SAN02000-3050

Computational Reasoning About Geometry
Applied to Intelligent Machines
Intelligent Systems and Robotics Center

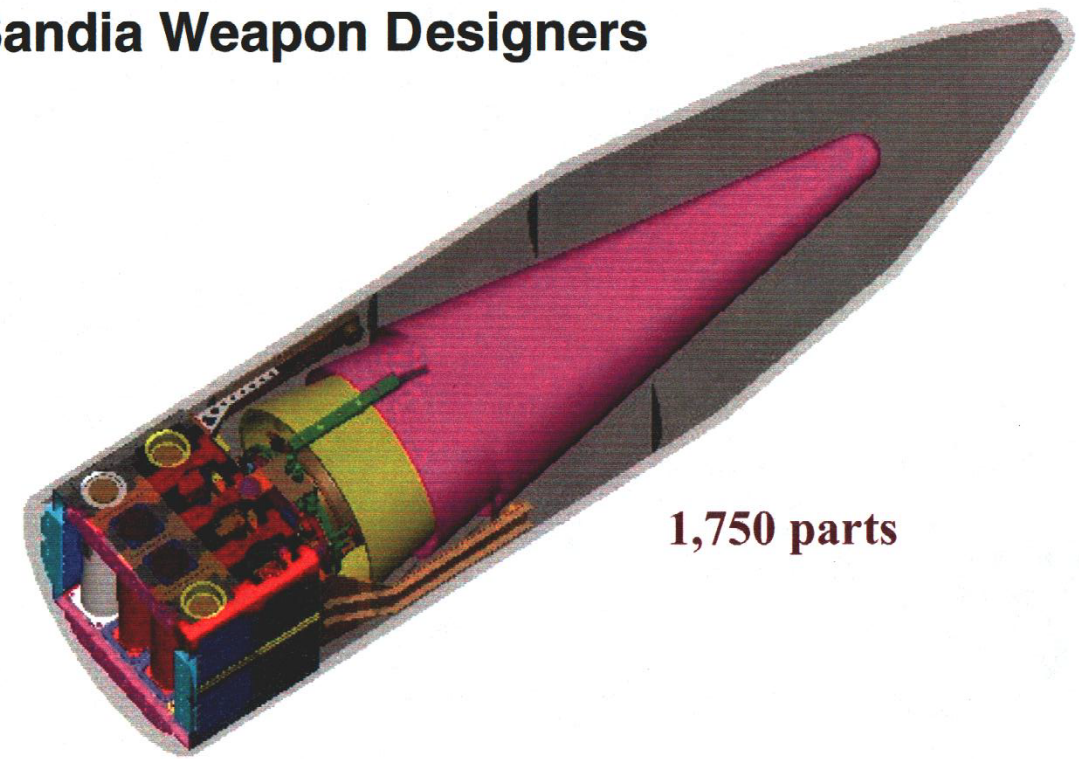
The DOE has numerous complex environments that require the precise, error-free handling of critical and sometime hazardous materials. As a result, the DOE has sponsored the development of advanced machines to automate many operations previously performed manually. In particular, tedious and hazardous tasks have received much attention. Unfortunately, standard machine programming approaches are prone to errors. The Intelligent Systems and Robotics Center has pioneered the automated generation of intelligent machine control programs using geometric reasoning. These techniques have shown great promise in rapidly solving very complex problems typical of DOE environments and have seen their first application at various DOE sites. These promising techniques are now being extended and coupled to high fidelity physical models of materials and processes. Through the integration of mathematical formalisms in areas such as topology we will provide closed form representations which allow rapid optimization and development of provably correct solutions to complex manipulation tasks.

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

Notable Accomplishments

Project: Target Array Assembly (missile interceptor)

Customer: Sandia Weapon Designers



1,750 parts

Impact: Time for performing assembly analysis three times faster than previous

- ~ 10 minutes to load & perform contact analysis
- ~ 8 minutes to plan initial sequence
- ~ 1-2 minutes for interactive replanning

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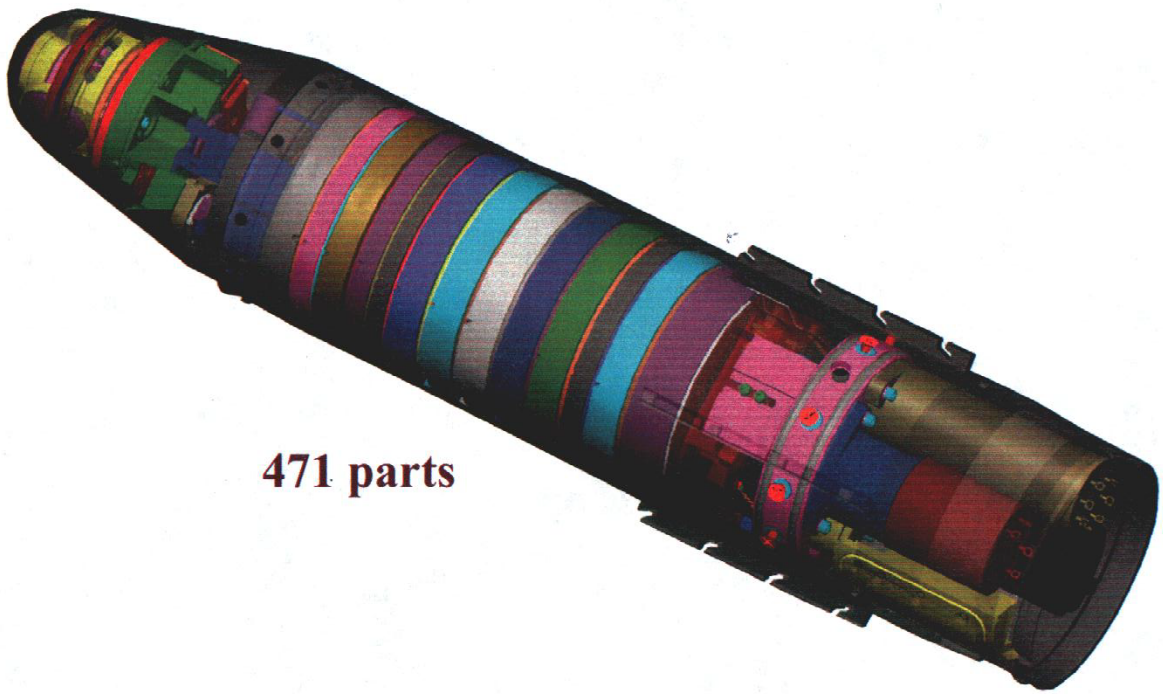
Notable Accomplishments

Project: AIM 9X Guidance Section

Customer: Raytheon



471 parts

Impact: New record for planning complex assembly sequences

- ~ 22 minutes to perform initial contact analysis & generate first assembly plan
- ~ 2 minutes for interactive replanning

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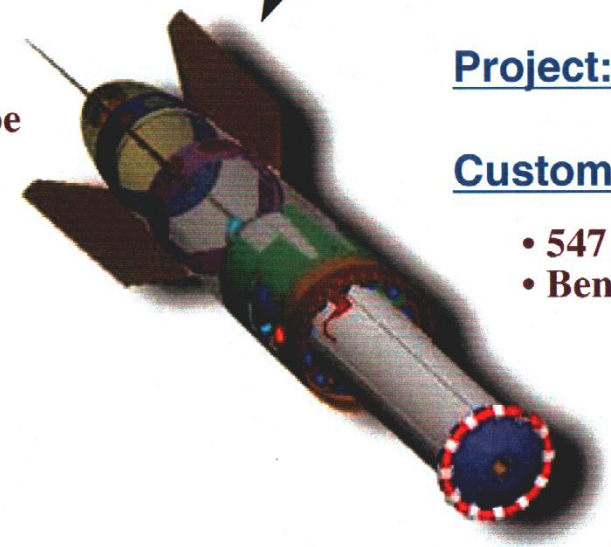
Notable Accomplishments

Project: B61 Parachute Replacement

Customer: Pantex

- 258 parts
- Optimized search for the fewest number of parts to be removed to access the parachute.



Project: B61 Alt 339 Retrofit Program Center Case (Classified)

Customer: Sandia Weapons Designers

- 547 parts
- Benchmark Case Study

Project: Re-manufacturing of B61 Nose Assembly

Customer: Allied Signal Kansas City

- 88 parts

Impact: Teamed with three DOE sites to accomplish separate but related weapons projects

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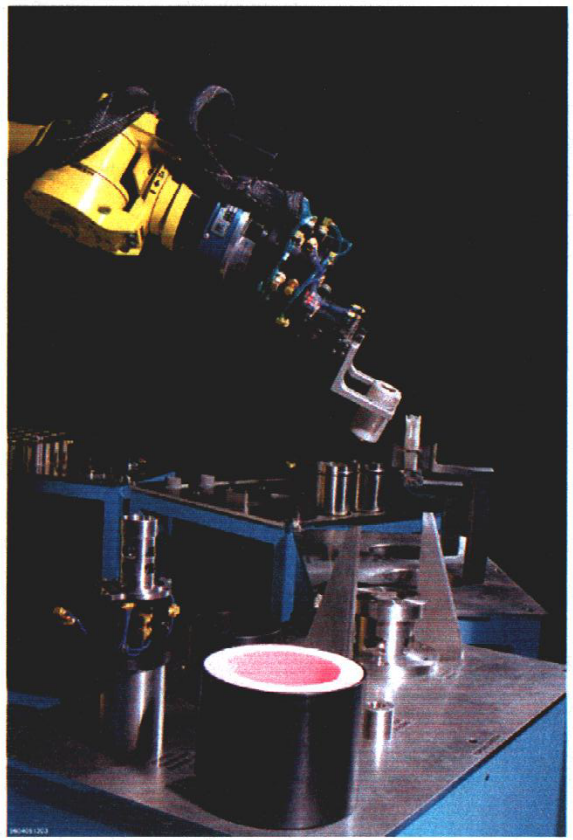
Notable Accomplishments

Project: Automated Gas Generator Disassembly (AGGDIS)

Customer: Pantex



Impact: Force control coupled with geometric information enables safe explosive component disassembly – over 2000 units safely processed

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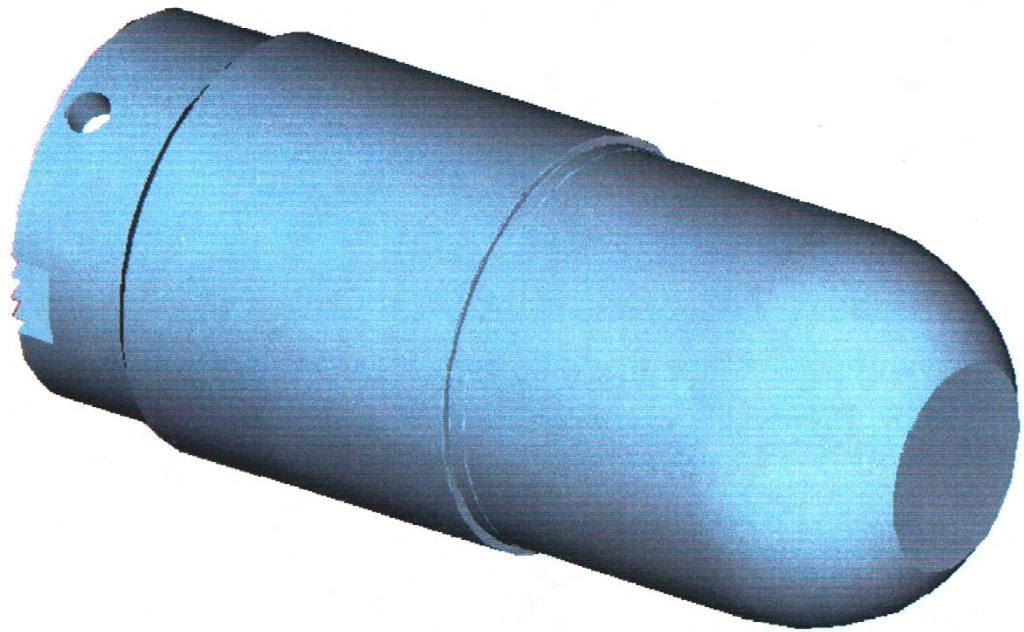
Notable Accomplishments

Project: Automated Fixture Design

Customer: Neutron Generator Production Facility



Impact: Semiautomatic design of component fixtures which stabilize critical geometries during thermal processing such as brazing

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New mathematical formalisms provide closed form solutions to very difficult problems

Rigorous Mathematical Basis enables:

- Proof of tractability of required DOE operations in complex environments
- Optimal algorithms for planning operations
- Extension of theorems and algorithms from a purely geometric domain into one involving multiple physical phenomena

Approach:

- Modern algebraic and differential topology to understand global mathematical structure of planning and design spaces
- Deformation theory to understand how parameter variations affect plans and designs

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Computational Reasoning about Geometry Applied to Intelligent Machines

Motivation

- DOE must perform error free high consequence operations involving complex environments

Challenge

- Connect the science of mathematics to real DOE manipulation problems to provide deterministic processes

Significance

- We are applying initial geometric reasoning algorithms to DOE problems with great impact