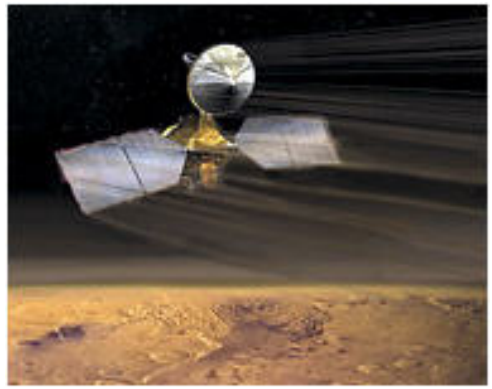
Modeling Motion Control Systems in Air and Space Vehicles



Terry Denery, PhD
The MathWorks

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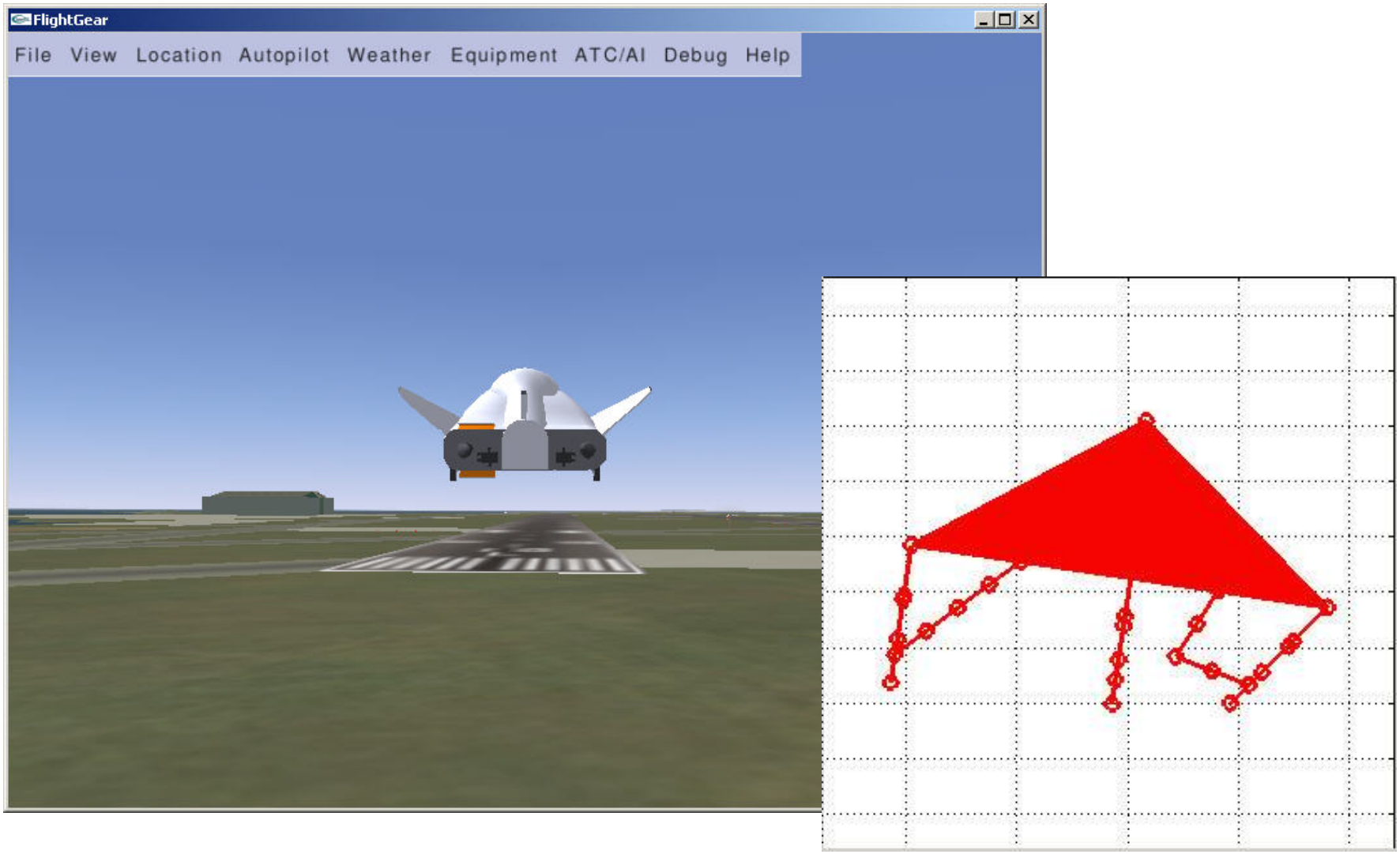
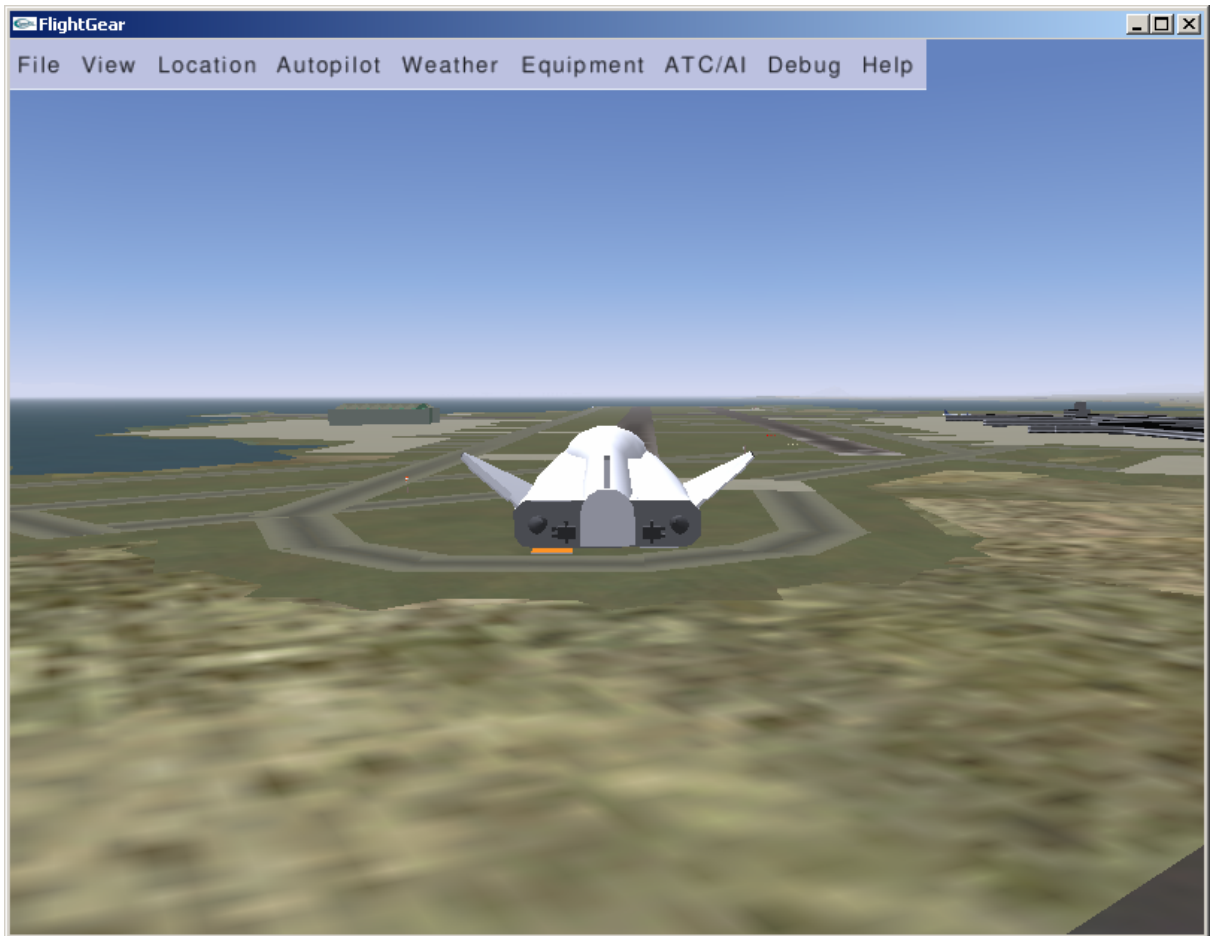

FlightGear
File View Location Autopilot Weather Equipment ATC/AI Debug Help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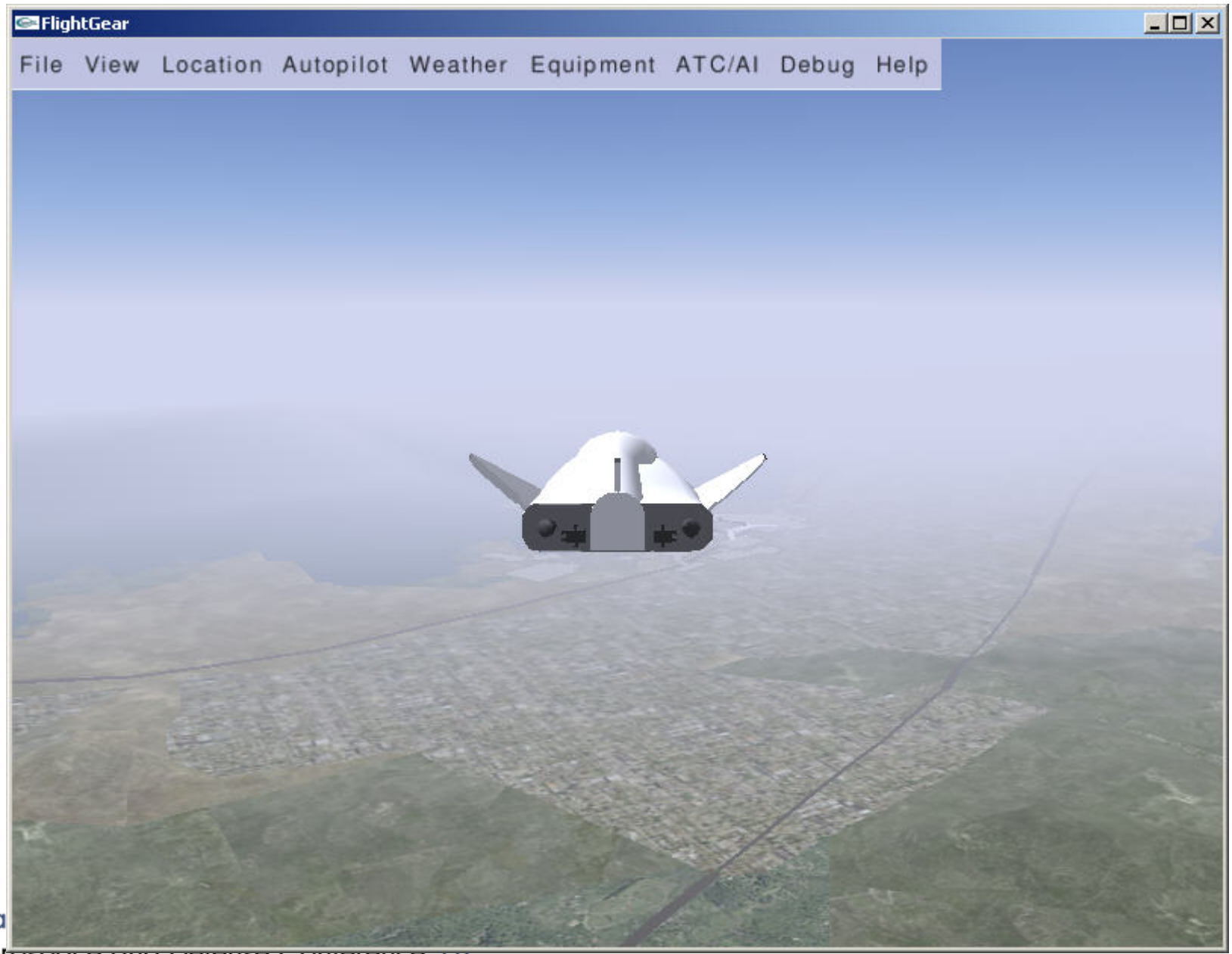
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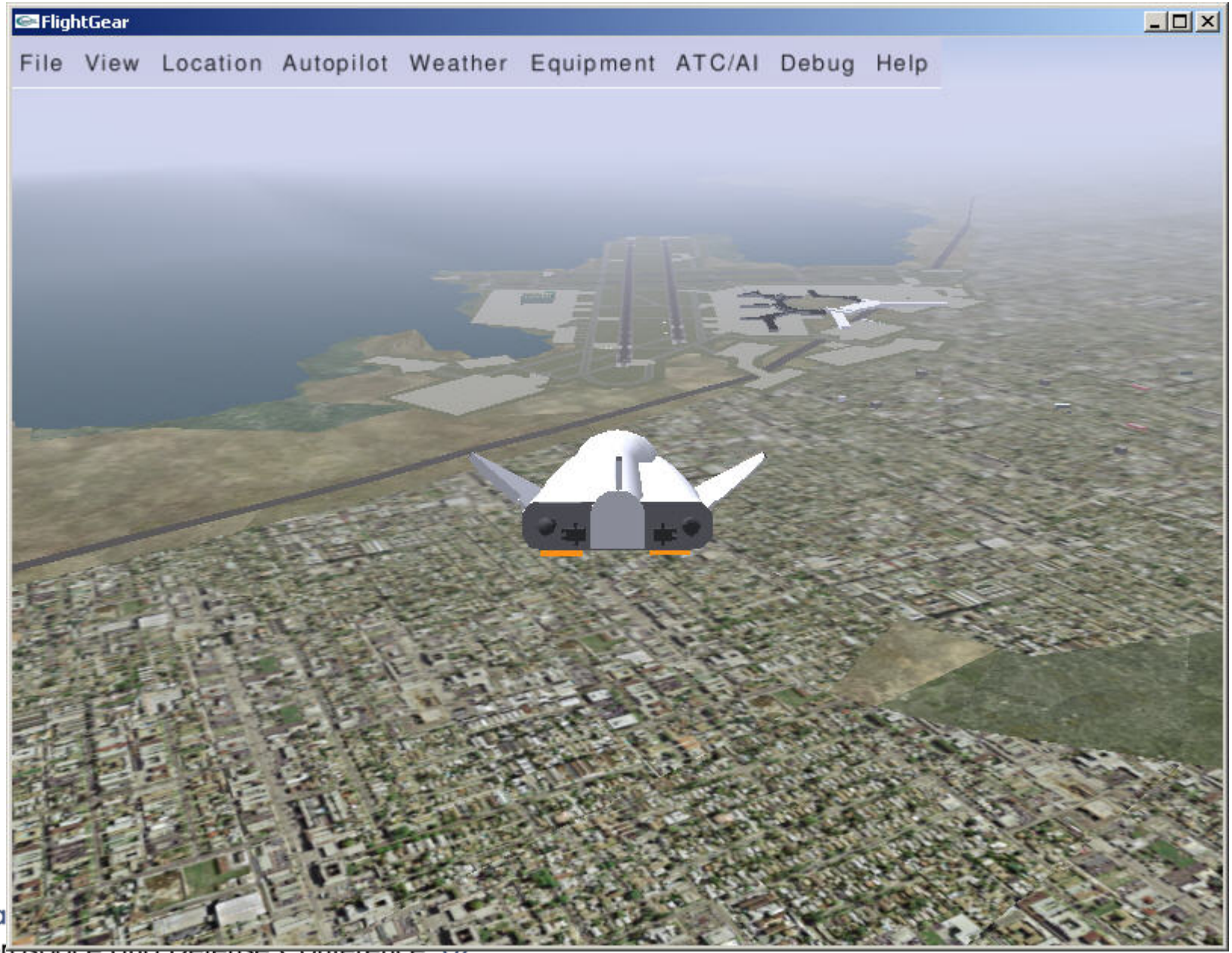
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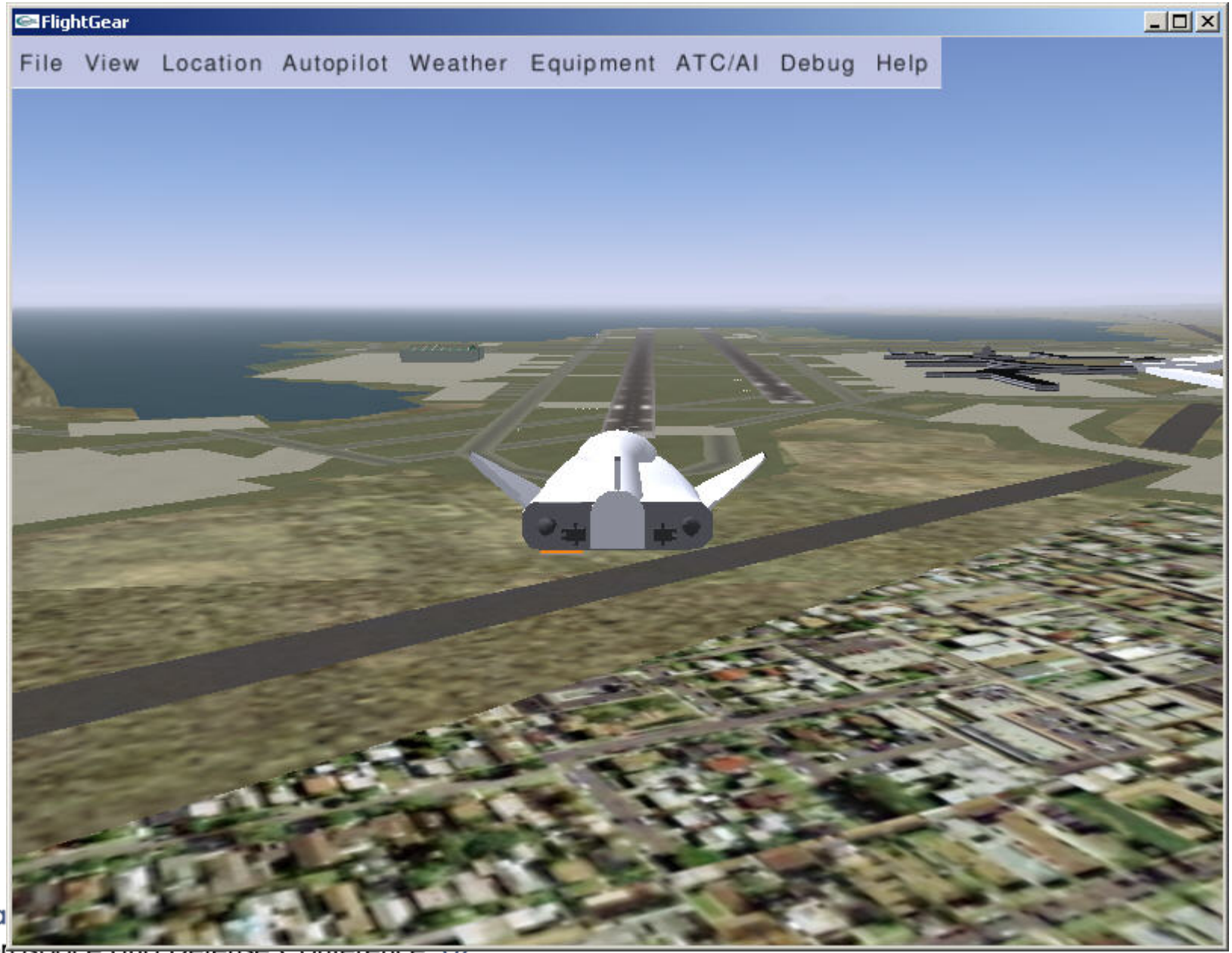
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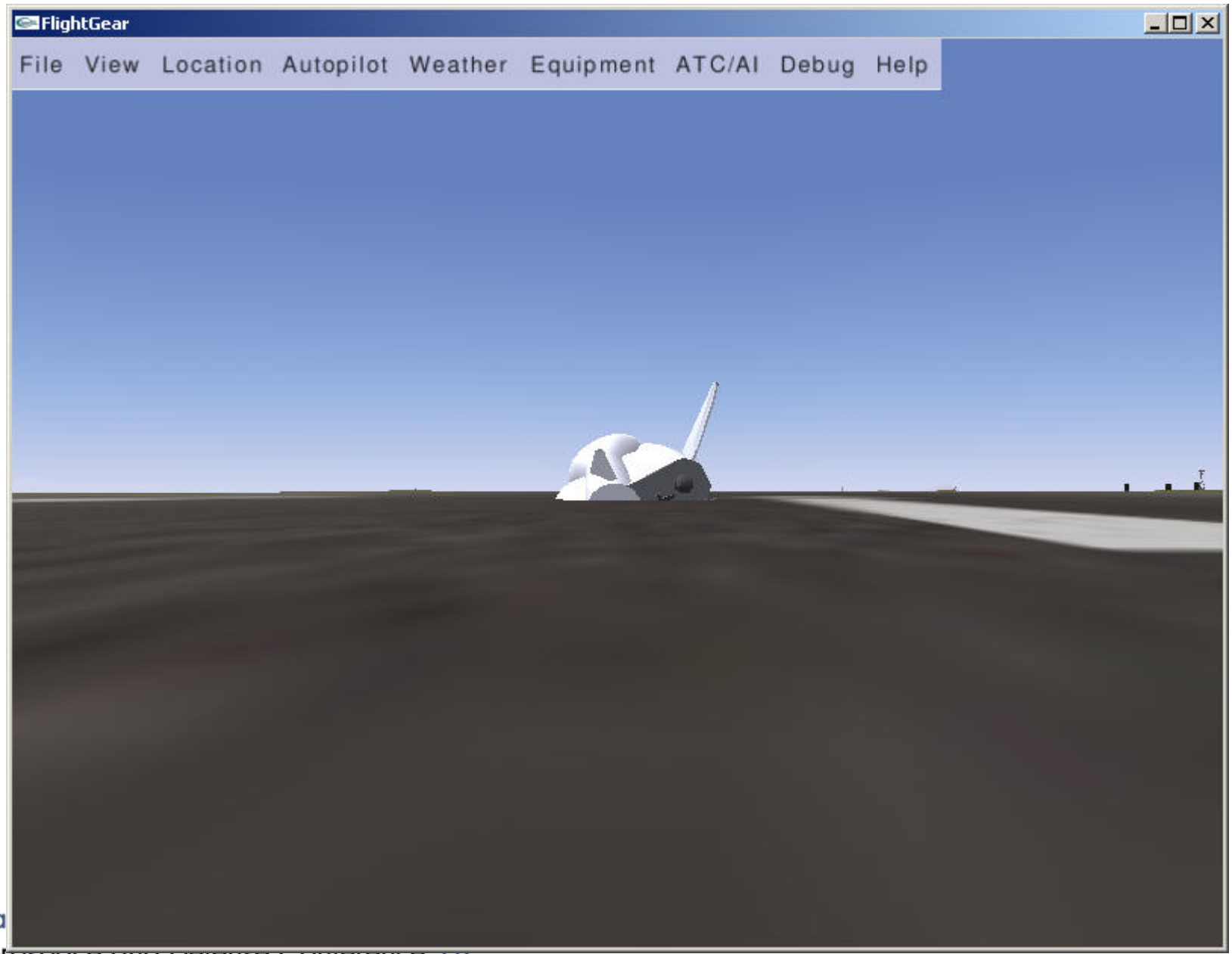
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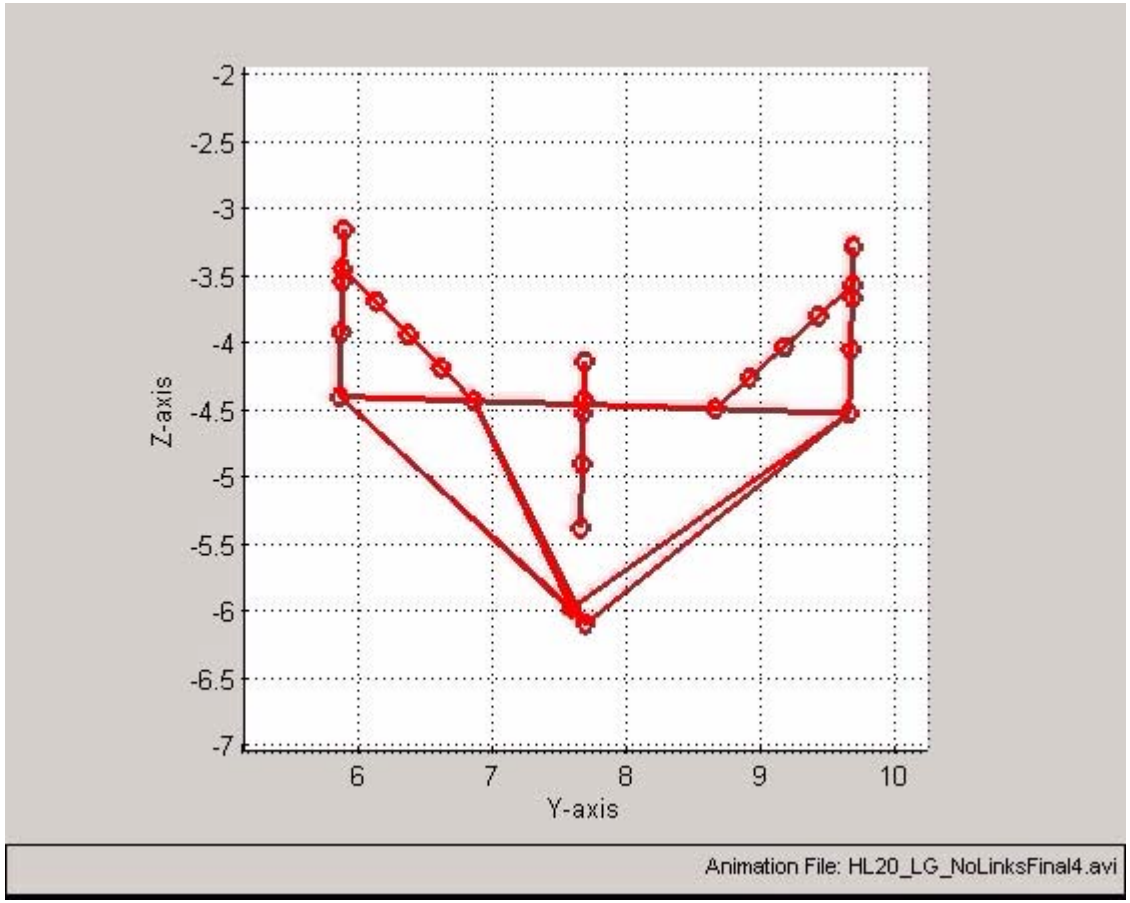
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-2.5
-3
-3.5
-4
-4.5
-5
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-6
-6.5
-7
Z-axis
6
7
8
9
10
Y-axis
Animation File: HL20_LG_NoLinksFinal4.avi

Agenda

- Linkage motion in accelerating vehicles
- Adaptation to workflows and adoption of standards
- Demonstration
  - Flight simulation for landing gear design
  - Flight simulation for satellite design

Linkage Motion in Accelerating Vehicles

Inertial (Non-Accelerating) Reference Frames

$$\vec{\mathbf{F}} = m\vec{\mathbf{a}}$$

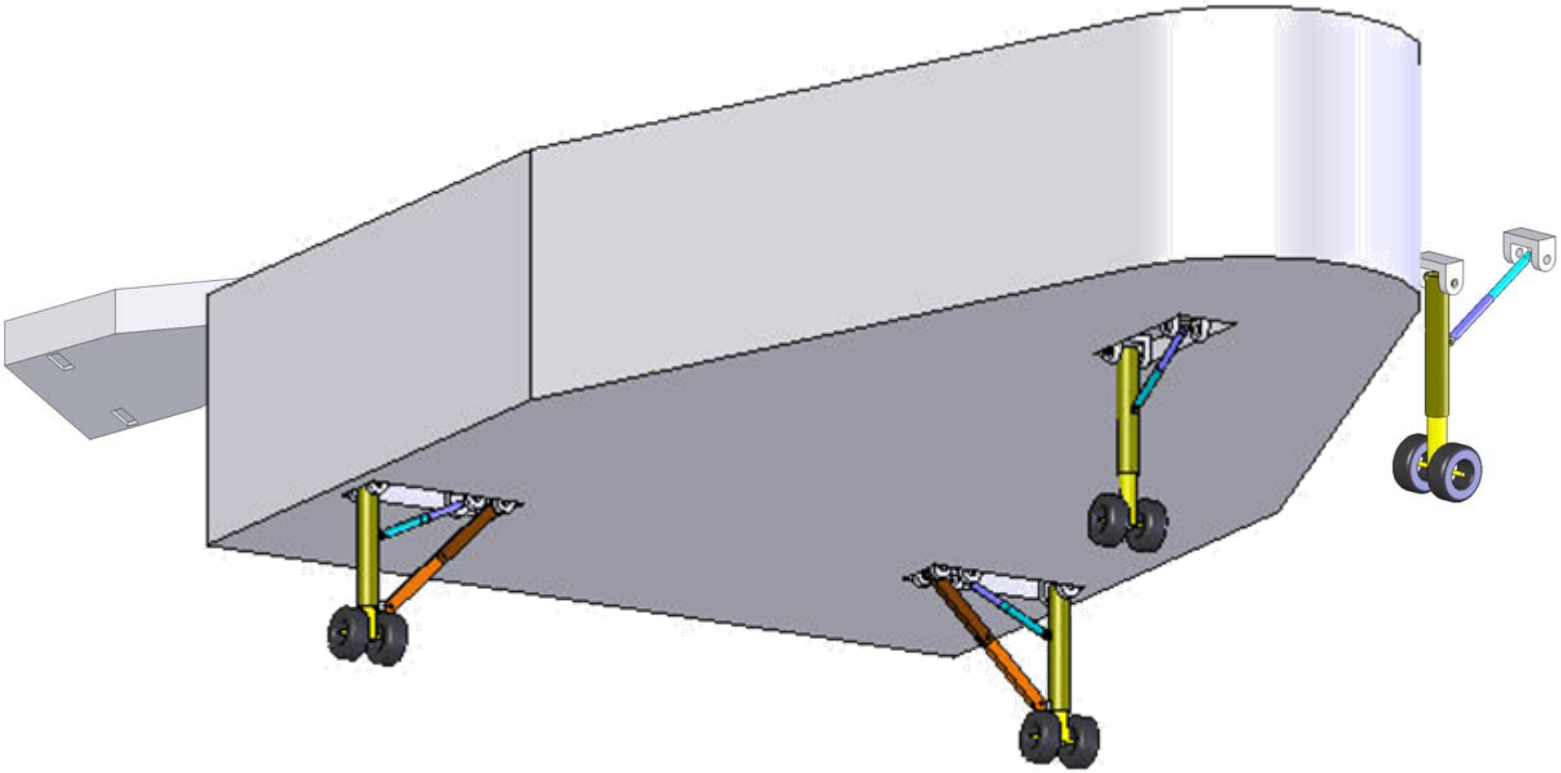
Not An Option!

Non-Inertial (Accelerating) Reference Frames

$$\vec{\mathbf{F}} \neq m\vec{\mathbf{a}}$$

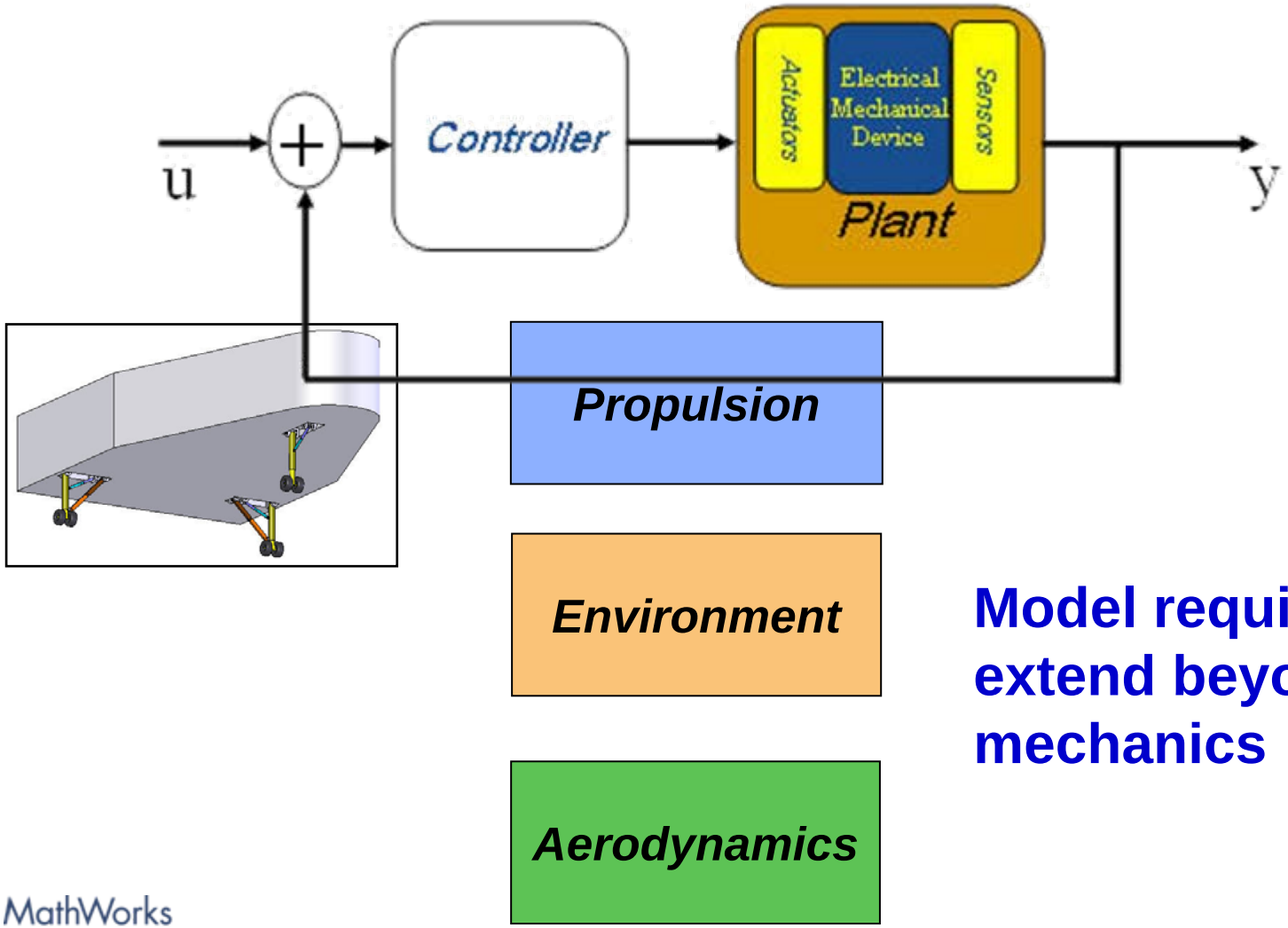
Very Difficult!

Linkage Motion in Accelerating Vehicles



Model the Entire System

Linkage Motion in Accelerating Vehicles

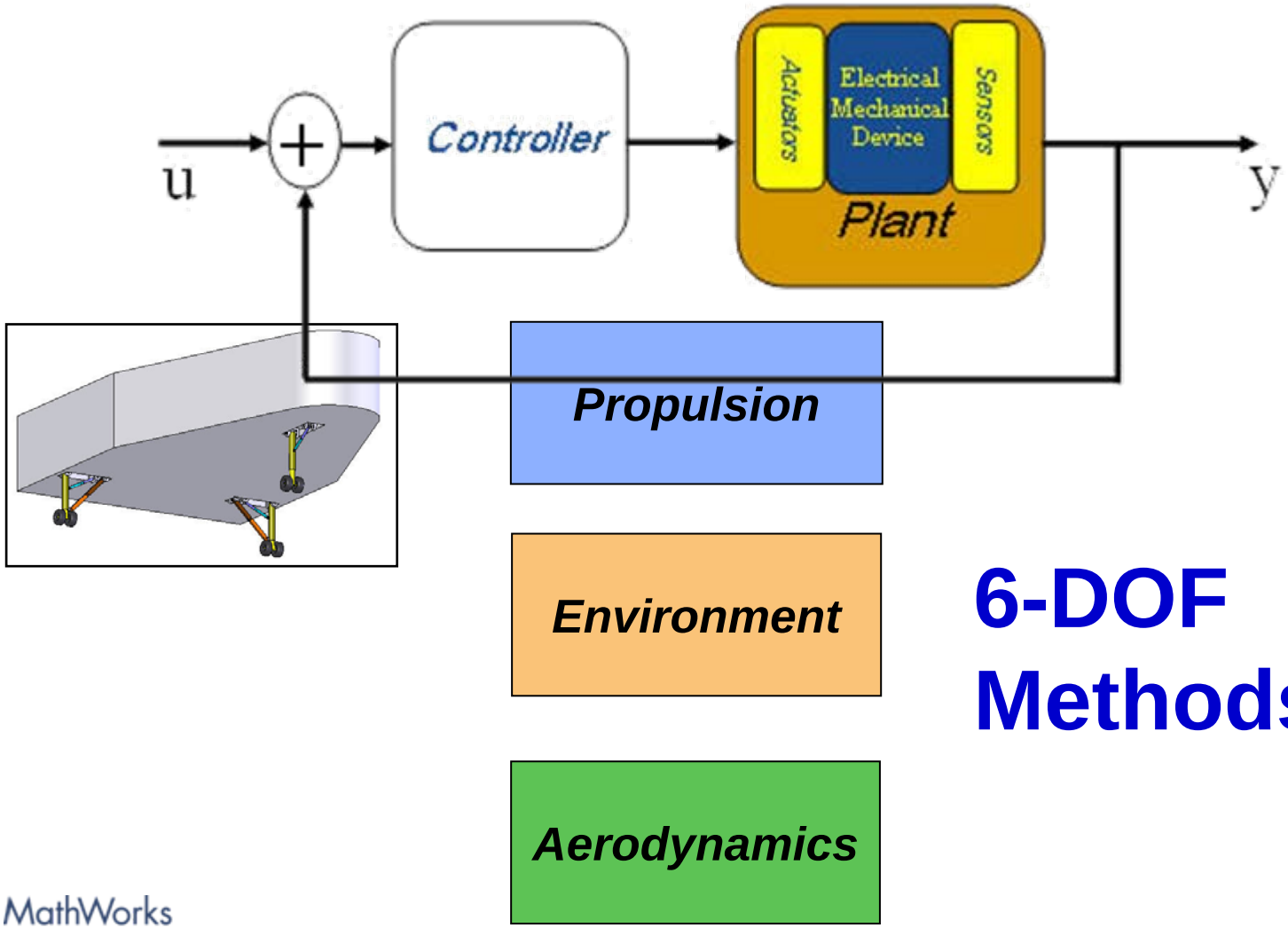


Model requirements extend beyond mechanics

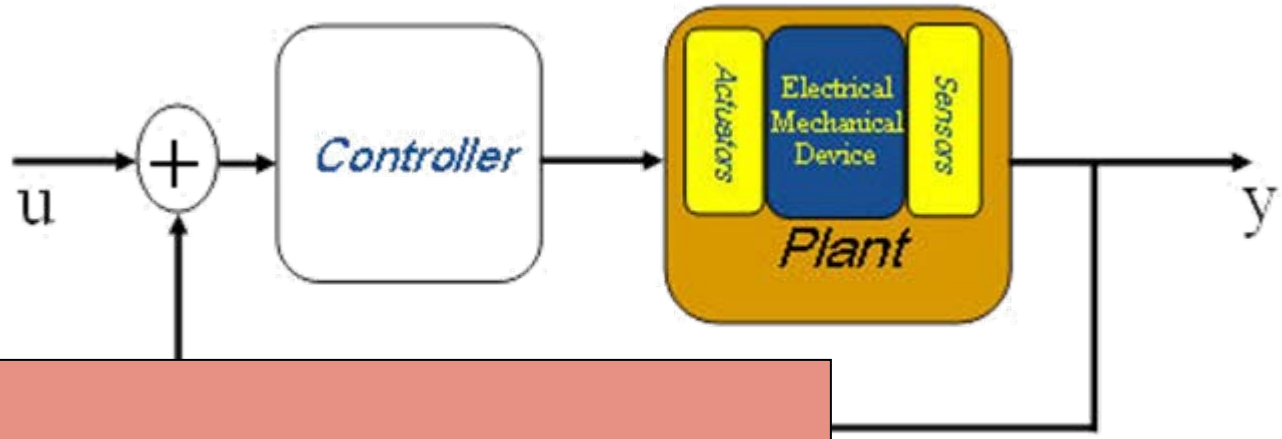
Adaptation and Adoption

- ***Adaptation***
  - 6DOF methods to include Multi-body
  - Adapting to Cross-Domain Collaboration
- ***Adoption***
  - Standards for Describing Position and Orientation

Adapting 6-DOF to Multi-Body Methods



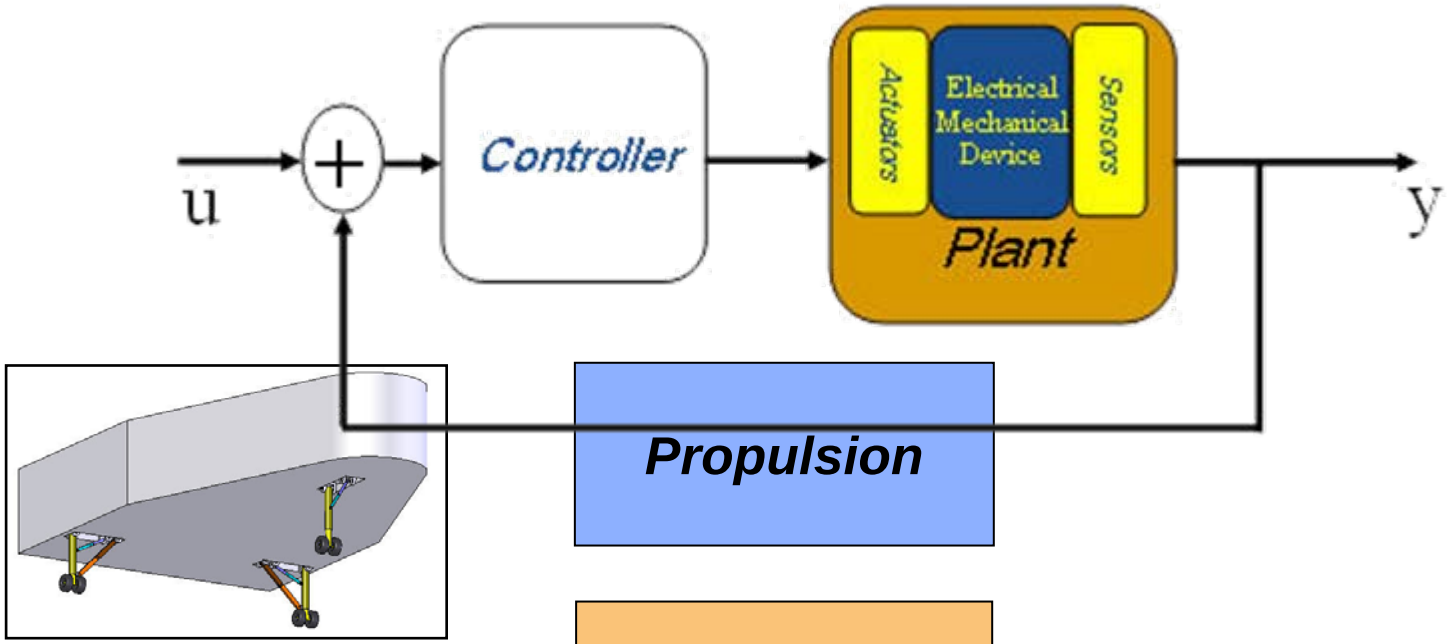
Adapting 6-DOF to Multi-Body Methods



Aerospace Blockset

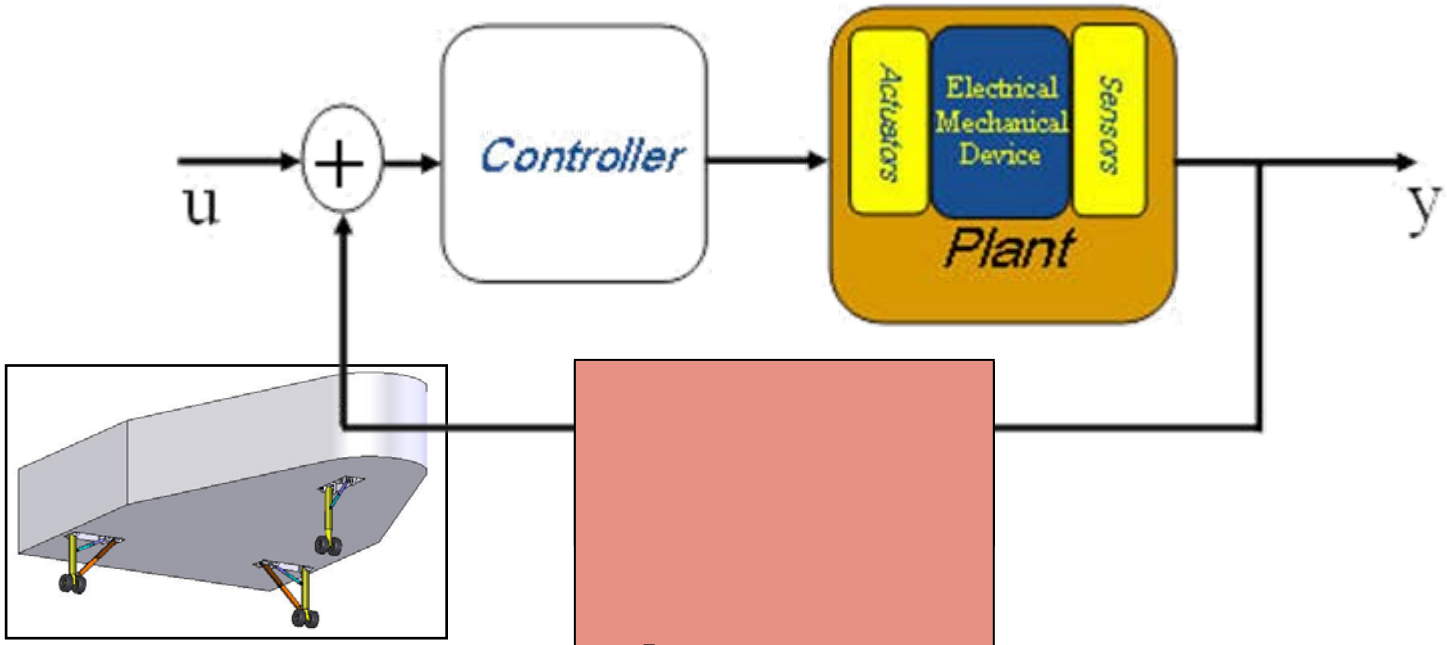
6-DOF Methods

Adapting 6DOF to Multi-Body Methods



Multi-Body Methods

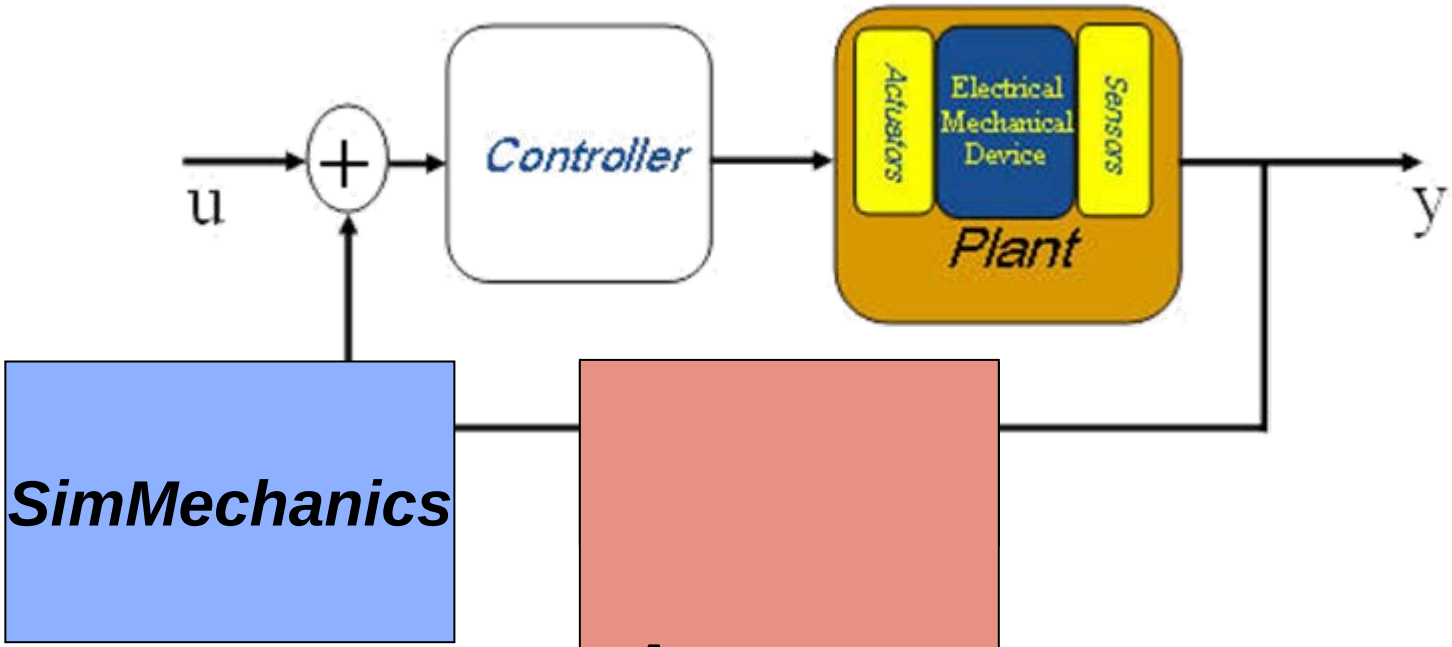
Adapting 6DOF to Multi-Body Methods



Multi-Body Methods

Aerospace Blockset

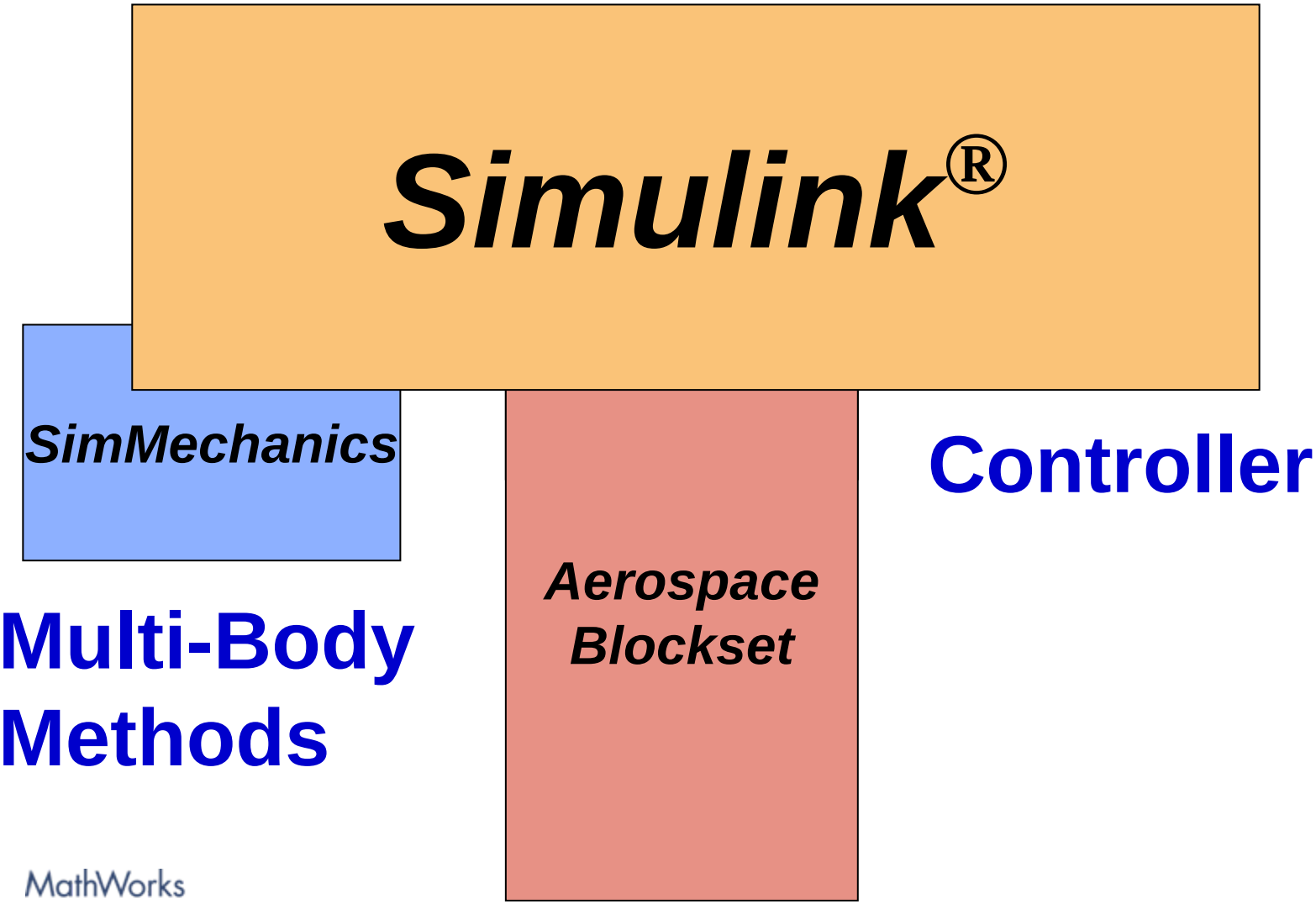
Adapting 6DOF to Multi-Body Methods



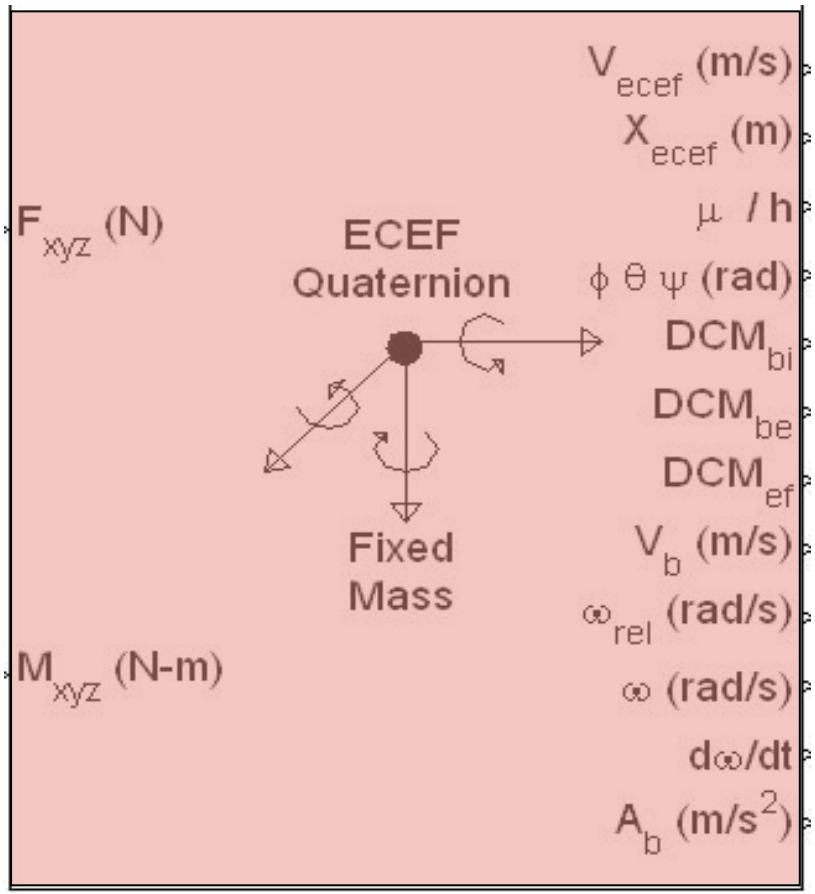
Multi-Body Methods

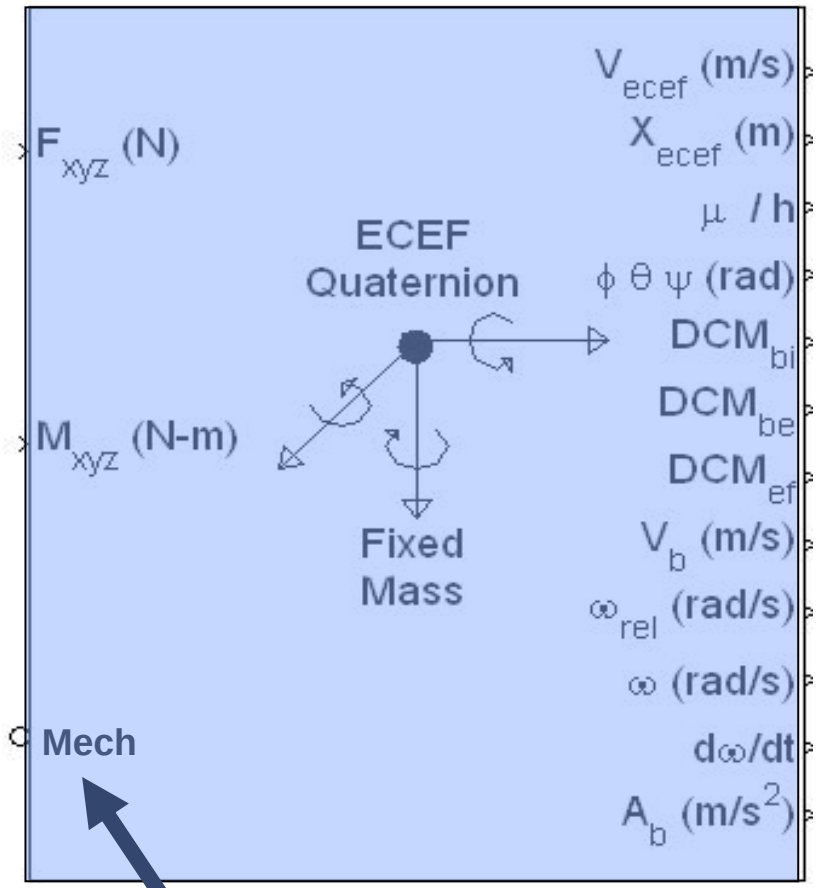
Aerospace Blockset

Adapting 6DOF to Multi-Body Methods



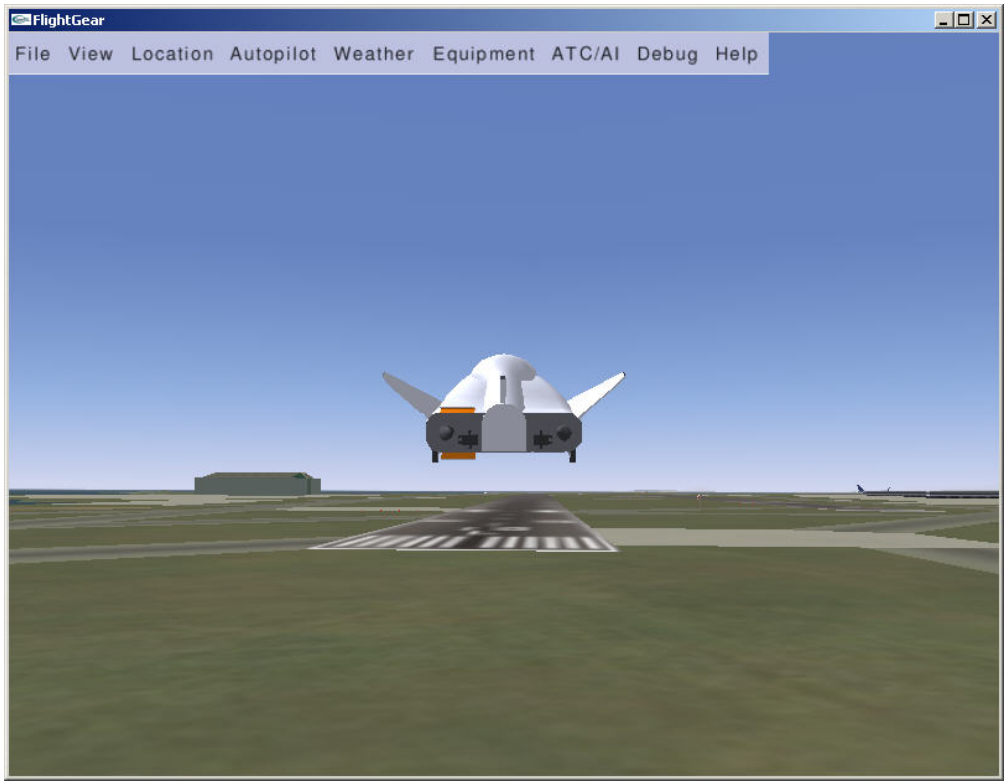
Adopting Standards for Reporting Position

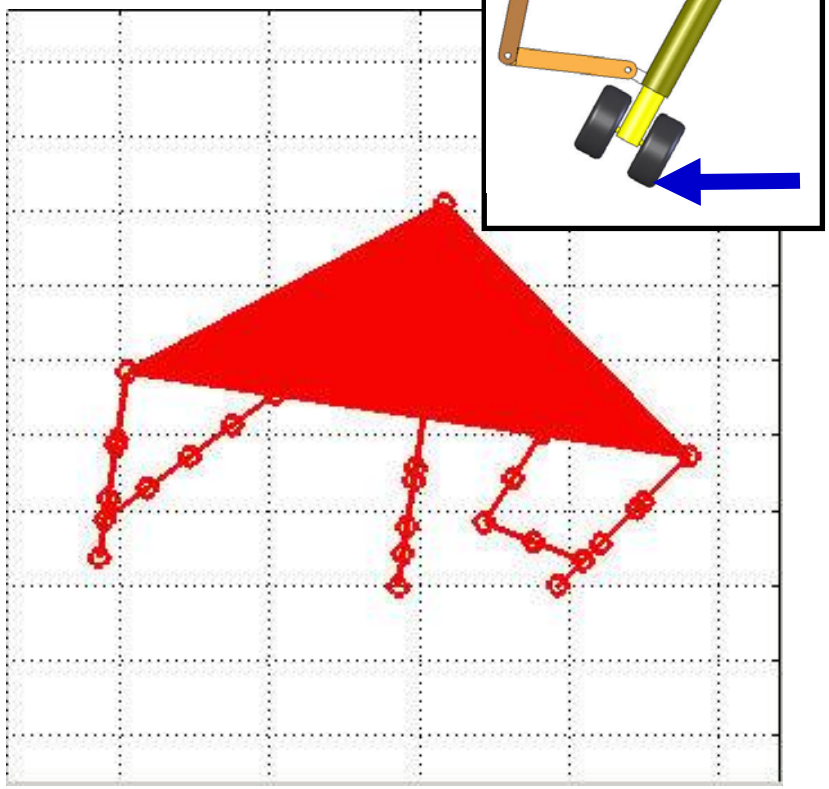




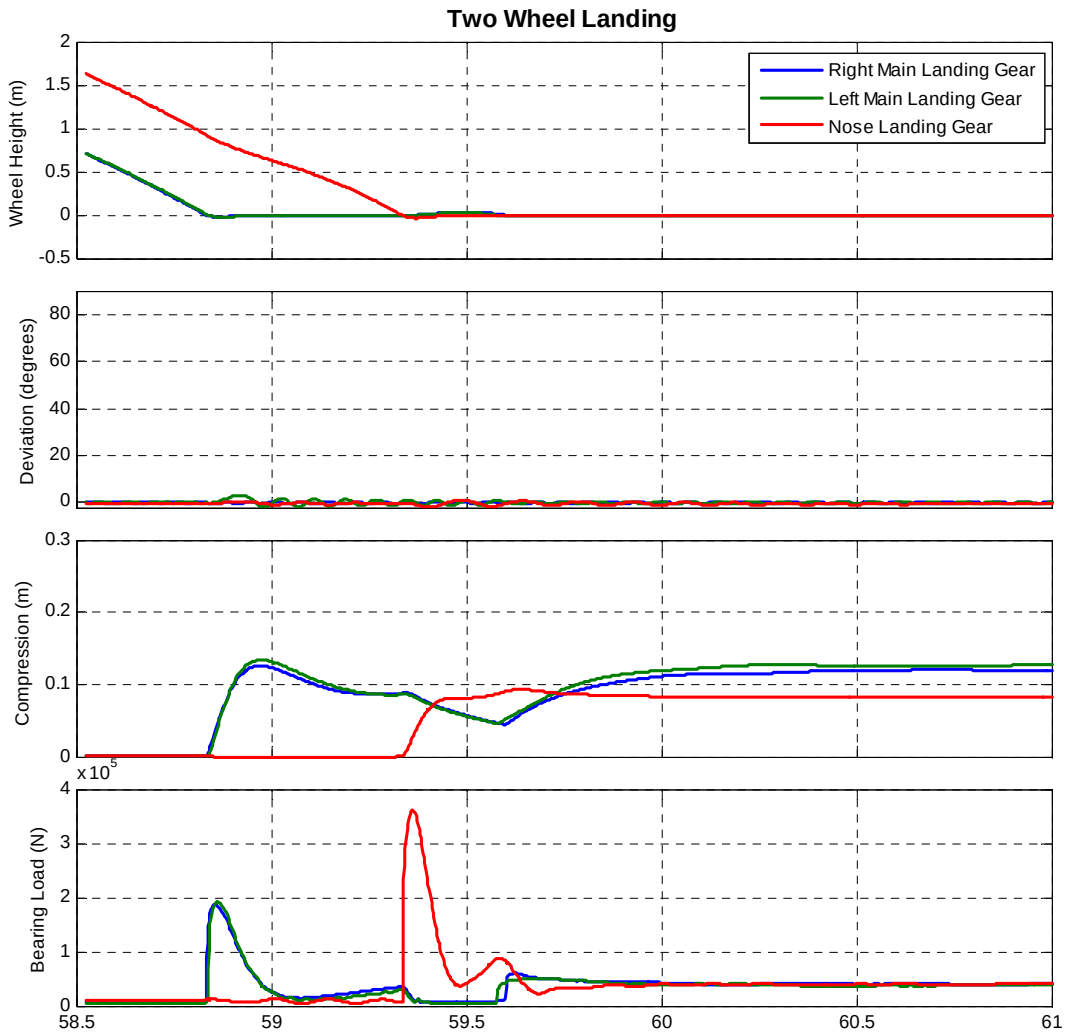
SimMechanics Connector

Demonstration – Flight Simulation for Designing Landing Gear

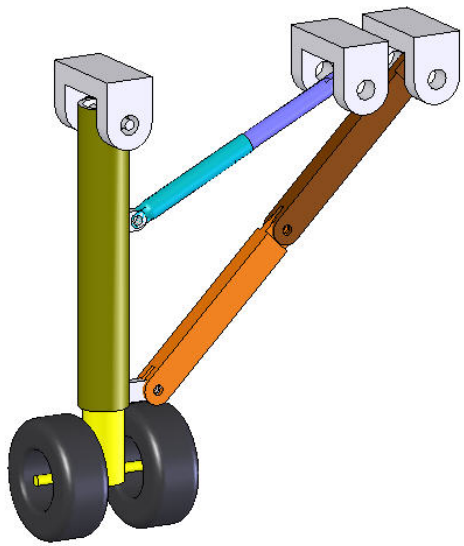




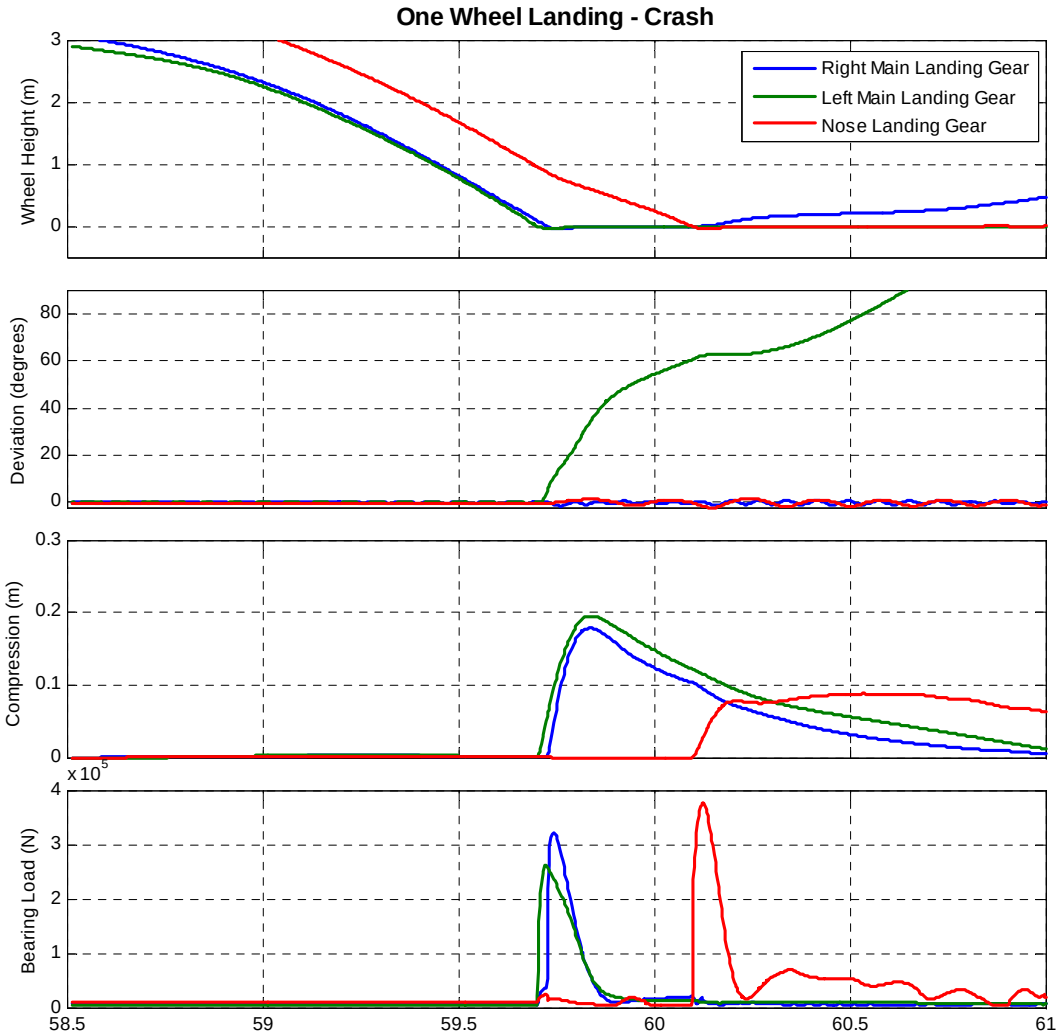
Demonstration – Landing Gear



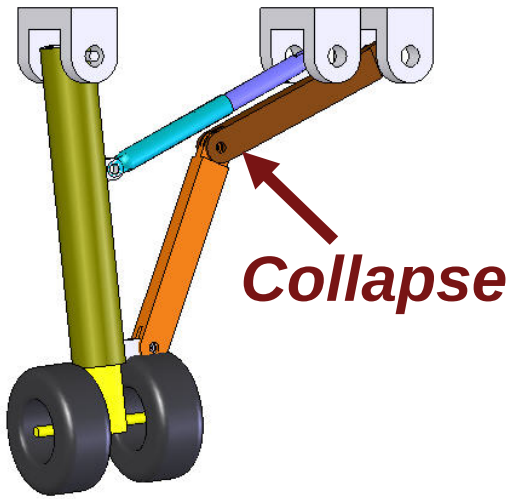
Two-Wheel Successful Landing



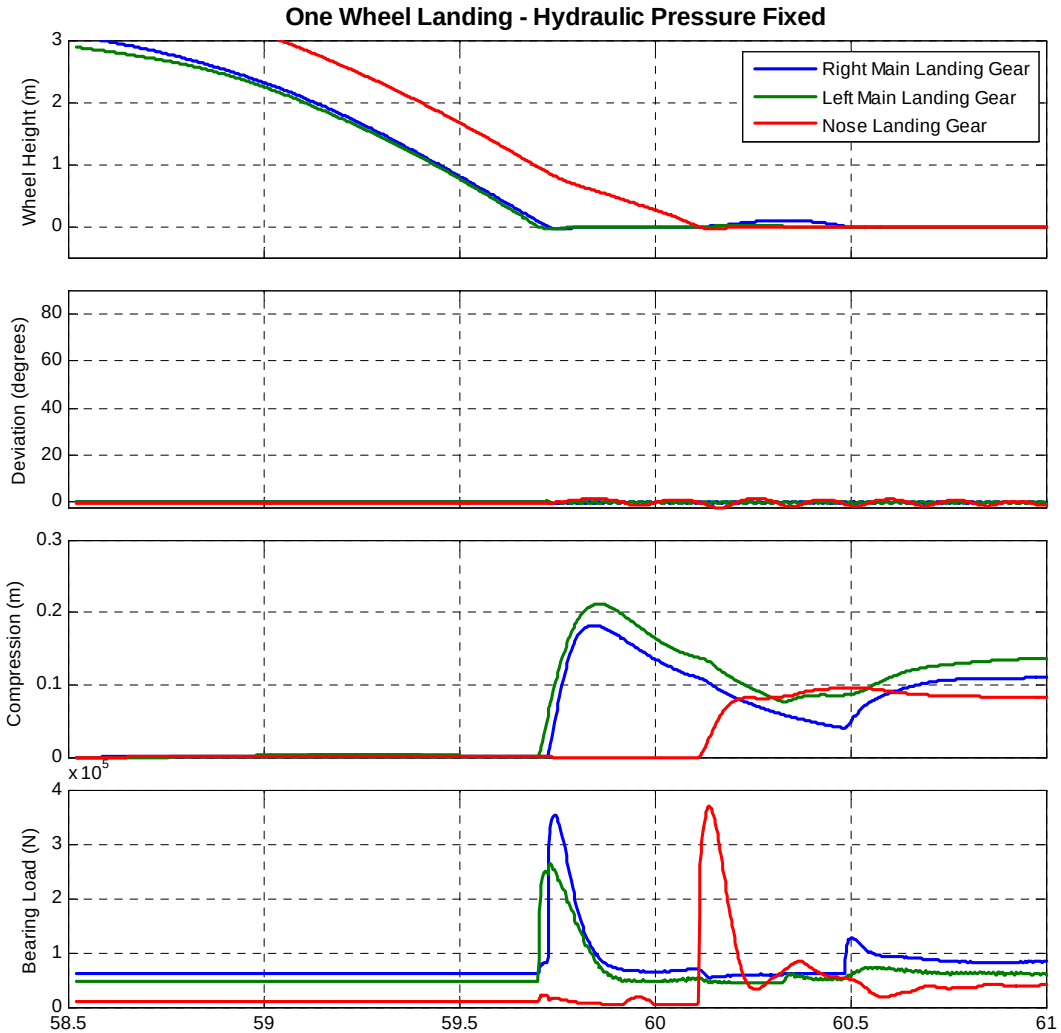
Demonstration – Landing Gear



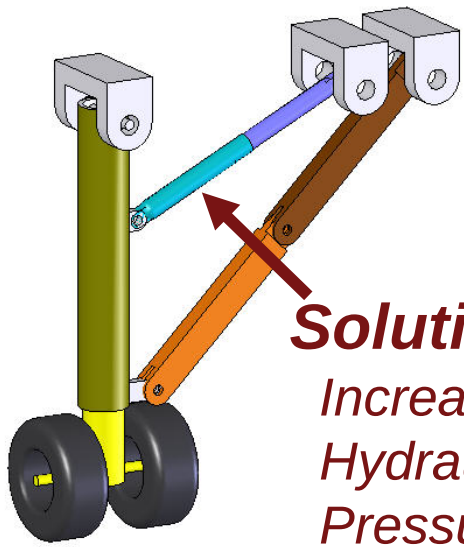
One-Wheel Failed Landing



Demonstration – Landing Gear



One-Wheel Successful Landing

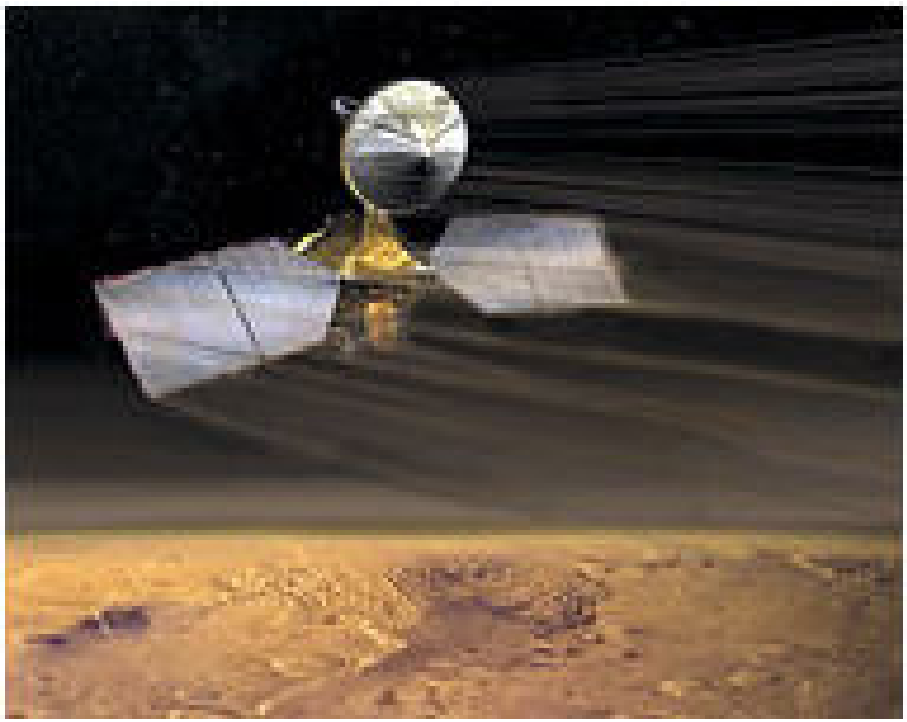


Solution:
Increase Hydraulic Pressure

Demonstration – Landing Gear

- Employed 6-DOF based on SimMechanics
- Developed contact model for wheel-ground interaction
- Identified method for linkage design in air vehicles

Demonstration – Flight Simulation of Satellite



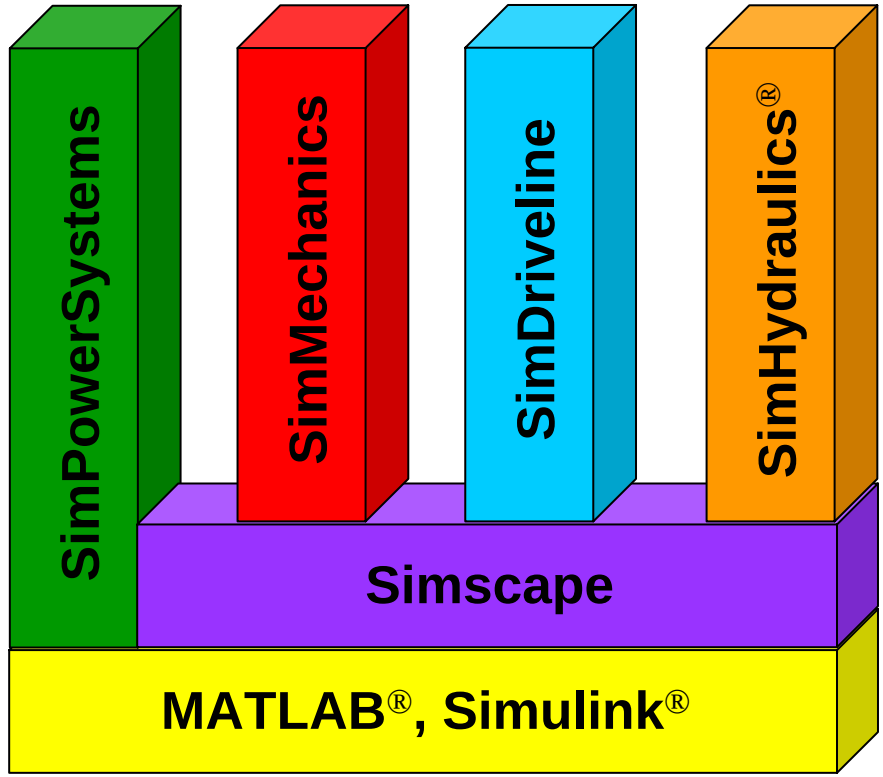
- Maximize power through solar array position
- Point camera at targets

Demonstration – Flight Simulation of Satellite

- Developed pointing system
- Developed motion model for orbital mechanics
- Identified general method for linkage control design in space vehicles

What Next?

- Design Hydraulic Actuation for Landing Gear
- Design Electric Actuation for Satellite
- Design Reaction Wheel Actuation for Satellite



Complete solution enabled for mechanics, power transmission, and actuation

In summary

- Developed flight simulations
  - Landing gear design
  - Satellite design
- Simulink enables the adaptation and adoption to create collaborative workflow
- Established general solution for motion systems in air and space vehicles