TAMU-AERO/STC/APL Micro Mechanism Development

Plan of Work

Summer 2003

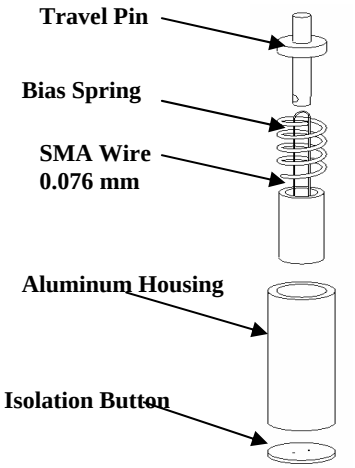
Introduction:

- Participants-
  - Texas A&M University
    - Active Materials Laboratory
    - Spacecraft Technology Center
  - Johns Hopkins University
    - Applied Physics Laboratory
- Purpose-
  - To collaborate in an effort to develop and improve Shape Memory Alloy (SMA) based micro satellite actuators.

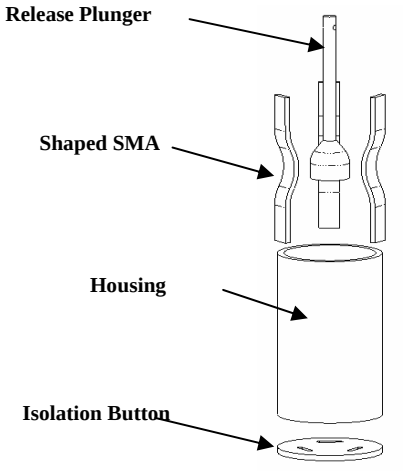
Topics at Hand

- Validate and examine the properties of SMA springs for use in linear and rotational actuators.
- Analyze thermal requirements of SMA actuators in various orbital conditions.
- Characterize SMA materials as needed.
- Explore mechanism improvements in order to meet and exceed APL-established performance goals.

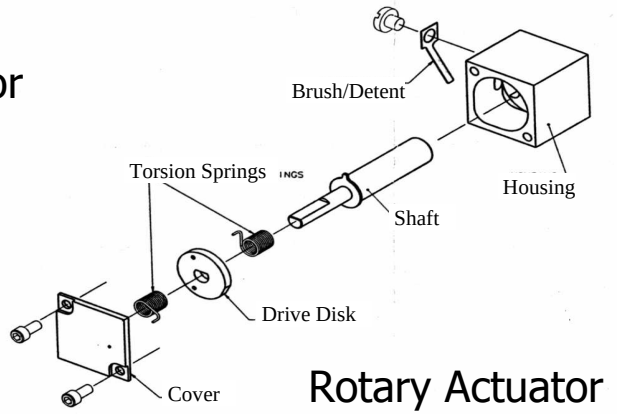
Mechanisms Discussed



Linear Actuator



Redundant Release



Rotary Actuator

Linear/Rotational Spring Actuators

- Linear Actuators-
  - Examine the use of SMA springs in linear actuation by allowing expansion/contraction along spring axis.
  - Attempt to meet the following criteria:
    - Stroke: 0.125”
    - Force: 1-5 lb.
    - Holding Force: 2-10 lb
    - Actuation Time: 10-100 ms
    - Total Actuations: 100-1000 cycles

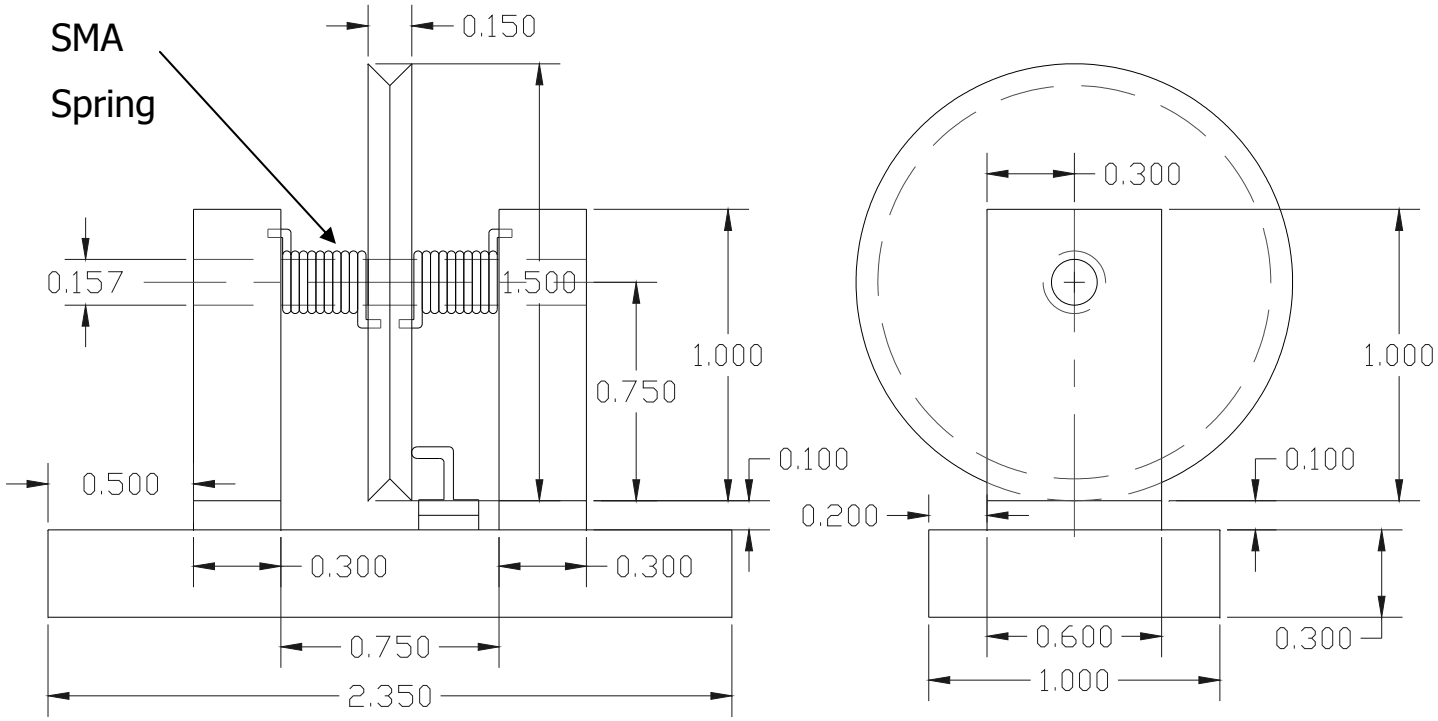
Linear/Rotational Spring Actuators

- Rotary Actuators (1/2)-
  - Validate APL-obtained rotary actuator torque values via direct spring measurement.
    - Test 2X scale spring
    - Extrapolate results to APL-required dimensions
    - Attempt to test spring of APL-required dimensions
    - Compare results
  - Required spring dimensions:
    - Spring Diameter: 0.105” ID
    - Wire Diameter: 0.014”
    - Turns: ~10.5

Linear/Rotational Spring Actuators

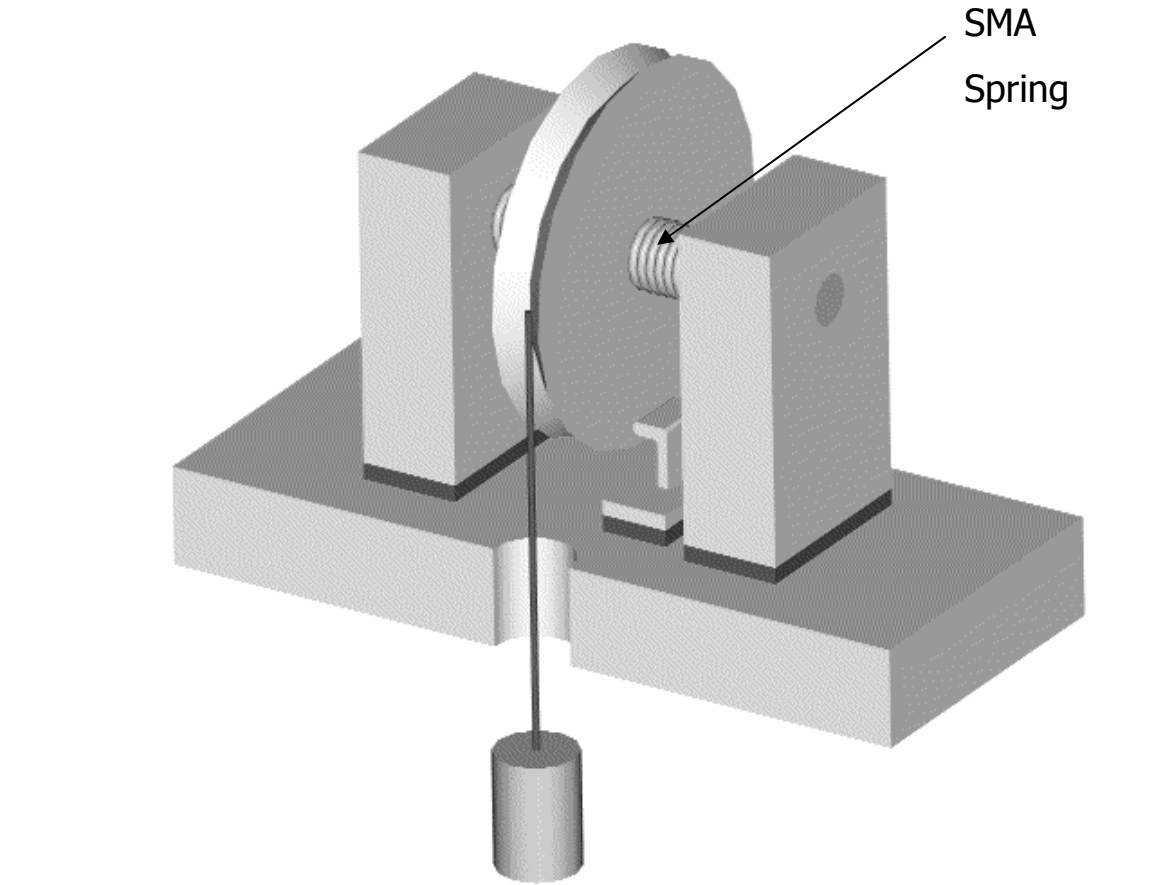
- Rotary Actuators (2/2)-
  - In addition, attempt to meet the following design requirements:
    - Rotation Angle: 0-120 degrees
    - Speed of Rotation: <1 min
    - Detent Torque: 0.1 N-m
    - Lifetime: 1000 cycles

Linear/Rotational Spring Actuators



Spring Torque Testing Fixture

Linear/Rotational Spring Actuators



Spring Torque Testing Fixture

Orbital Thermal Analysis

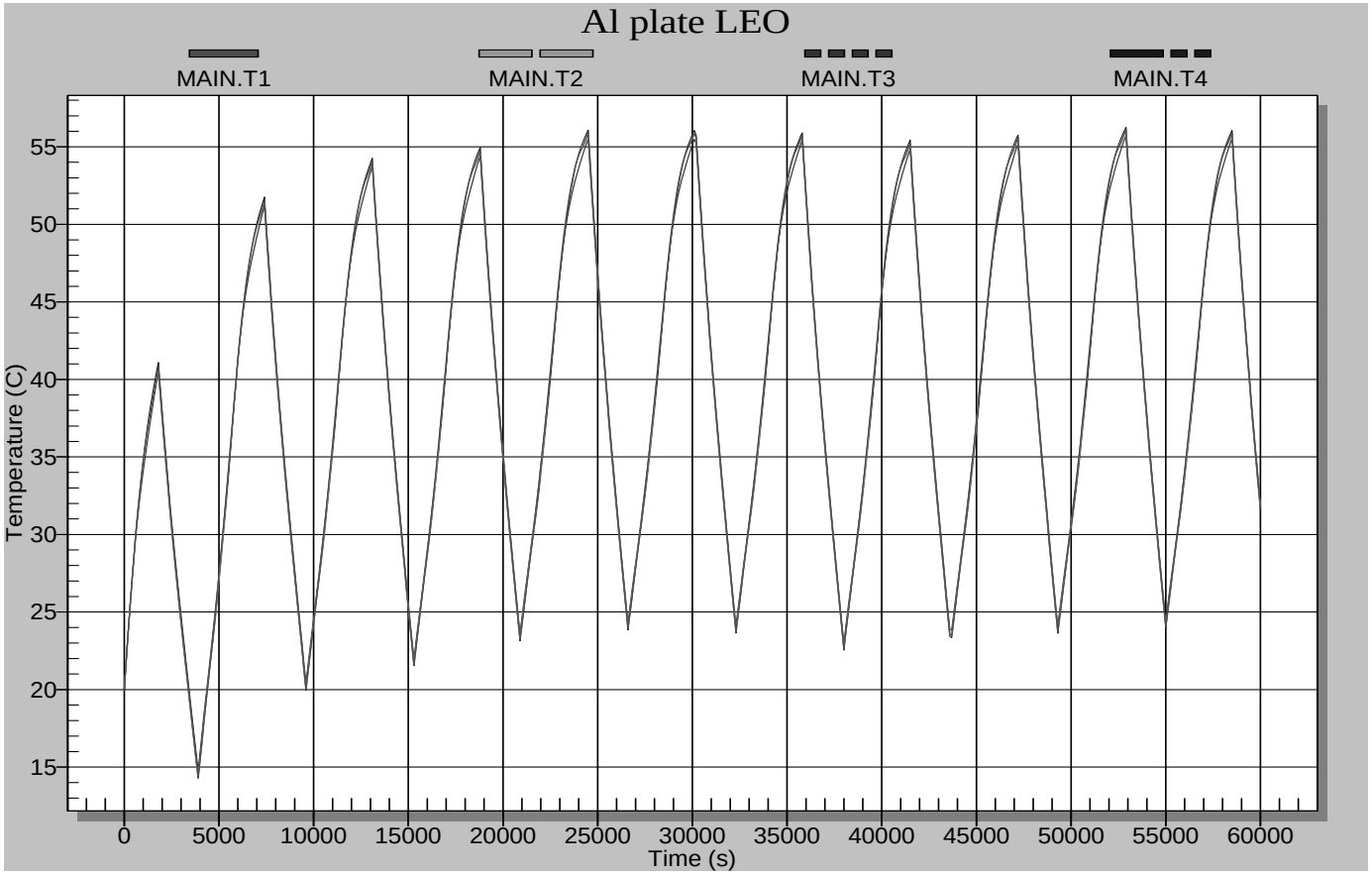
- The following configuration was analyzed in this preliminary run:
  - The plate is a 1m by 1m aluminum plate, 2cm thick
  - Its thermal properties are
    - IR emissivity:0.8
    - IR absorptivity: 0.8
    - Specific heat: 896 J/Kg.K
    - Density: 2700 Kg/m^3

Orbital Thermal Analysis

- Four cases were examined:
  - LEO tracking the sun
  - LEO always looking at the Earth
  - GEO tracking the sun
  - GEO always looking at the Earth

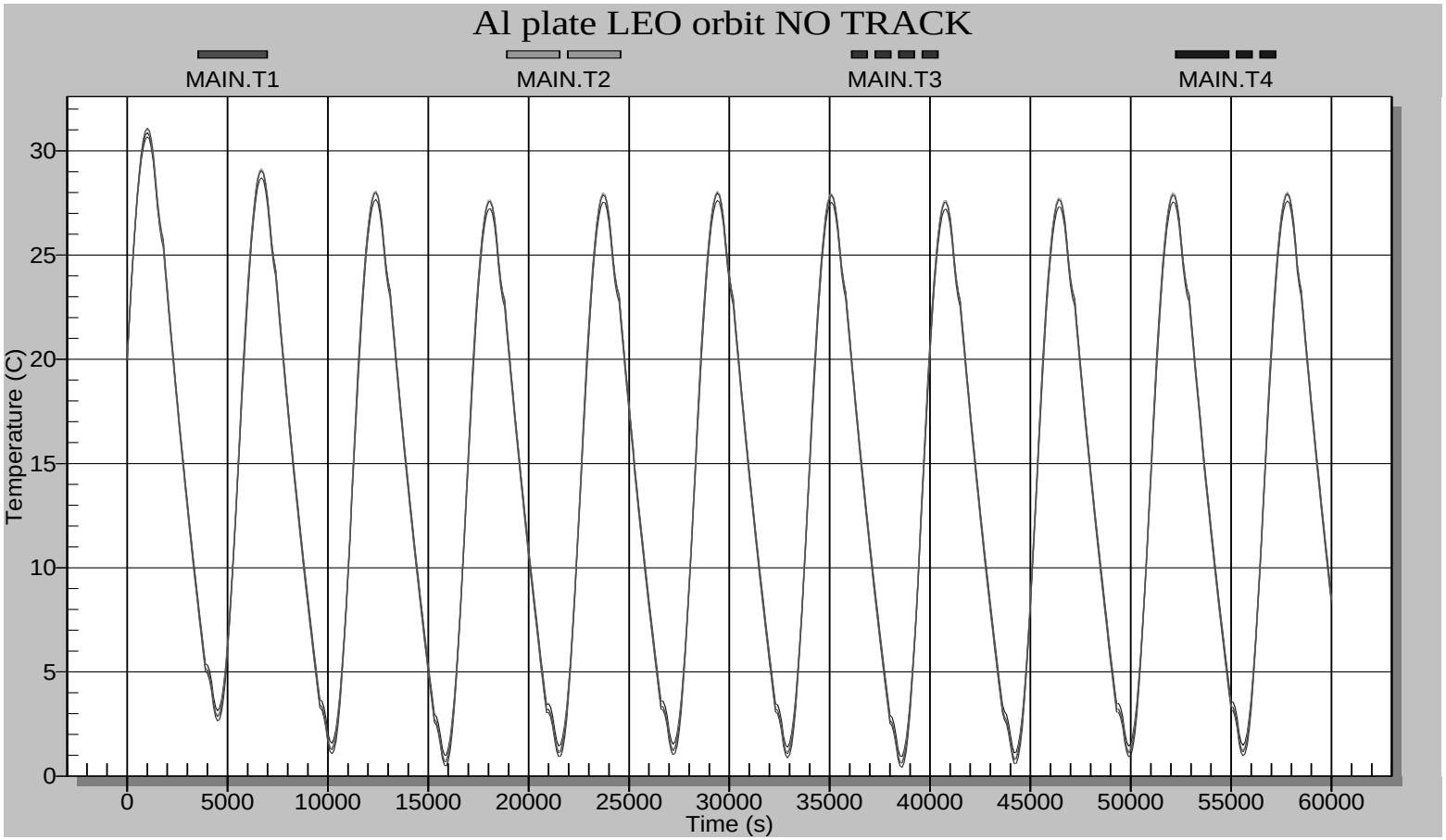
Orbital Thermal Analysis

- LEO temperatures tracking the sun



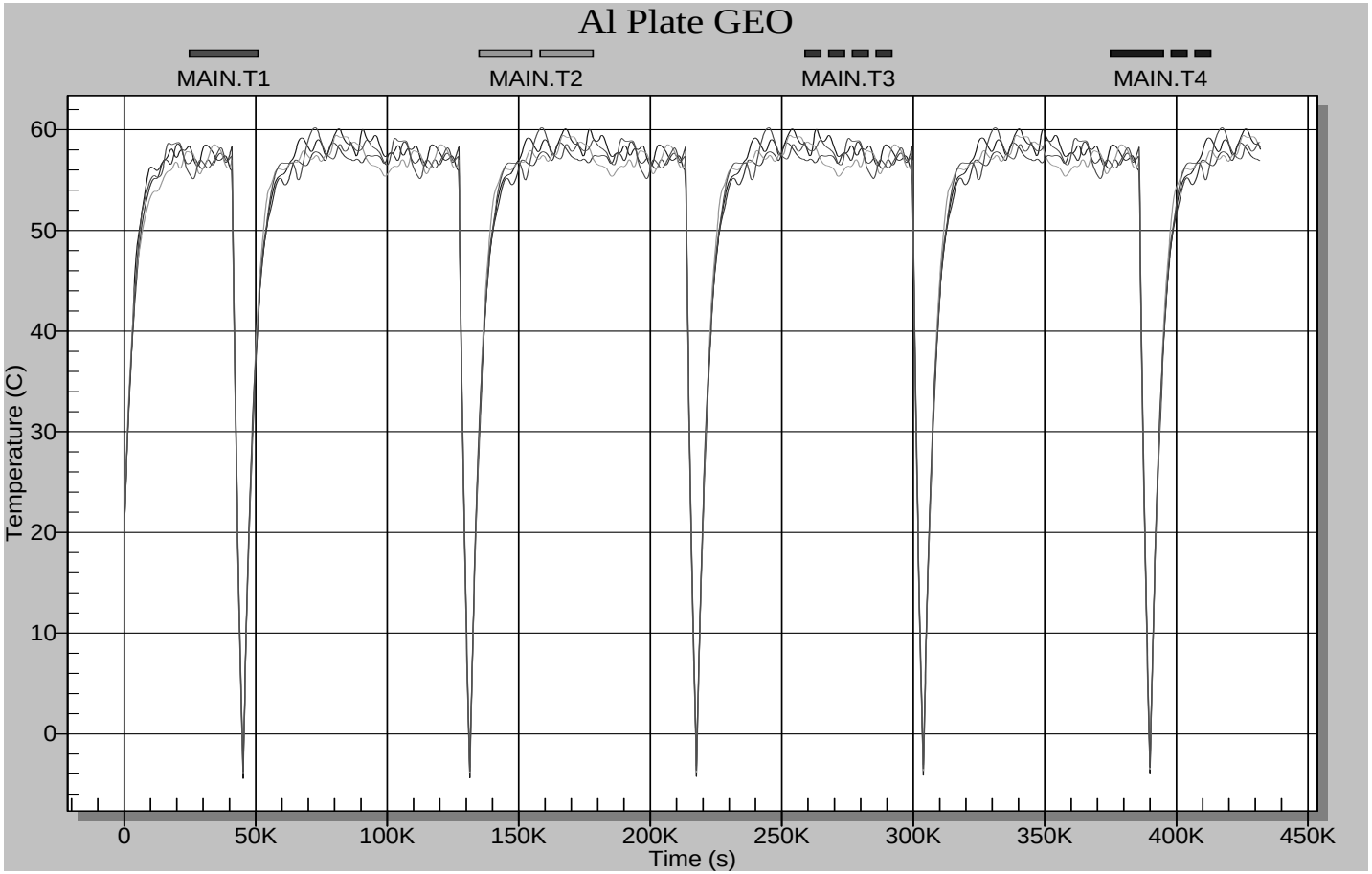
Orbital Thermal Analysis

- LEO temperatures w/out sun tracking



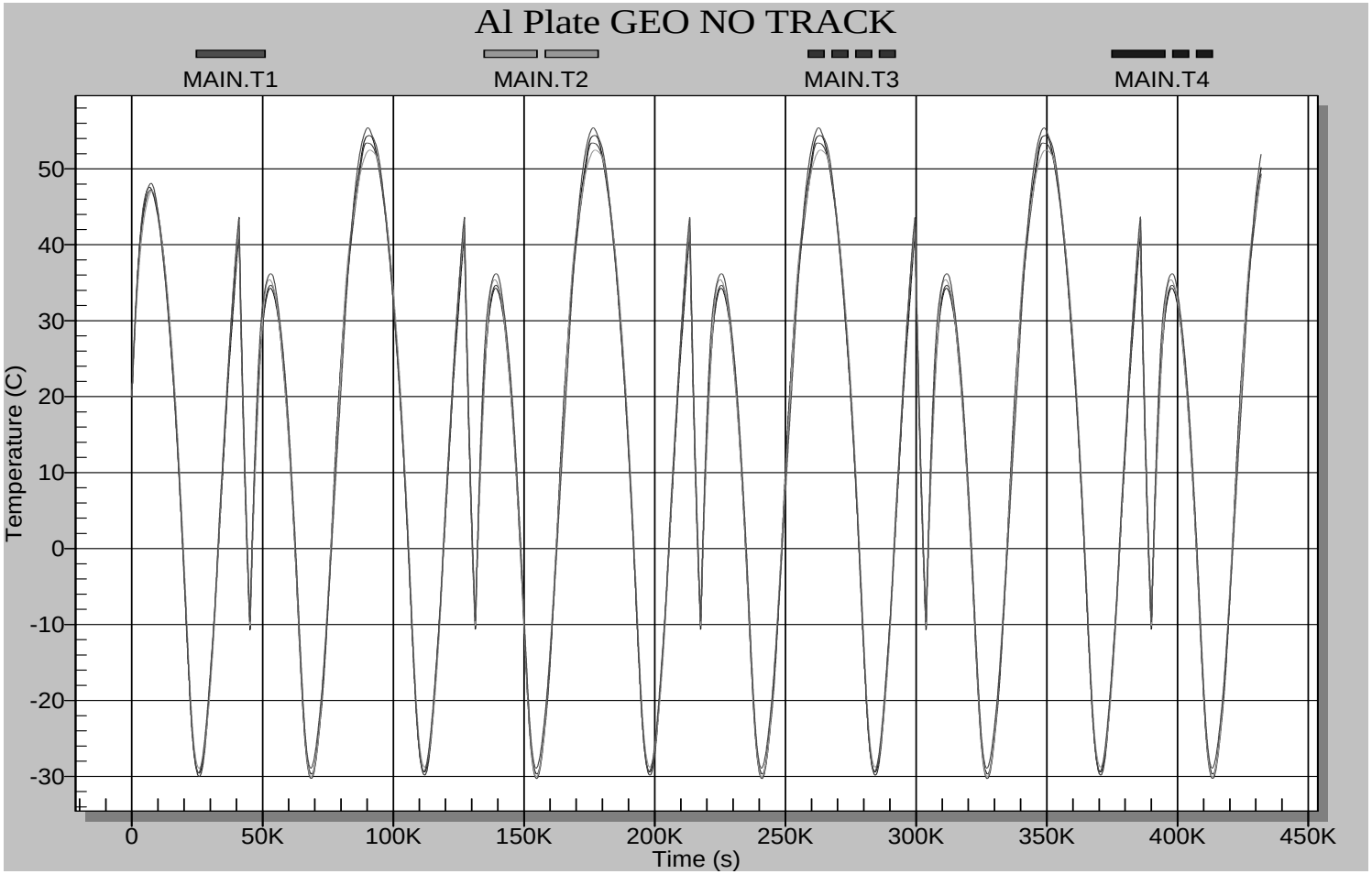
Orbital Thermal Analysis

- GEO temperatures tracking the sun



Orbital Thermal Analysis

- GEO temperatures w/out sun tracking



Orbital Thermal Analysis

- This analysis allows us to determine the thermal actuation characteristics necessary for SMA actuators to be used in space

Material Characterization

- SMA material chosen for mechanism fabrication to be characterized
  - DSC testing to determine thermal attributes
  - Mechanical analysis
  - Training characteristics
- Special attention will be paid to transformation temperatures, especially as they relate to ambient orbit conditions

Mechanism Optimization

- In addition to exploring improvement to the linear actuator, the rotary actuator and release mechanisms may be examined for improvement
  - Examine detent/locking in rotary actuator
  - Explore direct resistance heating of redundant release mechanism