MSC.ADAMS Applications to Space Equipment

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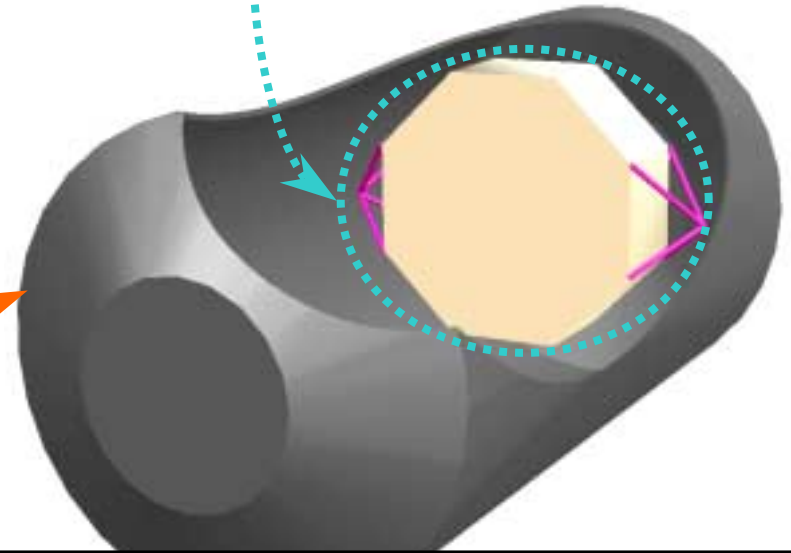
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Centrifuge (Life Science Experiment Module)

CR: Centrifuge Rotor

CAM: Centrifuge Accommodations Module

ISS: International Space Station

- Newly developing space machinery equipped in ISS in cooperation with NASDA (NT Space/Toshiba) and NASA

- Life cycle experiment on orbit to investigate the effect of gravity on rodent and plant
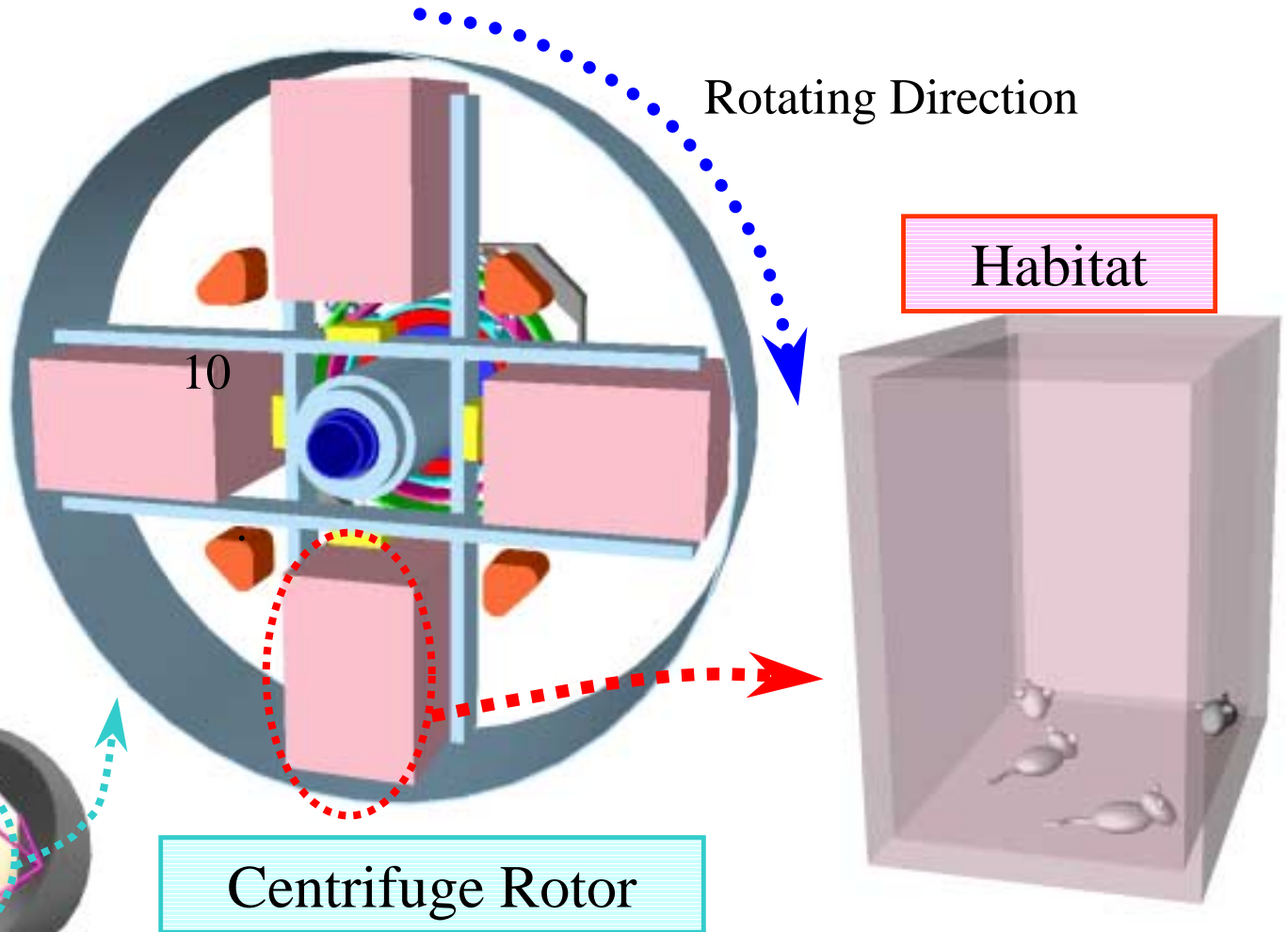
Centrifuge Rotor (Artificial Gravity Generator)

Rotor Mass
1500kg

Rotating Diameter
2.5 m

Operating Period
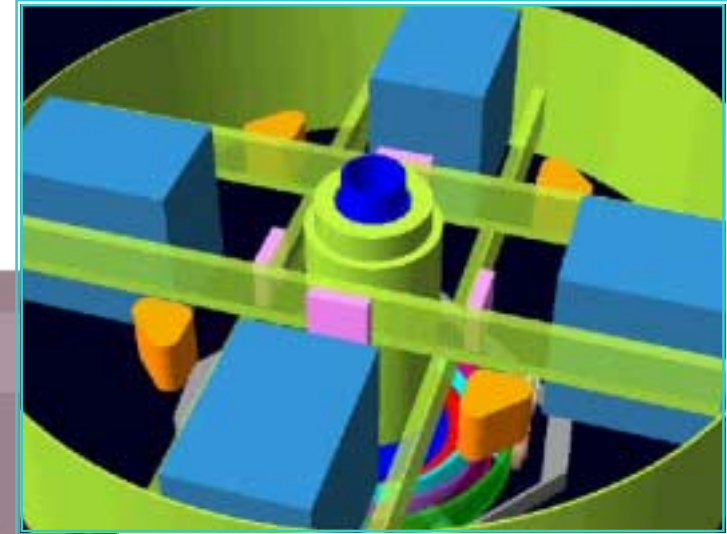years

Rotating Speed:
Max. 42 rpm
(2.2 g equivalent)

Rotating Direction

Habitat

10

Centrifuge Rotor

CR rotates habitats at selected gravity for scientist to
compare how differing gravity level affect the biology
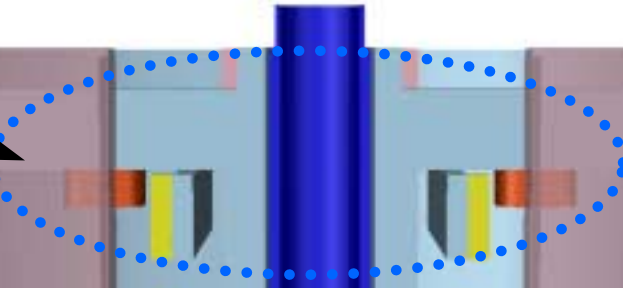
Technical Issues

To isolate vibration between CR and ISS

Cancel the imbalance in rotor
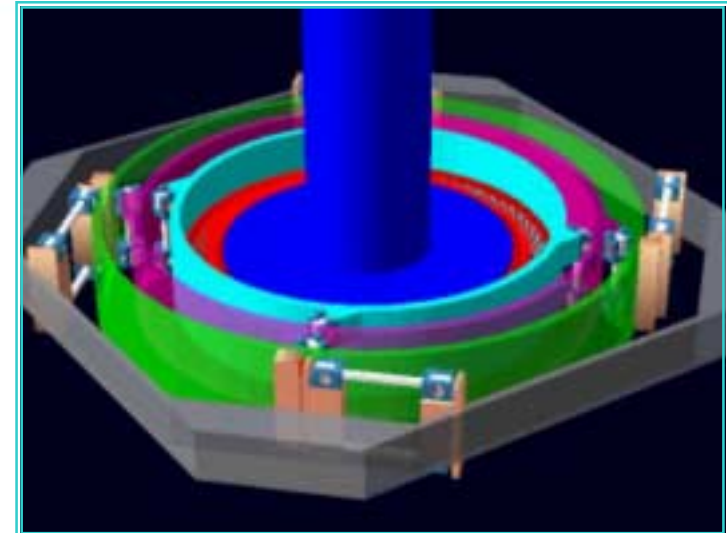
ABS: Auto-Balancing System

ISS Movement

Rotor-Induced Vibration

Suppress vibration

VIM: Vibration Isolation Mechanism

Requirements for ADAMS Simulation

Simulation technology is indispensable for Space Equipment Design, because we can't verify its performance in space by ground test.

Simulate vibration isolation mechanism (spring, damper)

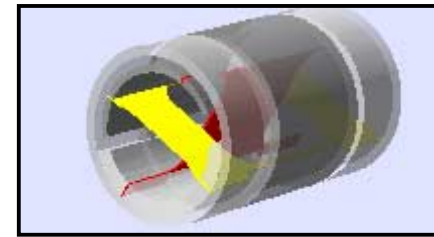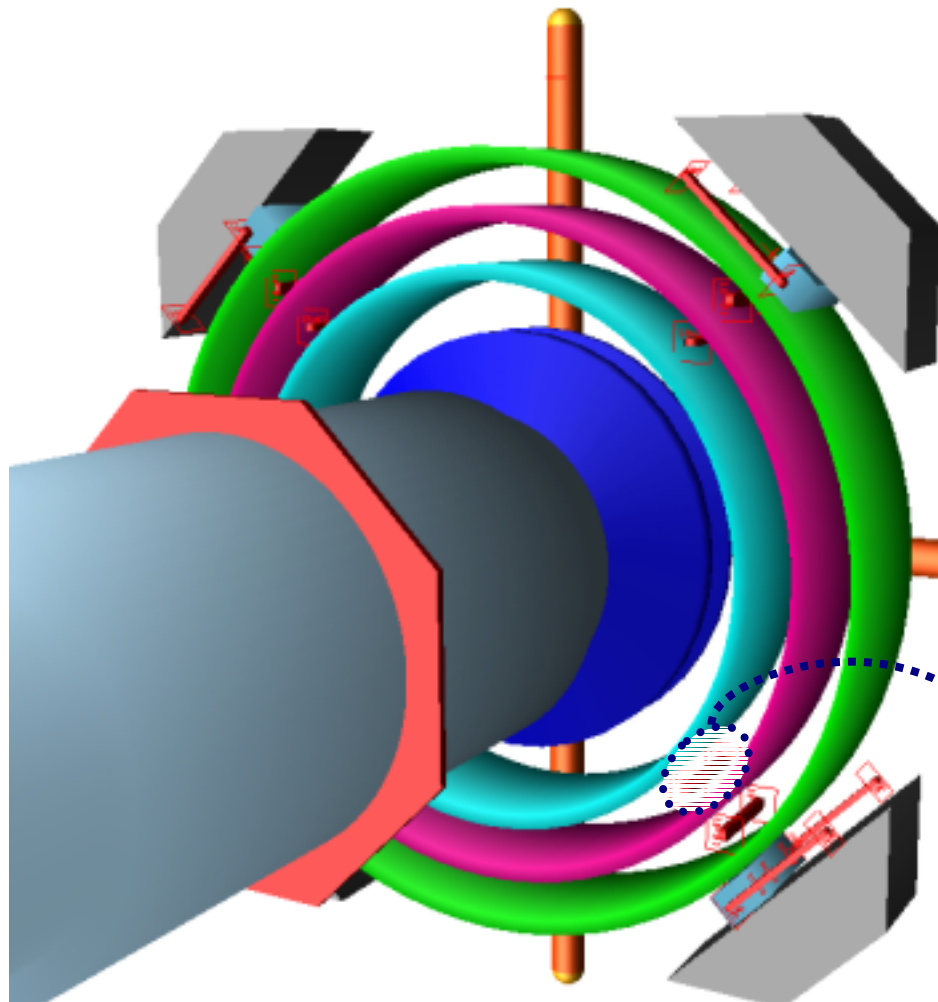Simulate accidental events

Response for external force

Simulate gyro-moment effect by orbital movement

Visualizations of complex mechanisms and their movement

Simulate characteristics of actuators

Modeling of Vibration Isolation Mechanism

Simplification of complex structure by FEM/Experiment
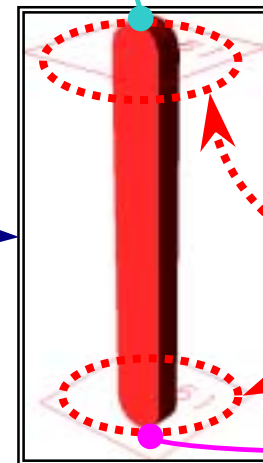

Free-Flex Pivot
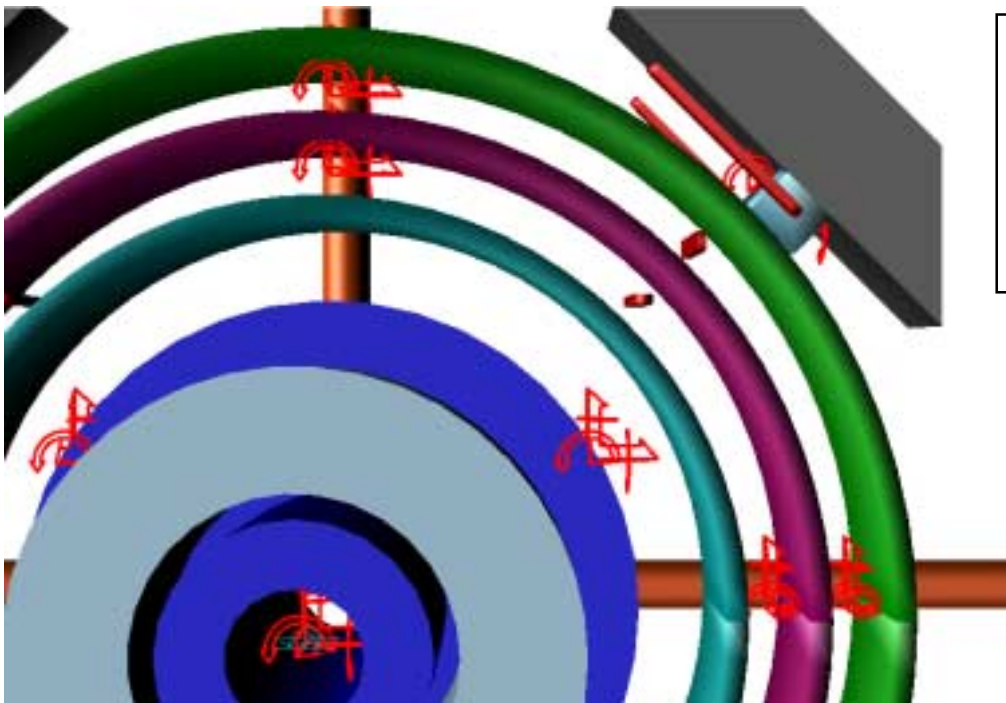
Pivot Link

FEM/Experiment

Ring1

Rigidity Matrix

Ring2

Modeling for ADAMS Simulation

Modeling of Actuator and Passive Damper

Modeling Actuator and Passive Damper by General Force

➢ Actuator: Definition based on simulating controller

➢ Passive Damper: Define frequency domain characteristics by Transfer Function and Linear State Equation
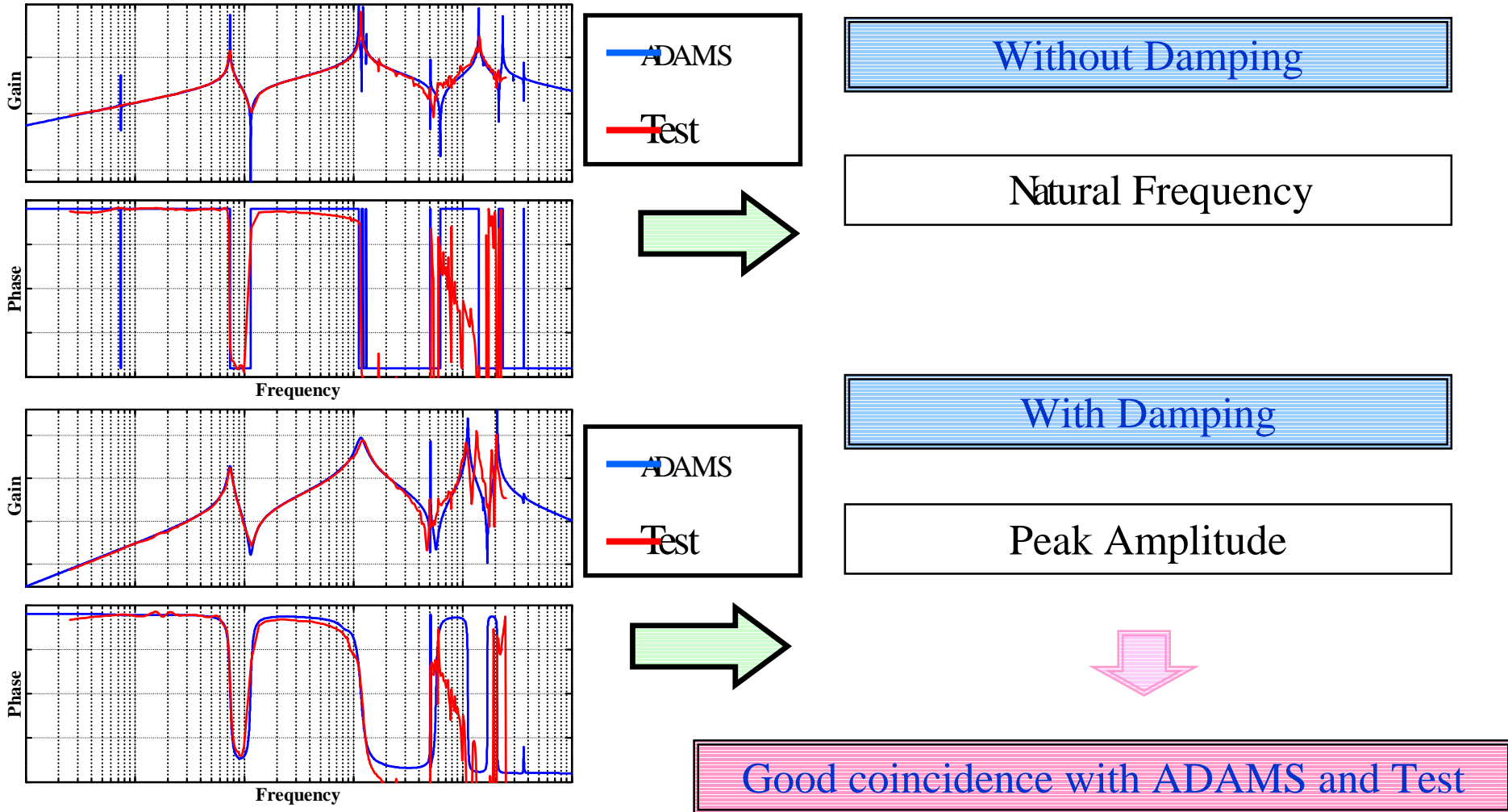
Define control by ADAMS

1. By System Element
2. By Standard Control Blocks
3. By User Subroutines

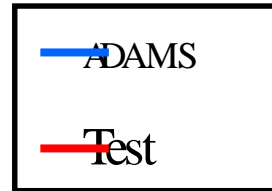Neither satisfactory

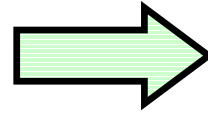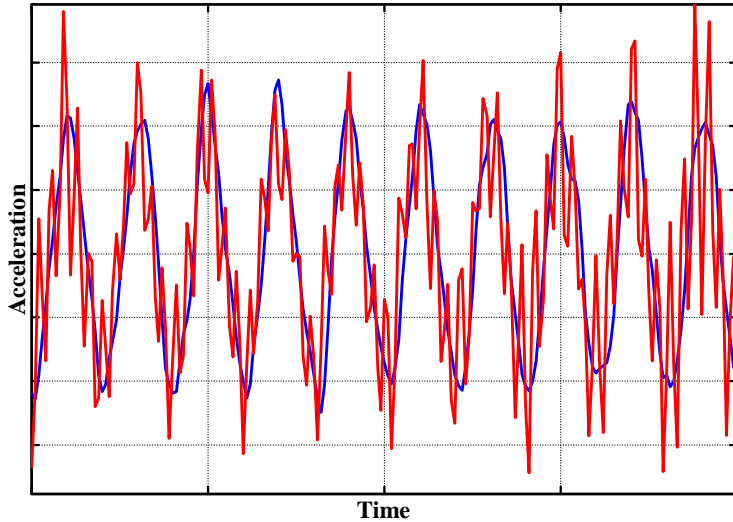ADAMS/Controls!!

Verification of ADAMS Model
(Frequency Domain)

➢Verification by comparing ADAMS simulation results and ground test results

Without Damping

Natural Frequency

With Damping

Peak Amplitude
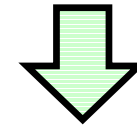
Good coincidence with ADAMS and Test

Verification of ADAMS Model
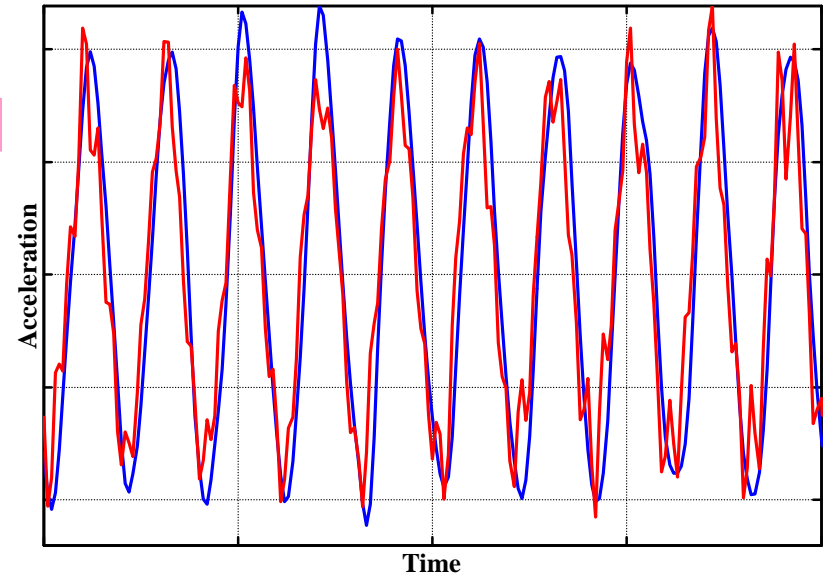## (Time History)

Raw Test Data

ADAMS

Test

Neglect local mode frequency
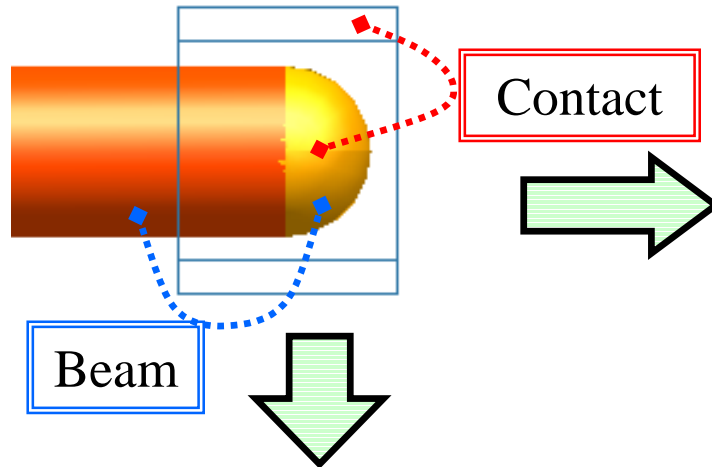by low-pass filtering

Filtered Test Data

ADAMS can simulate Test Data.

The ground test equipment is more
complex than the space equipment, because
it has a special device to compensate the
gravity effect. This means that the
simulation on ground condition would
rather be difficult than in space condition.

Contact Simulation of Stopper

➢ Contact simulation of stopper

➢ Contact point on divided elastic link → Simulation accuracy problem

Contact

Beam

How to simulate beam dynamics

Apply ADAMS/Flex ?

➢ Better simulation accuracy

➢ Equivalent simulation time ?

➢ Less quality of animation

- Determination of contact parameters

- Convergence of solutions

- From Impact Function to Contact Definition

  ➢Reduction of simulation time

  ➢Difficulty of signal processing

  ➢Less intuitive understandable animation

Further functional enhancement is needed.

Effects of Flexibility on CR Dynamics

➤ Weight saving is an important issue for Space Equipment Design, however it causes low rigidity of structures.

Treat structural members as elastic bodies
by ADAMS/Flex
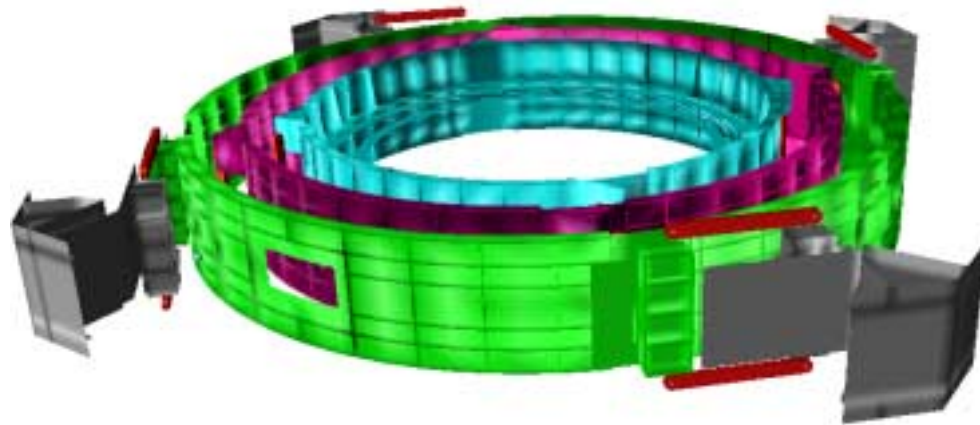
- Structural simulation by ADAMS/Flex = Experience of structural simulation + Understanding of CR structures itself

- Good accuracy for frequency domain simulation (Better than structural simulation only)

➡ Evaluation by time history simulation

Conclusions

➢ ADAMS could simulate the complex CR dynamic behavior.

➢ ADAMS was appraised as a strong tool for CR development.

➢ ADAMS animation enabled us to understand a mechanism of the newly developing complex machinery.

➢ ADAMS could deal with structure and control in a same framework.

Future Works

➢ Development of integrated CR/CAM/ISS models by ADAMS

➢ Timer history analysis of elastic rotor by ADAMS/Flex

➢ Integrated simulation with structure and control by ADAMS/Controls