Model-Based Engineering/Manufacturing Review from the Y-12 National Security Complex

MBE/TDP Summit
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Donna F. Bennett
Manager, Engineering Analysis & Technology Engineering
B&W Y-12

National Nuclear Security Administration

National Security Complex

Overview

- **Introduce the Y-12 National Security Complex**
  - nearly 70 years of expertise in science and technology

- **Discuss the unique facilities, technology capabilities, knowledge and expertise that Y-12 offers,**
  - as part of the Nuclear Security Enterprise, for finding solutions to scientific and technological challenges

- **Describe Y-12 programs and partnerships**
  - providing a wide network of specialists with an array of knowledge and skills

- **Open the door to future collaborations**
  - working with federal agencies and others to advance science and technology to meet national and global needs

Who Are We?

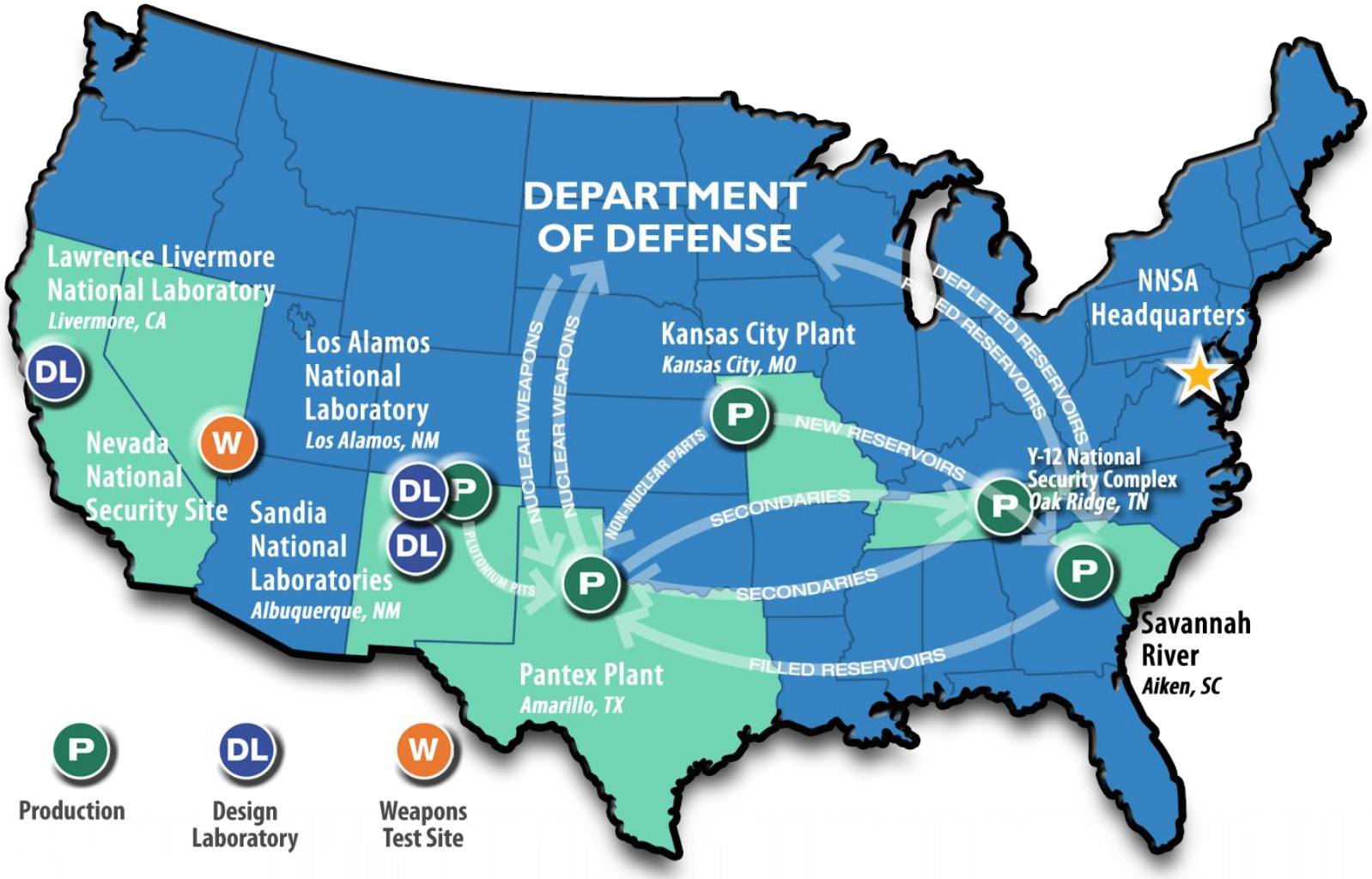
- The Y-12 National Security Complex is a premier manufacturing facility dedicated to making our nation and our world a safer place

- Operated by B&W Y-12 for the National Nuclear Security Administration (NNSA), Y-12 plays a vital role in the Department of Energy's (DOE's) Nuclear Security Enterprise (NSE)

http://www.y12.doe.gov/

Uranium Center of Excellence
Located in Oak Ridge, Tennessee
More than 8,000 uniquely skilled, dedicated employees

Y-12—One Part of DOE's NNSA



Y-12 National Security Complex Missions

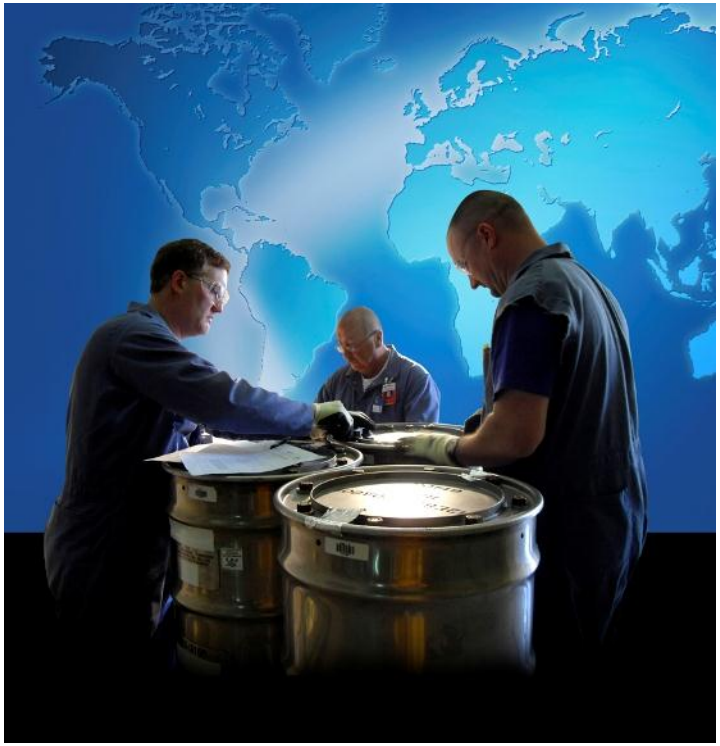
- Sustain a safe, secure and effective nuclear arsenal
- Processes highly enriched uranium for the U.S. nuclear Navy to propel nuclear submarines
- Prevent nuclear proliferation and nuclear terrorism
- Solve global security challenges

Y-12 Engineering

Engineering has 626 employees including 88 Development employees

Four Core Areas of Research and Development

- Technology development, maturation and deployment activities at the Y-12 Complex focus on four core areas:
  - Defense Programs
  - Transformation
  - Complementary Work
  - Basic Science

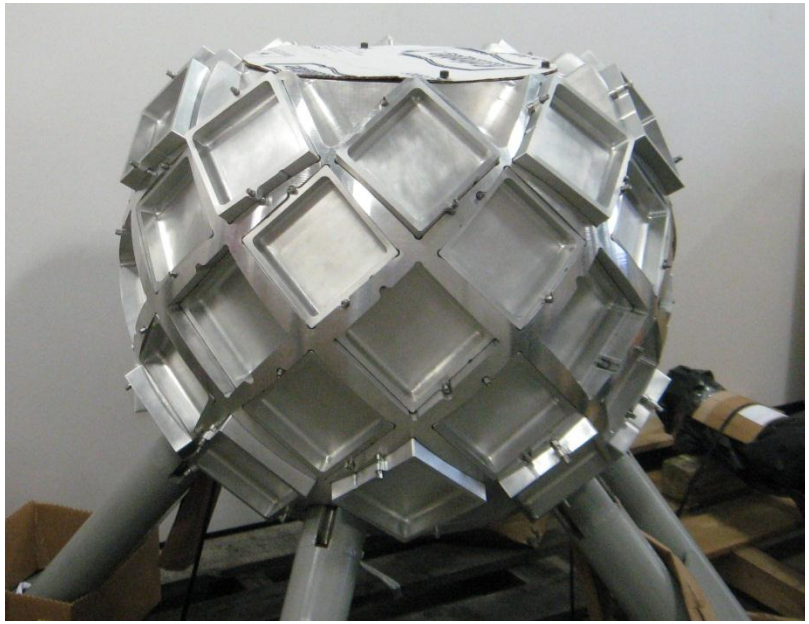


Y-12 Model-Based Engineering

Y-12 effectively integrates model-based engineering and manufacturing (MBE/M)

Model-based Engineering and Manufacturing (MBE/M)

- Y-12 is modernizing the business of science-based stockpile stewardship by creating and using 3-D geometric models for
  1. Defining the refurbished stockpile product
  2. Supporting certification, and
  3. Integrating design, engineering and manufacturing activities across the NSE



ORNL Topaz Detector Array Tank, TOPAZ DAT

Y-12 Effectively Integrates Model-Based Engineering/Manufacturing (MBE/M)

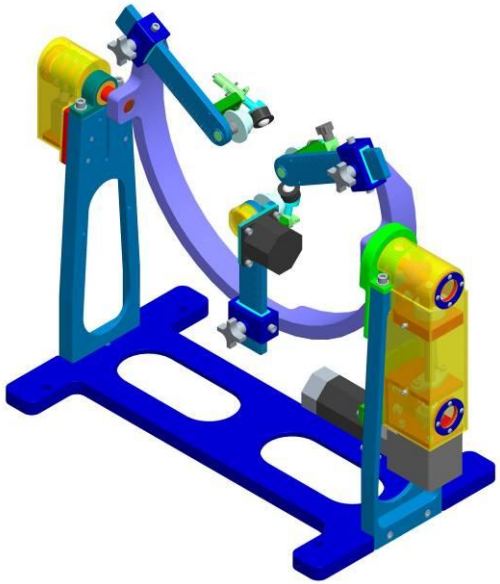
- MBE/M concepts are applied during
  - Design and analysis/simulation
  - Manufacturing
  - Inspection
  - Packaging
- Projects often involve hazardous materials
- Y-12 expertise ensures that MBE/M is applied **safely and securely**

MBE/M (cont.)

- MBE/M is used at various project stages
  - Total life cycle
    - Life extension program (LEP)
    - Uranium Processing Facility (UPF)

- Single phase of life cycle
  - Conceptual design only
  - Design only
  - Manufacturing (fabrication/inspection)

- Blend of several phases

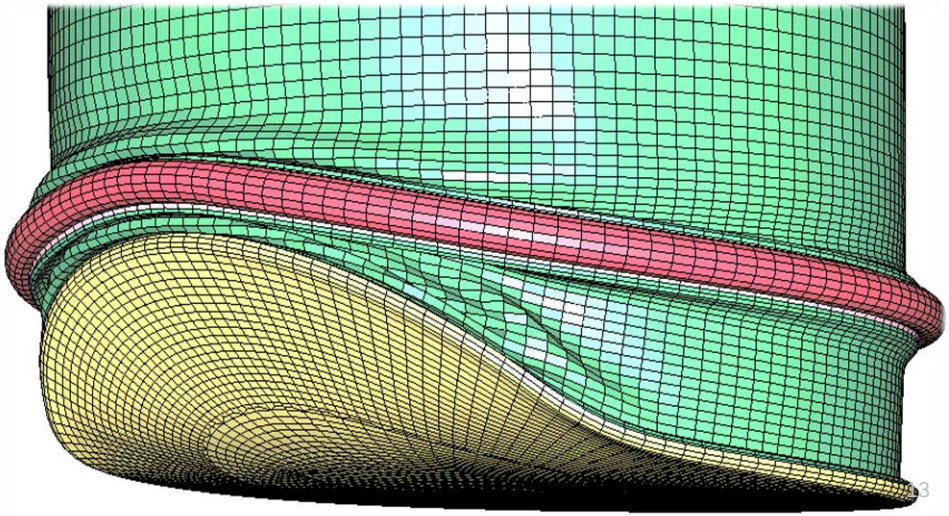


MBE/M Technology Applied to Many Projects

- Packaging Engineering designs packaging for shipping/transporting nuclear materials
- Life Extension Programs (LEPs)
  - Full product life cycle
  - Started MBE/M pilot project for NSE in FY 2002
- Integrated Glove Box System (IGBS) for dismantlement project installed FY 2010
- Uranium Processing Facility (UPF) ongoing

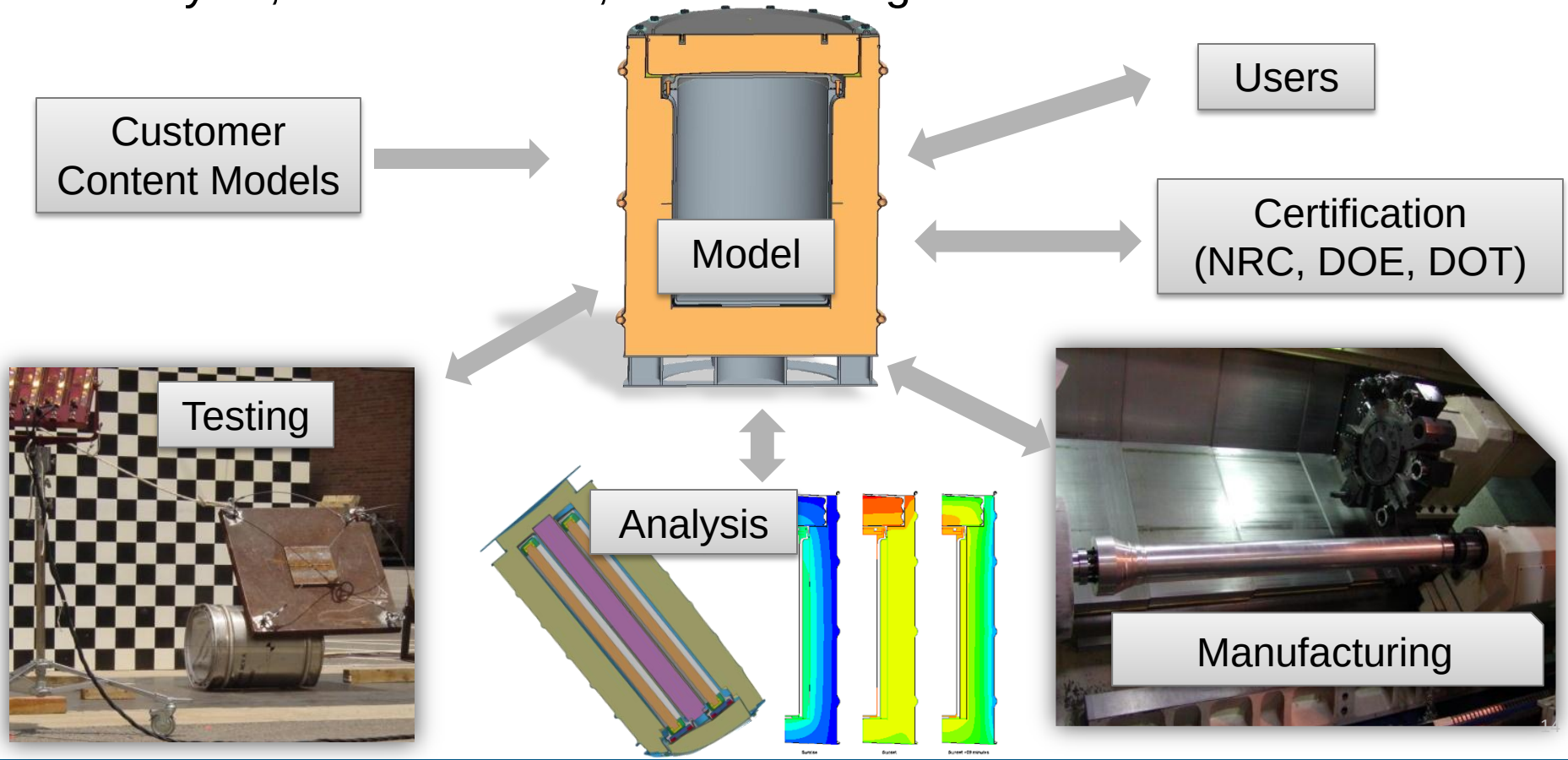
Packaging Engineering

- Long history of successful designs in a wide variety of containers and shipping packages
- Thermal and impact analysis experience and capability
- Complete support solution, including concept design, end-user support, maintenance and decommissioning
- Experience with certification of hazardous material packages in a strictly regulated environment



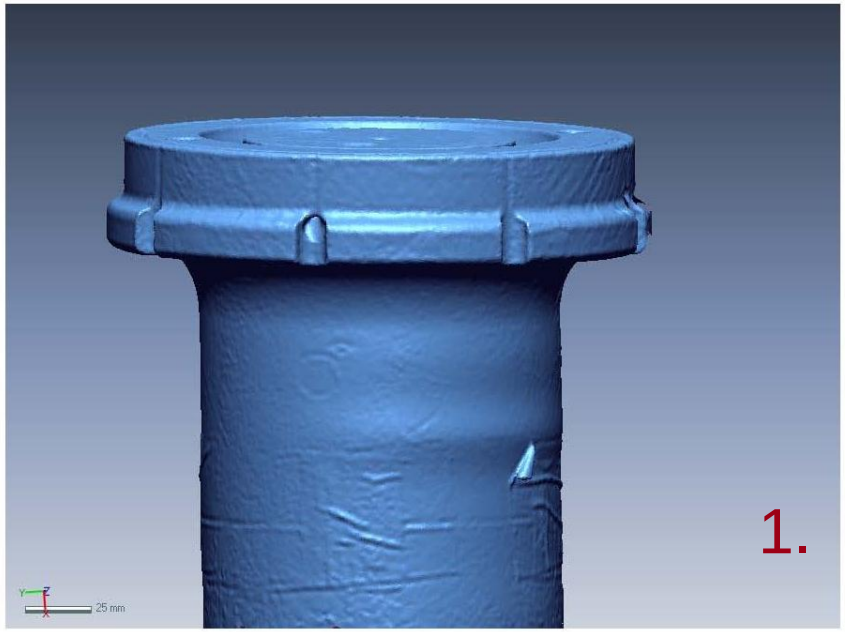
MBE/M Saves Packaging Engineering Time, Money

- Cradle-to-grave design authority over packages used on-site and worldwide
- Model-centric approach eases communication among customers, analysts, manufacturers, users and regulators

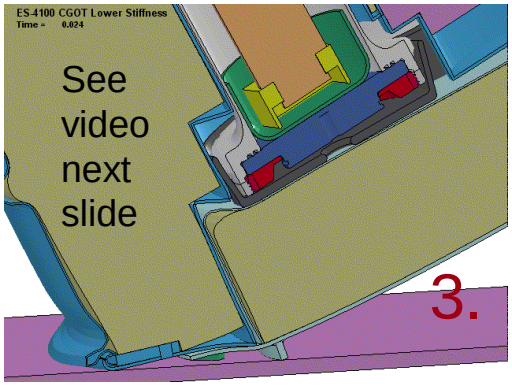


Packaging Engineering Using Virtual Testing

3-D Scan of ES-4100 Abnormal Surface Feature

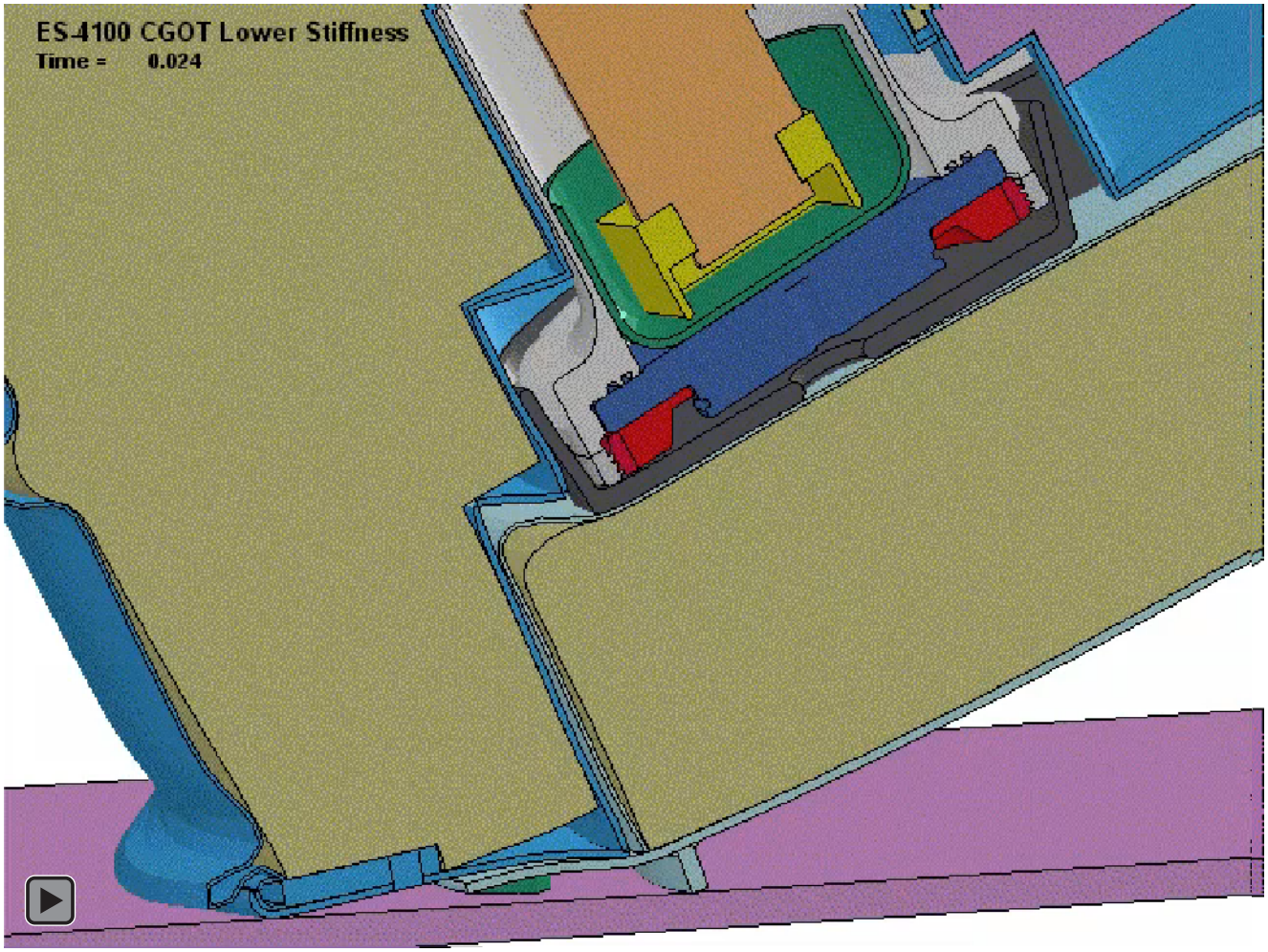


1. 3-D scanner creates virtual model after physical testing—good for capturing data
2. Photo of item for comparison
3. Finite element analysis (FEA) used for virtual testing/refining design (creates prediction of item after testing)



Packaging Engineering Using Virtual Testing *(cont.)*

3-D Scan of ES-4100 Abnormal Surface Feature



Avoid Physical Testing: Use MBE for Virtual Testing

Cost of 6 prototypes in 2005	$150K
Regulatory drop testing on 6 units	$400K
Revision of safety analysis report (SAR) to add new test results	$ 25K
FEA engineering and SAR revision only	$ 40K

Cost difference…

$575,000 (drop test) vs $40,000 (MBE)

Life Extension Program—Pilot Project

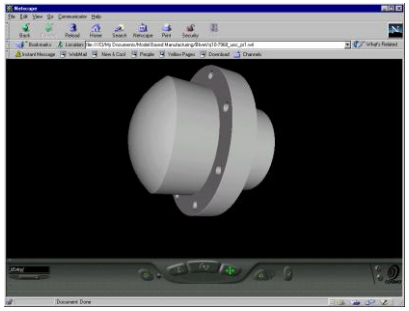
- MBE/M concepts were applied in all life cycles in this project
- Conducted first pilot MBE/M project between design agency and Y-12 starting in FY 2002
- Developed business rules around MBE/M needs and requirements
- Developed verification process for electronic Pro/Engineer model
- Embraced concept of trinity (drawing, model, pdf or tiff for legacy standard format)
- Conducted MBE/M workshop to help facilitate change of Y-12 culture

Life Extension Program—Pilot Project *(cont.)*

- Used Pro/E models in tooling design
- Completed process planning using work-in-process models
- Programmed numerical control (NC) machines directly from Pro/E model
- Used models for analysis and simulation at various stages
- Captured coordinate measuring machine (CMM) inspection data electronically for documentation for as-built models

Life Extension Program—Pilot Project *(cont.)*

- A process for verifying Pro/E models was deployed in FY 2002 and was used in FY 2003 for models-based product definition received from the design agency



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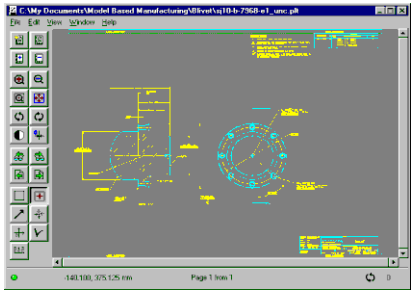
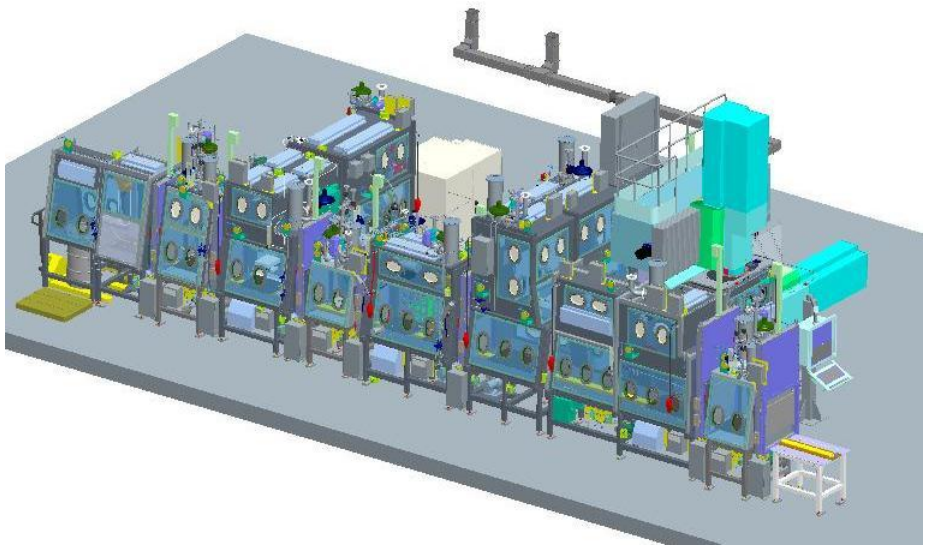


Model verification—a very important 1st step

- The process addresses
  - Geometric integrity and translatability
  - Standards compliance
  - Pro/E model and Pro/E drawing consistency
  - Design intent (in addition to normal design reviews
  - Policy and guidelines developed

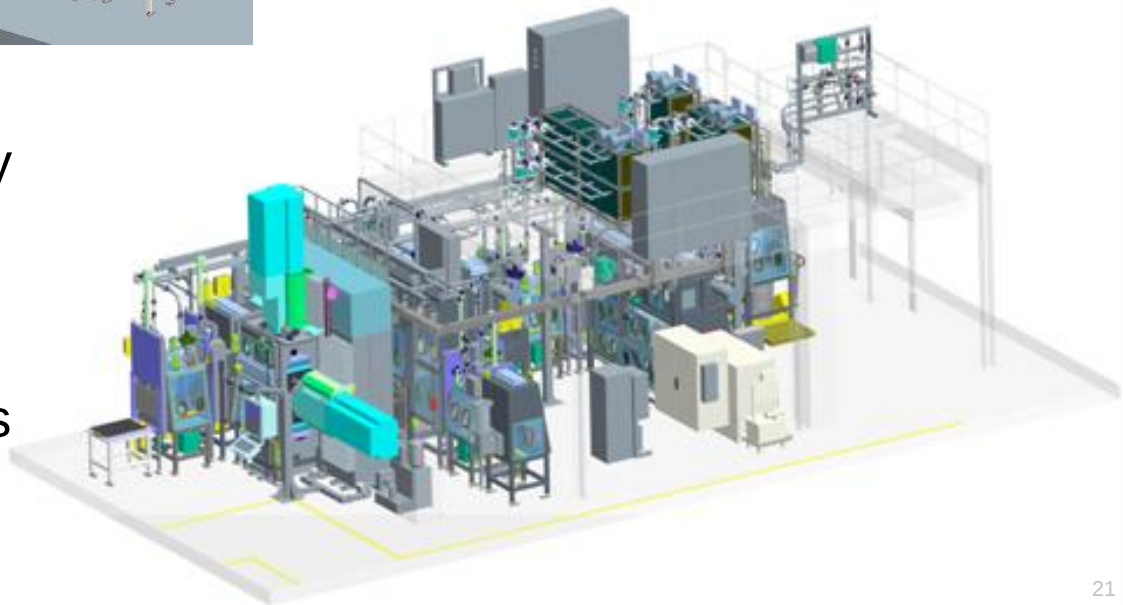
Integrated Glove Box System (IGBS)



~ 50 feet long
~ 20 feet wide
~ 20 feet high

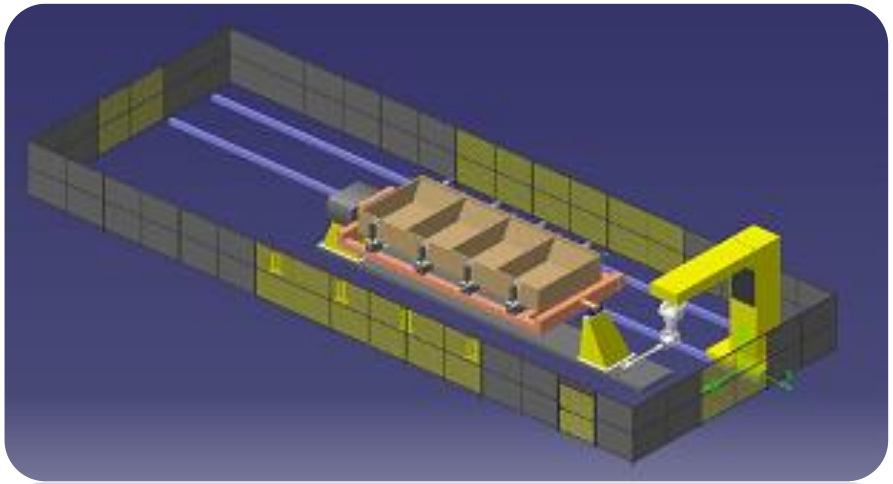
- Multiple glovebox zones with fully integrated environmentally interlocked system

  – hoists, one in each zone
  – fully integrated machine tools
  – ventilated hoods
  – drum transfer system



IGBS Implementation Completed in FY 2010

- Designed as general-purpose glovebox in existing facility
- Designed by outside architect engineer
- Manufactured by external subcontractor
- Used currently for specific purpose (dismantlement)
- Modeled legacy weapons parts in Pro/E
- Designed all machining and inspection fixtures in Pro/E

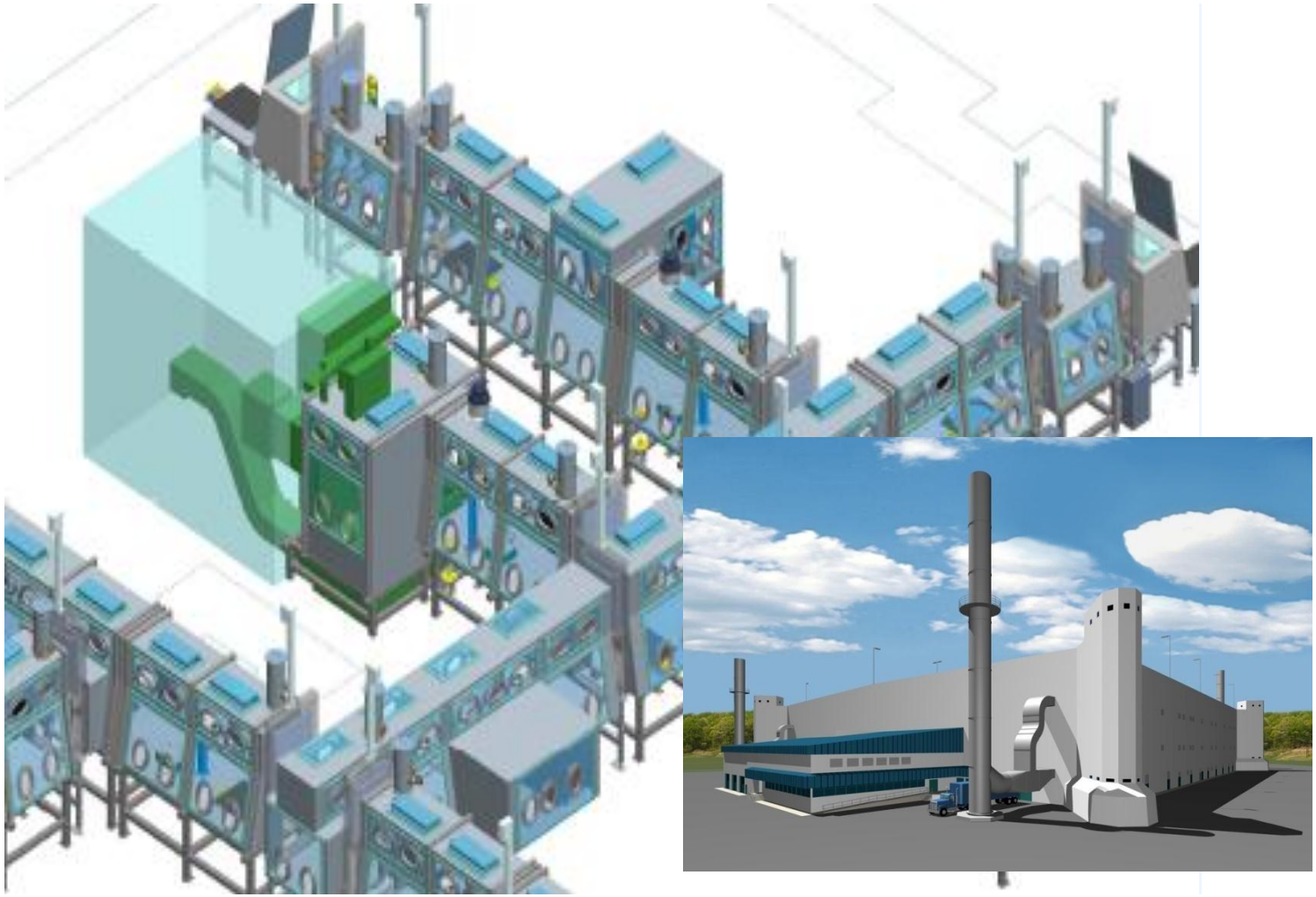


IGBS Applied MBE/M Technologies

- Process operation was simulated in Delmia and Pro/E Manikin software
- Generic facility (IGBS) presented many challenging requirements
  - Large dismantlement part
  - Very little operating room available
- Virtual process planning identified and avoided several trouble spots in fixture designs
- Simulations were provided for operator training
- Simulation was an excellent communication tool for commissioning activities

Support to Uranium Processing Facility (UPF)

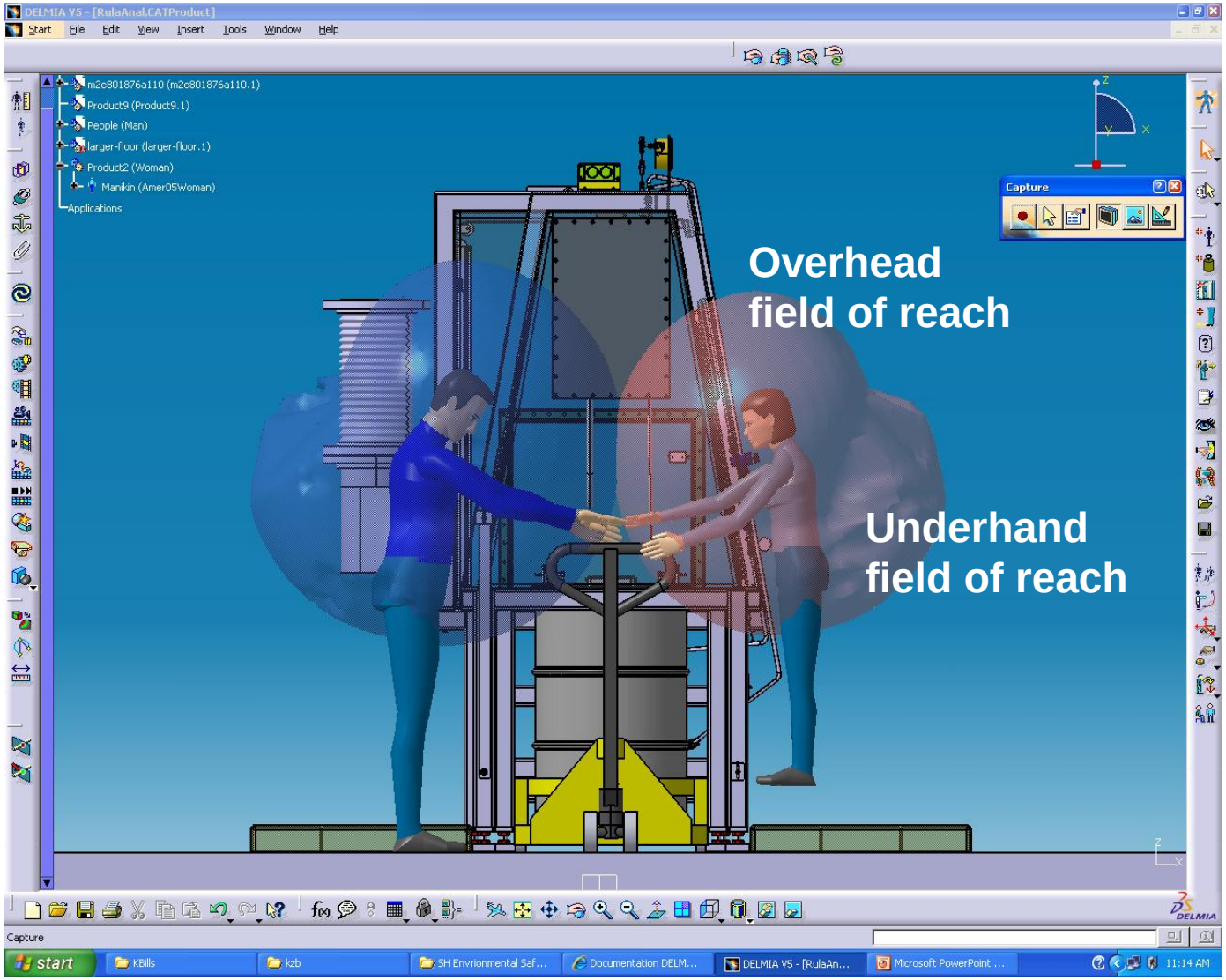
Modernization to Y-12



UPF Applies Many MBE/M Concepts

- Conceptual design
  - Used knowledge capture to support MBE/M
  - Used Extend software models for process design
  - Varied facility design virtually to evaluate cost/schedule impact
- Ergonomic design
  - Reviewed fit and function of proposed design
  - Avoided costly design flaws not typically caught before facility walk-down
  - Avoided health and safety problems with ergonomic design

UPF Design for Ergonomic Consideration



UPF Design for Ergonomic Consideration

Y-12 Partnerships and R&D Programs

- As part of the Nuclear Security Enterprise, the Y-12 Complex works with other Department of Energy sites and federal agencies as well as universities and private industry
- Y-12 participates in various partnerships and in groups dedicated to improving communications and facilitating the exchange of technical data and advancing technologies
- The Plant Directed Research, Development, and Demonstration Program (PDRD) supports innovative or high-risk design and manufacturing concepts and technologies with potentially high payoff for the Nuclear Security Enterprise
- Nuclear Safety Research & Development (NSR&D)
- Cooperative Research and Development Agreements (CRADA)

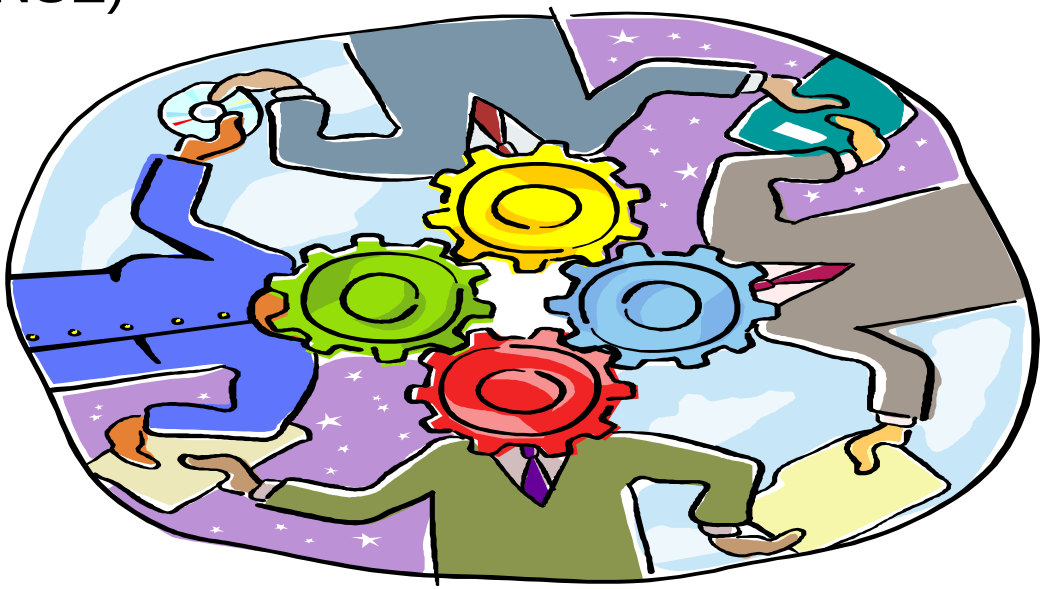
University Partnerships with Y-12

- University of Tennessee, Knoxville and Chattanooga
- University of Alabama, Huntsville
- University of Florida
- University of North Carolina, Charlotte
- Georgia Tech
- Syracuse University

Y-12 researchers and members of the University of North Carolina at Charlotte—recipients of an R&D 100 Award in 2010 for the Modulated Tool-Path Chip Breaking System

Y-12 Participation in IMOG

- Interagency Manufacturing Operations Group (IMOG)
  - Oldest NSE working group (60+ years)
  - Involves participation from majority of NNSA sites
  - SMEs exchange technical information—on design, manufacturing and acceptance problems—to maintain the manufacturing operations capability of the DOE weapons complex (NSE)



Y-12 Participation in MBIT

- **M**odels **B**ased **I**ntegrated **T**ools, a model-based working group, was formed 15 years ago and consists of managers, SMEs, from all NSE sites as well as other DOE labs and vendor of ProE - PTC

"Before all NSE sites adopted the computer software ProEngineer (ProE), each site had its own computer-aided design (CAD) system. The Department of Energy spent lots of time, effort, and money so the different CAD systems could communicate….

"We find a lot of value in [MBIT] relationships. When new ProE versions roll out, we all save money by avoiding reinventing the wheel or paying consultants."

- *Y-12 Steering Group Rep*

Y-12 Information Technology

Snapshot of MBIT

- MBIT members
  - Lawrence Livermore National Laboratory
  - Sandia National Laboratory, California
  - Los Alamos National Laboratory
  - Sandia National Laboratory, New Mexico
  - Pantex Plant
  - Savannah River National Laboratory
  - Y-12 National Security Complex
  - Kansas City Plant
  - Parametric Technology Corporation (PTC)—vendor for standardized design tool Pro/Engineer

The network saves money in licensing fees and in economies of scale in processes and techniques

Benefits of MBIT Participation

"By participating in MBIT, Y-12 engineers, designers, drafters, and numerical-control part programmers can share knowledge across the Nuclear Security Enterprise. That information exchange maximizes efficiency and quality in the creation of models, drawings, and machine tool programs and in file management."

- *Manager, NC Machining Y-12 Mechanical and Manufacturing Engineering*

What Does MBIT Do?

- Develops and maintains model-based standards and best practices for product realization
- Brings together users, SMEs, managers and vendors
- Serves as the user voice to communicate business and technical requirements related to model-based tools and processes
- Promotes common tools and processes that support NSE programmatic missions
- Promotes seamless sharing and reuse of models and associated data within the NSE and with commercial partners
- Forms strategic partnerships with vendors that support NSE product realization activities
- Collaborates with outside industry to share lessons learned and validate MBIT's vision and guiding principles

Summary

- Y-12 has diverse experience in all stages of design and manufacturing. This history gives Y-12 a unique, in-depth understanding of the engineering and manufacturing challenges that confront national security
- Model-based approach guarantees success through excellence in manufacturing
- Y-12's work with other NSE sites and Y-12's programs and partnerships create a vast network of highly skilled specialists and research facilities
- We look forward to expanding partnerships to advance science and technology to meet national and global security needs

Questions?

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