

ORS OPEN MANUFACTURING



The Next Generation of Space Manufacturing: Model Based and Digitally Assured

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Raytheon Missile Systems

- World's largest volume weapons producer
 - \$6.6 Billion in Sales
 - 35,000 weapons delivered In 2014
 - 14,000 employees
- Manufacture Operations
 - Air, Sea, Land, and Space based products
 - 6 technology-based strategic manufacturing centers with 17 manufacturing facilities
 - 23 active production programs
 - 1.75M ft² in manufacturing space
 - 3,400 employees
- World class OSHA safety
- Support organizations
 - Manufacturing and Test Engineering
 - Facilities Services
 - Environmental, Health, Safety, and Sustainability (EHSS)

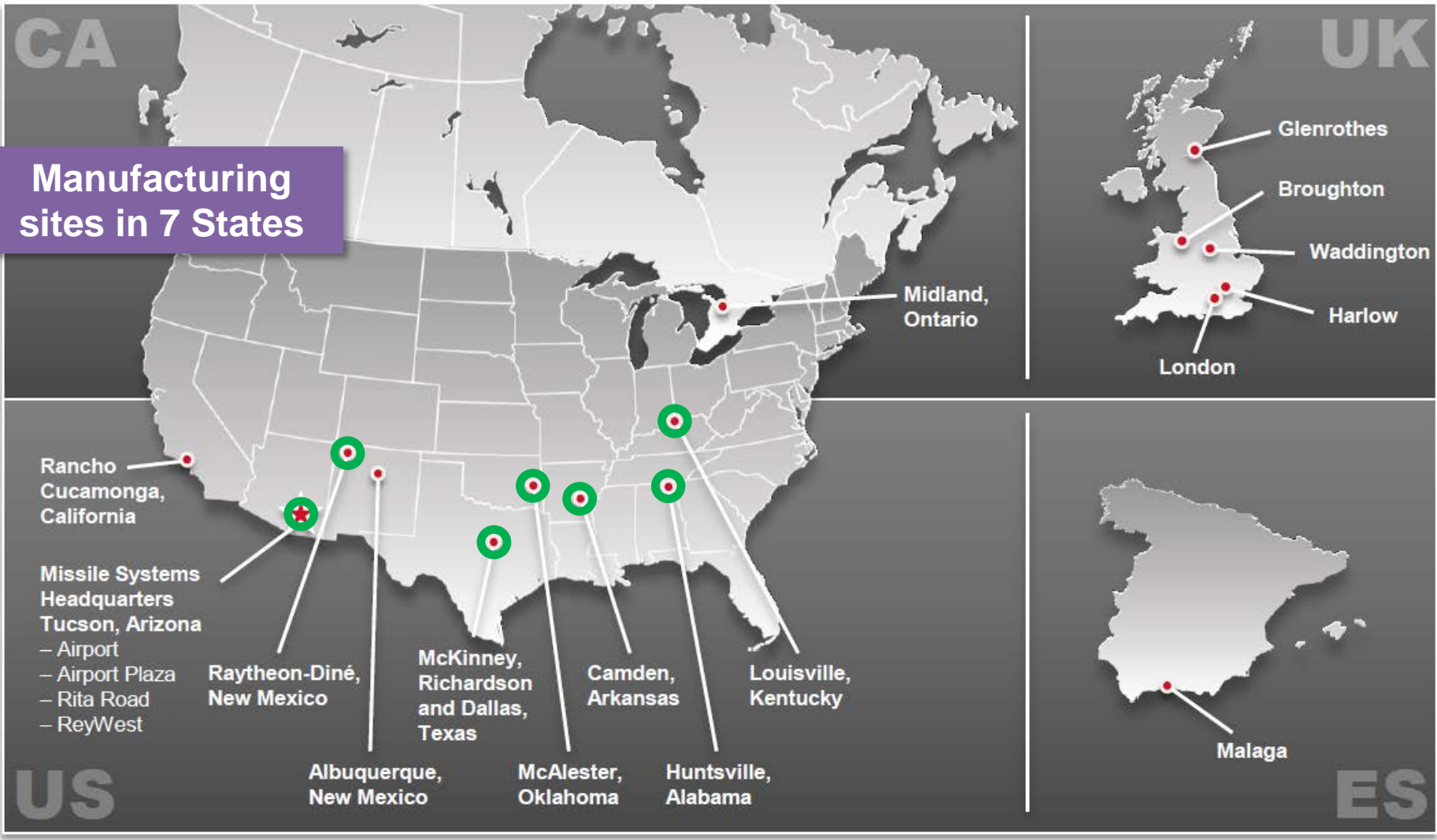


*Three Time National Shingo
Prize Award Winner for
Excellence in Manufacturing*





Operation's Manufacturing Locations





Products and Capabilities

■ Production Competencies

- Weapon Integration
- RF Missile Integration
- EO Missile Integration
- GPS / INS Missile Integration
- Missile Ordnance Integration
- Missile Electronics Systems
- Electro-Optical Sensor Assembly
- Precision Machining
- Composite Airframe Fabrication

■ Product Areas

- Air-to-Air Missiles
- Air-to-Ground Missiles
- Surface-to-Air Missiles
- Cruise Missiles
- Guided Munitions
- Guided Projectiles
- Kinetic Kill Vehicles
- Small Space Systems
- Missile Launching Systems
- Close In Weapon Systems
- Man Portable Systems





Next Generation Space Manufacturing Fusion

Partnership sponsored by Operationally Responsive Space Office

Key Members

- ORS
- MEI
- AMI
- SDL
- RMS



ORS/MEI

Extensive satellite integration experience

RMS

*Model Based System Engineering
Production Capabilities*

SDL

Satellite Design 6U

AMI

Innovative Continuous Chain of Custody



Top Level Mission Objectives:

- Demonstrate semi-autonomous manufacturing of low-volume, high value assets
- Validate the ability of autonomous digital techniques to provide mission assurance

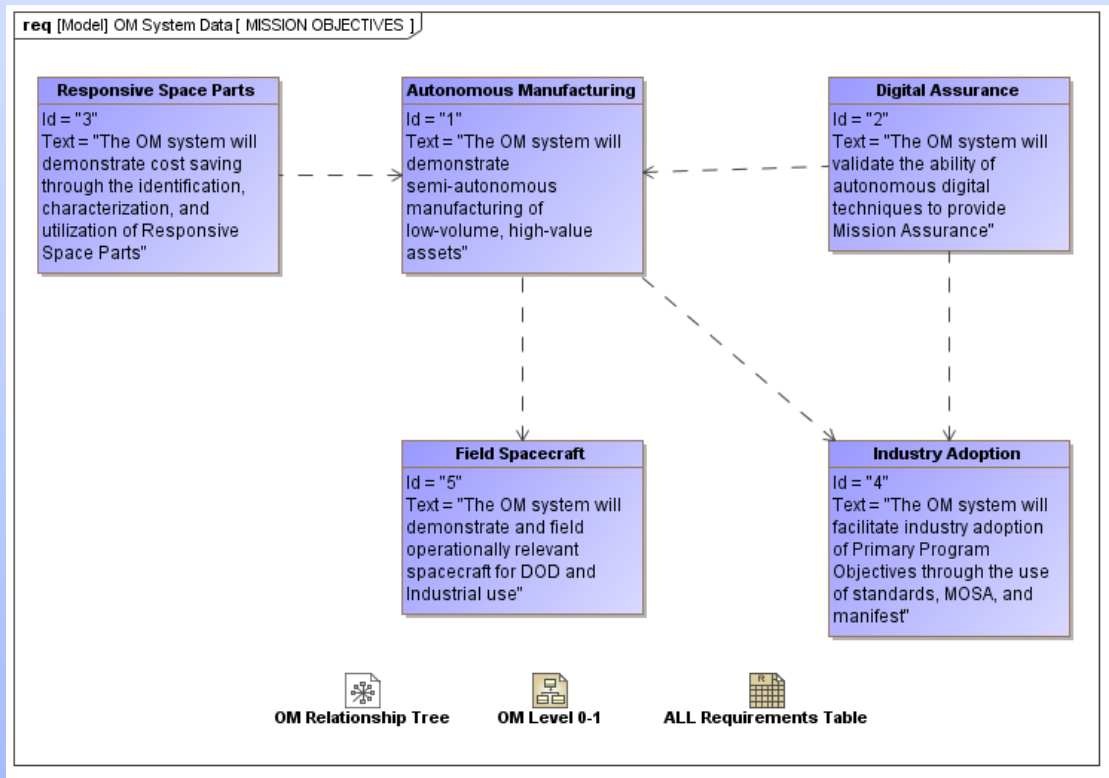


Model Based Systems Engineering Collaboration

- Integrated ORS teams leverage MBSE to help guide system design
- MBSE process enables rapid acceleration from concept to functioning system and design
 - Quickly adapt to changes in scope, budget, and technical capability
 - MBSE enabled model modifications to be made between the SDL, AMI, RMS, and ORS

- Graphical Language using SysML - Magic Draw

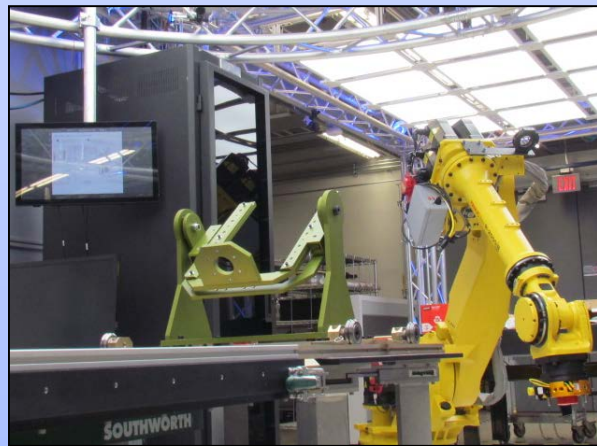
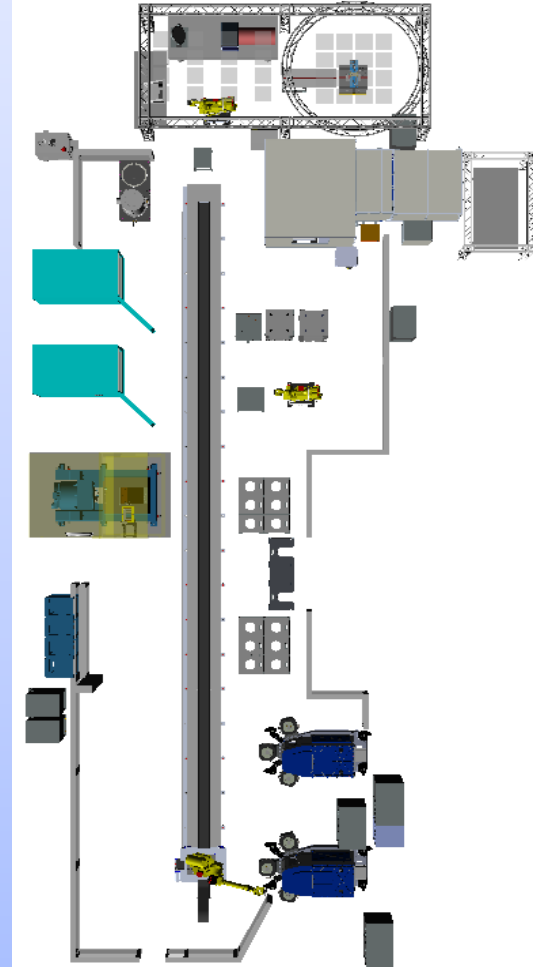
- Easily exportable to web-based format
- Pictorial view of requirements, use-cases, and functional block diagram





Next Generation Space Factory

- Evolving missile business drove changes to Raytheon manufacturing
 - Automated factory capabilities
- Adapted Assemble/Test for Small Space Products
 - Backbone of assembly workstation to includes proven production systems
 - Robotic material handling
 - Thermal vacuum chamber
 - Vibration and thermal chambers
 - Solar simulator
 - Star field generator
 - GPS antenna test
 - Inertial measurement test
 - 3-axis magnetometer



Small Space Work Cell

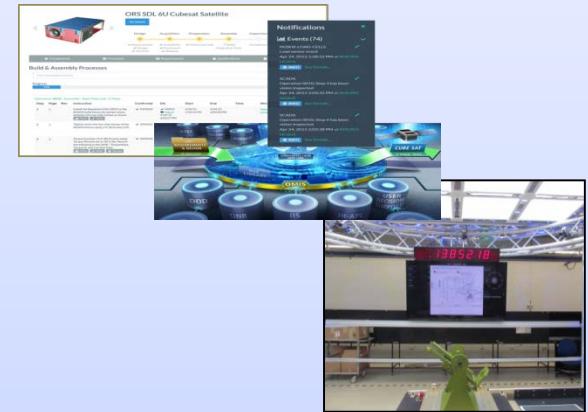
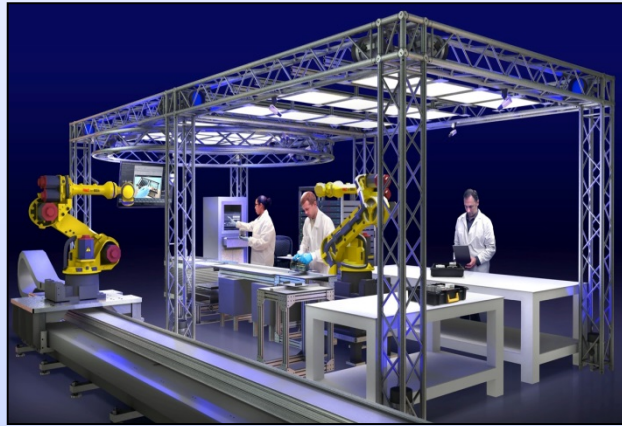


Material Handling Robot

Fusion Test Line and Small Space Cell



ORS Open Manufacturing – Digital Assurance



Initial Design Concept
(courtesy of Applied Minds Inc.)



Digital Assurance Vision
System Installed by AMI



Factory Integration/ Mission
Assurance

• Continuous Chain of Custody

– Vision System

- High definition cameras (16) and microphones (3) creates continuous chain custody of satellite components, build and test processes
- High definition machine vision system cameras (4)
 - Recognize and categorize components/assemblies

• Archived and searchable Agile Manufacturing Object Graph (AMOG)

• Open Manufacturing Information System (OMIS)

• Digital capture systems provides a innovative Mission Assurance solution



Summary and Acknowledgments

- By combining a robust capability with innovative digital assurance systems the ORS partnerships have created a competitive and reliable small satellite factory
- This novel approach opens the door for small space designers

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