Inertial Property Algorithm Validation

IPAV

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Overview

- Background
- The Future
- Mission Objectives
- Experiment Hardware/Procedure
  - Free Floating System (FFS) Design
  - Mounted Release System (MRS) Design
- Feasibility Assessment
- Conclusion

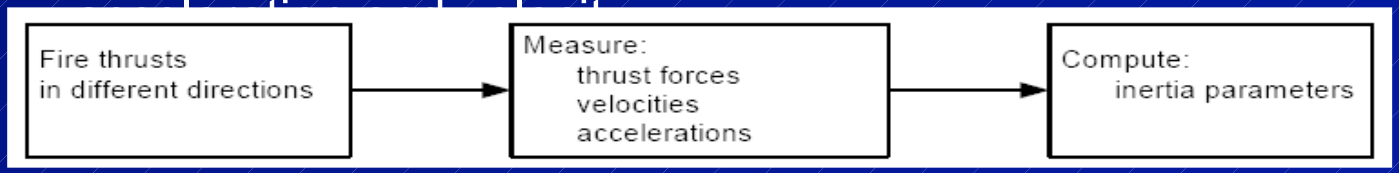
Background

- Spacecraft Inertial Properties (mass, center of mass, and inertia tensor) change in orbit
  - Fuel consumption
  - Hardware reconfiguration
  - Docking maneuvers
  - Etc.
- Inertial Parameters critical for Satellite Control Systems
- Problem:
  - Previous methods used vector thrusting
    - Requires fuel consumption
  - Previous methods also based on equations of motion
    - Requires thrust forces, Past Methodology

$$\sum \boldsymbol{F}_{ext} = m\boldsymbol{a}_G$$

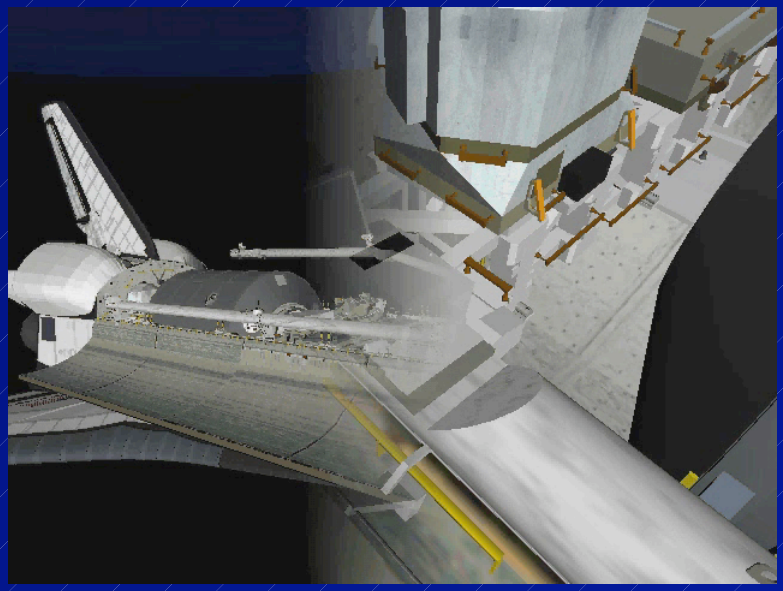
$$\sum \mathbf{M}_G = \dot{\mathbf{H}}_G$$

Equations of Motion

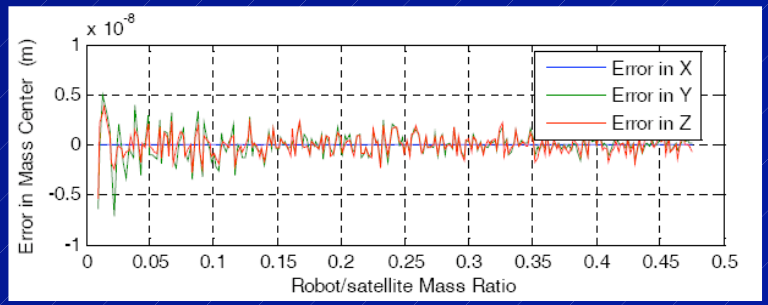


The Future

- Robotics-based Algorithm using conservation of momentum
  - Induce change in velocity with robotic arm or appendage
    - Powered by renewable solar energy
  - Only Requires steady-state velocity measurements
    - Less Measured parameters = Less Error
  - Not susceptible to transient energy dampening effects
    - Fuel sloshing
    - Solar array flexing
    - Etc.
  - Theoretically proven to generate results with a high degree of accuracy
  - Industry requires experimental validation prior to use

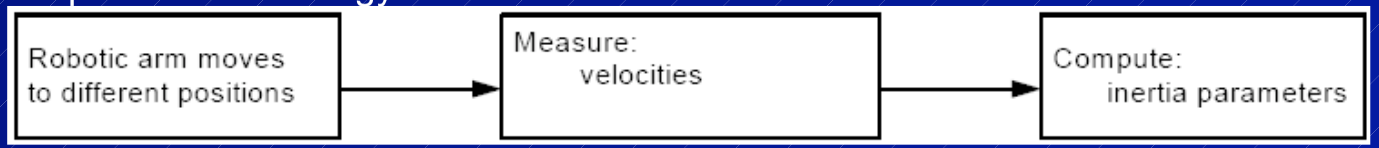


Robotics Application in Parameter Estimation



Simulation results with varying mass ratios

Proposed Methodology

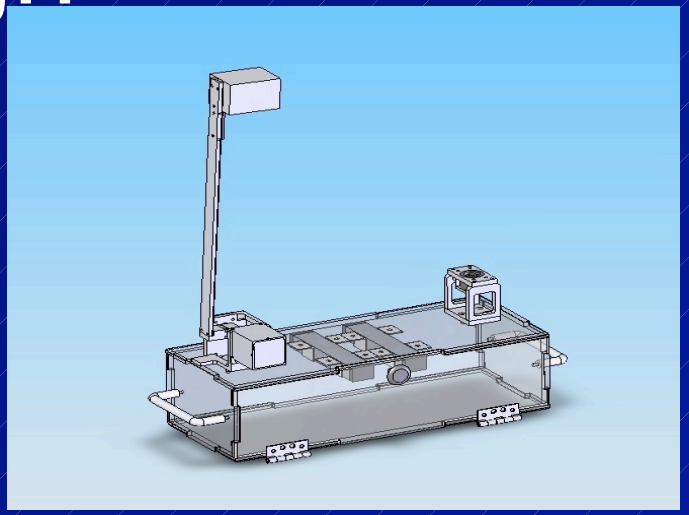


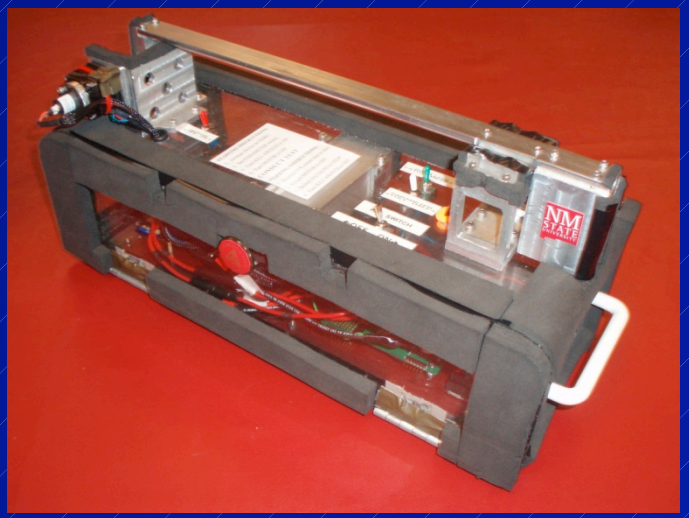
Mission Objectives

- Obtain experimental data for a spacecraft-robotic arm mock-up system in order to validate the newly developed algorithm
- Perform experiments in space-like environments for sufficiently representative data of orbiting systems

Free Floating System (FFS) Design

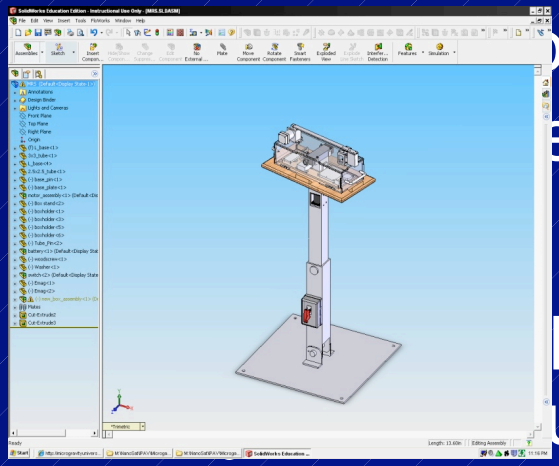
- Main Housing
  - Representative of the spacecraft body
  - Made of high impact Polycarbonate
  - Sensors include
    - 3 Triaxial accelerometers
    - 3 orthogonally configured single axis Rate-gyros
  - Interior mounted secondary mass
    - Provides variance in the mass ratio
- Robotic Arm
  - Pivot Housing Assembly
    - Includes Stepper motor for precision control
      - With encoder feedback
    - Magnetic Encoder mounted on motor shaft
  - Armature



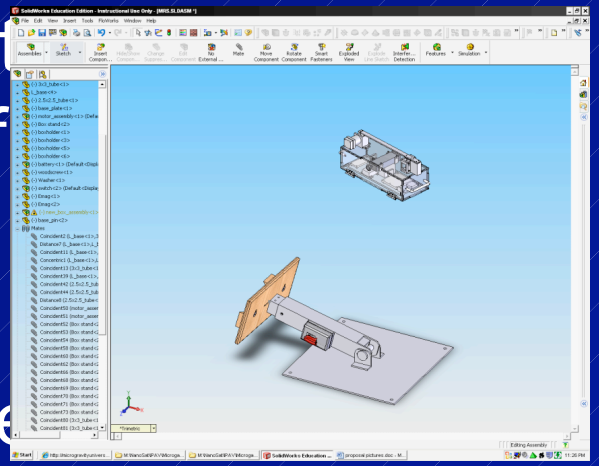


Mounted Release System (MRS)

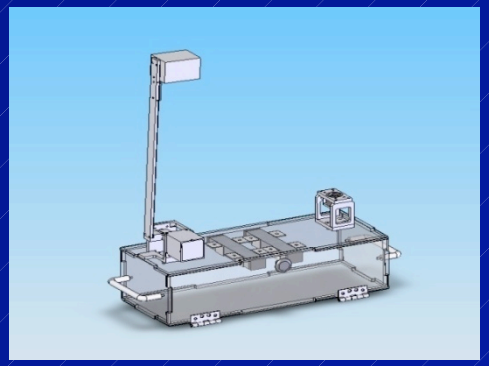
- Design Functionality
  - Rotating platform provides a controlled initial angular velocity
  - Electromagnets restrain the Free Floating System (FFS) in place until microgravity commences
  - Collapses and folds to the

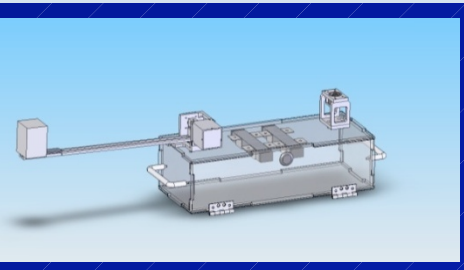


Before microgravity commences



After microgravity





Preprogrammed

Feasibility Assessment

- Previous Zero-G testing
  - Issues with previous "Parabolic Trajectory" zero-G testing
    - Uncontrolled fuselage motion cause by aerodynamic forces on the aircraft
    - Insufficient test run time
  - Justification for sub-orbital experimentation
    - More controlled test environment – negligible aerodynamic forces

Conclusion

- A robotics-based inertial parameter identification method has been proposed by the NMSU Dynamics and Controls research Group
- Proposal
  - To experimentally validate this method utilizing the zero gravity environment provided by the up and coming privatized sub-orbital research programs
- Once validated the method can be applied to any space mission to increase the efficiency of the system identification

- Questions?

Thank you!