493	-11.345	-18.992	0
M_POINT004	53.105	-39.744	6.207	0
M_POINT005	-24.651	7.2137	6.207	0
M_POINT006	53.5545	-7.5359	7.3224	0
M_POINT007	48.288	-9.274	94.873	0
M_POINT008	47.2436	-15.478	130.66	0
C_DEVICEPOS002				
M_POINT009	-22.513	36.1752	73.4477	0
M_POINT010	-29.465	-39.313	96.133	0
M_POINT011	-32.274	37.6945	120.432	0
C_DEVICEPOS003				
M_POINT012	-30.539	-32.851	73.3956	0
M_POINT013	-30.42	-36.053	96.2763	0

Transitioning from discrete measurements to structured light scanning, more full inspection coverage and the ability to compare "as built" directly to "as designed" models, reducing inspection time and increasing fidelity.

Logistics and Operations



Using 3D virtual simulations in addition to drawings to reduce cost and schedule by evaluating interfaces during the initial design phase. Simulations can significantly increase efficiency and preparedness for operations.