LUROVA - From Render Engine to Thermal Model

Ron Creel
Apollo Lunar Roving Vehicle Team Member

Apollo Rover on the Moon

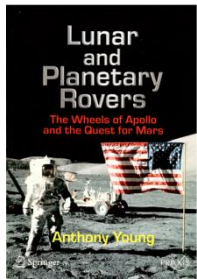Thermal & Fluids Analysis Workshop
TFAWS 2014
August 4 - 8, 2014
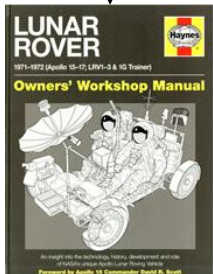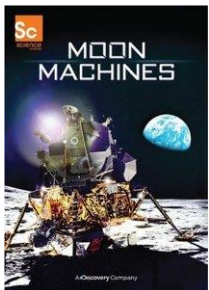NASA Glenn Research Center
Cleveland, OH

- Full Interactive Mission Support Thermal Model Needed for LUROVA Book and STEM Challenge Simulation for Students
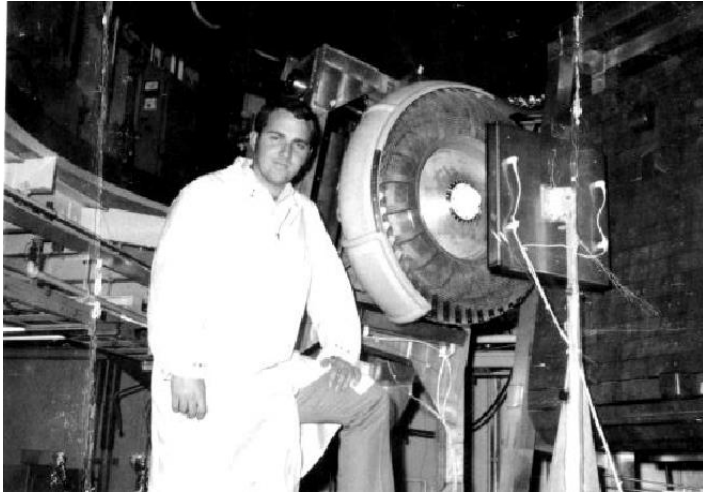
Previous Books

Movie

DVD for LUROVA Book

1
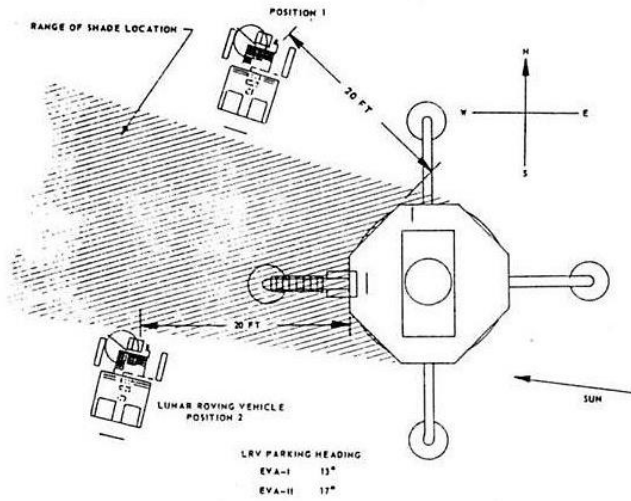
Rotating Rendered Rover Model
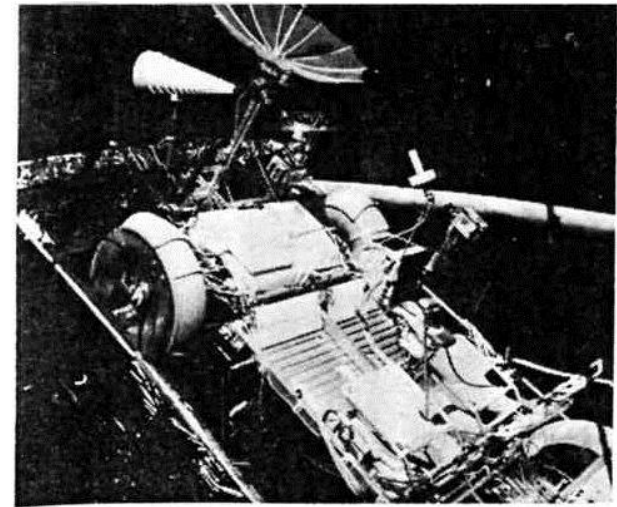
Mobility Subsystem TVAC Testing

- 177 Node "Full" Model Correlated with TVAC Testing
- Separate Forward, Center, and Aft Section Models Required Due to LOHARP 140 Surface Node Limit
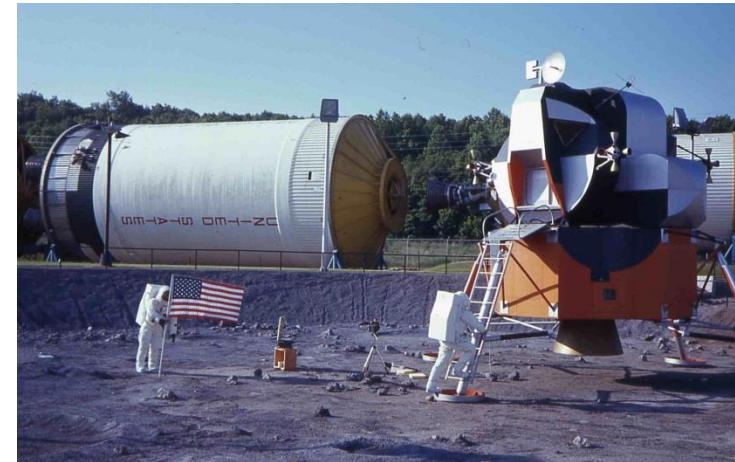

Qualification and Flight Units TVAC

LOHARP Calculated View Factors and "Wireframe" Verification Plots

- 19 Node Forward Chassis Batteries and Electronics Model Developed for Responsive Mission Support

View Factor Verification using Full Scale LM Model at U.S. Space and Rocket Center

Render Engine Provides High Quality Surface Data

- Original "Full" Rover Thermal Model Nodes and Linear Conductors Located, But No Surface Model for Radiation Conductors and Heat Rates

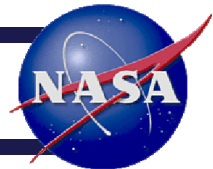- Candidate "Lightwave" Rendered Polygons Used for Rover Poster
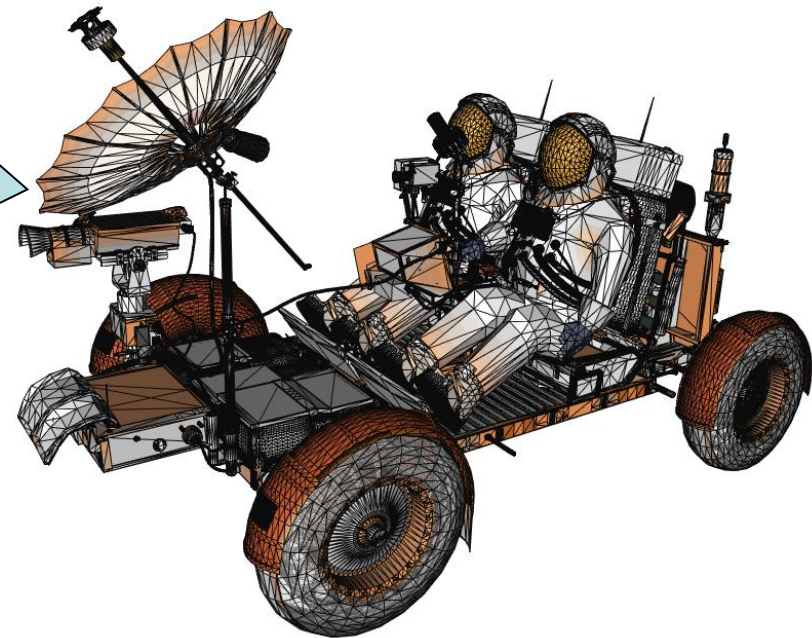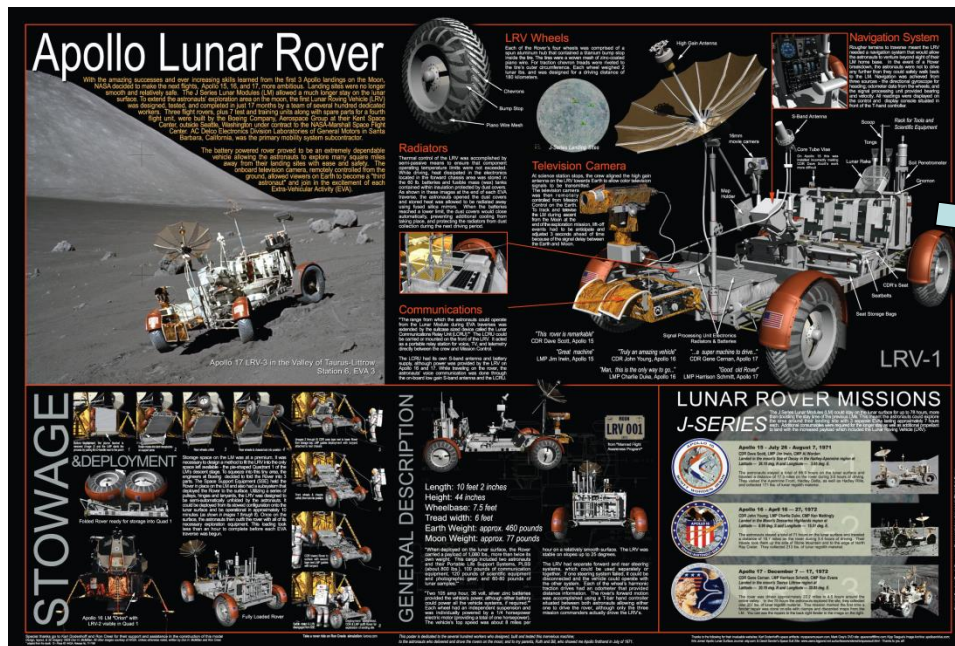
Rover 3D Model and Poster Created by Don McMillan

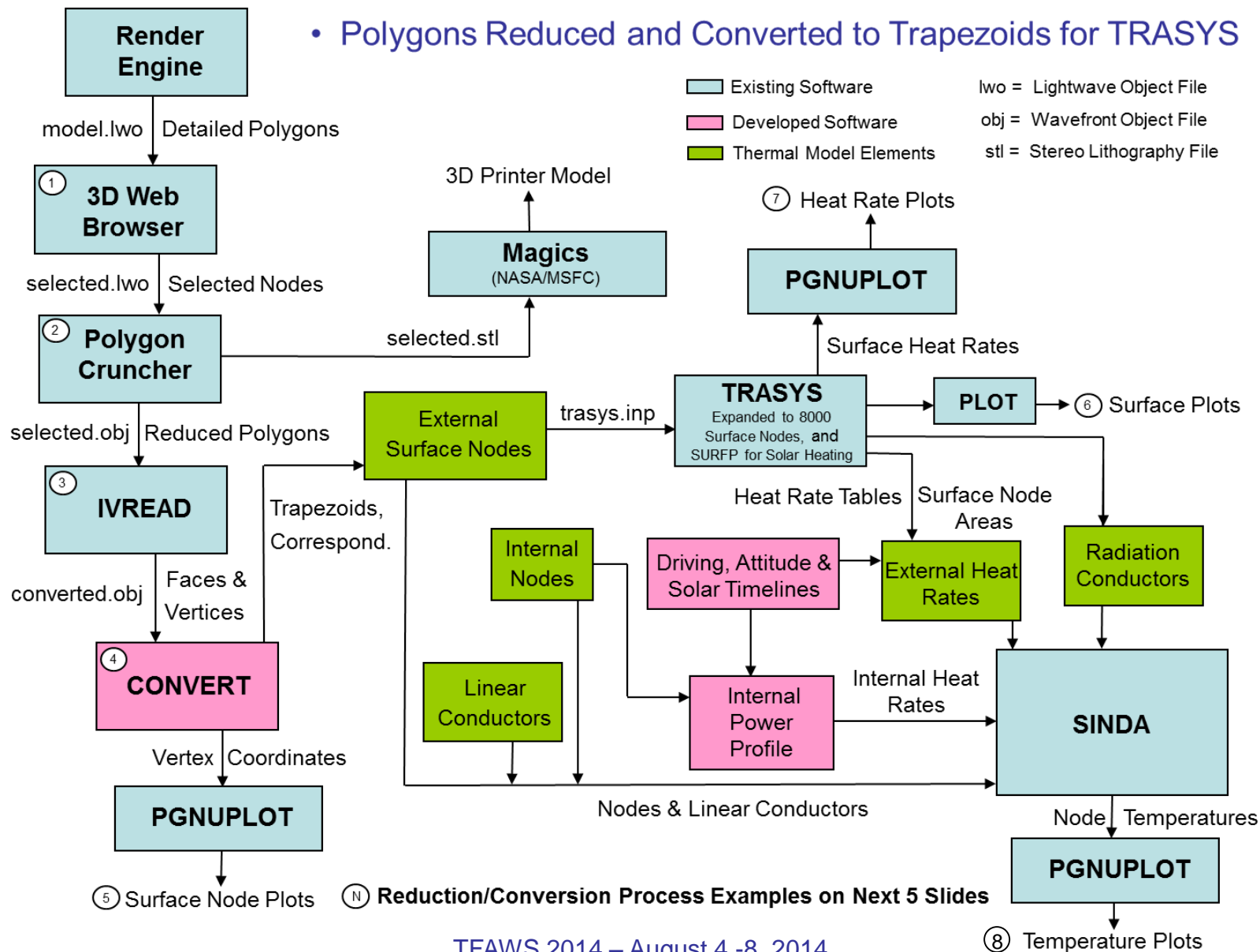**911,509 Surface Polygons with 489,731 Vertices**
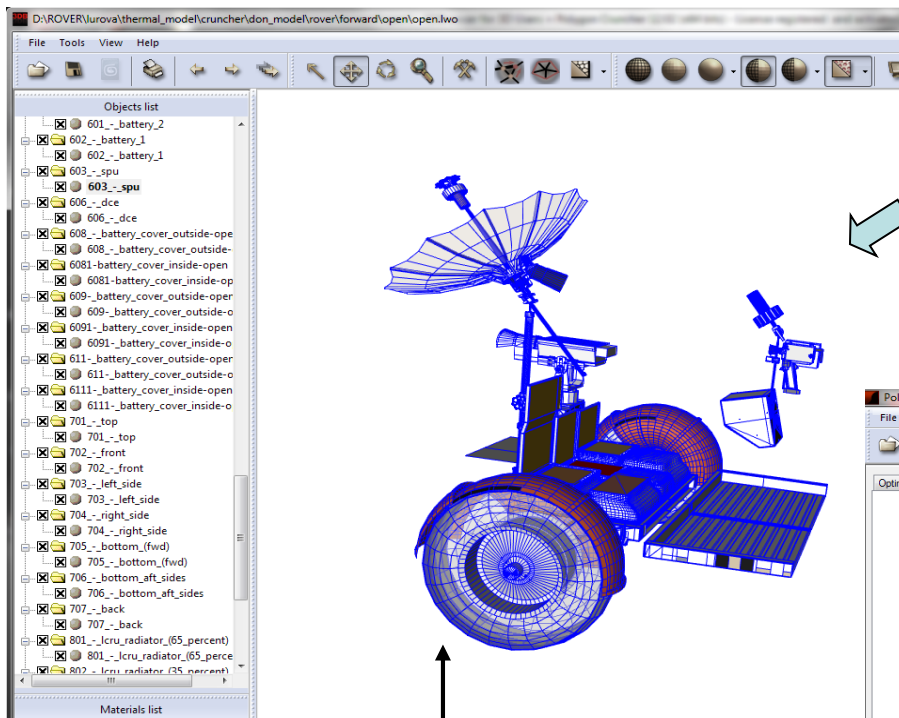
- Too Many Polygon Surfaces for TRASYS 4000 Node Limit

• Polygons Reduced and Converted to Trapezoids for TRASYS

Polygon Reduction Steps & Products

- Render Engine Polygons Selected and Reduced for Forward Chassis Thermal Model
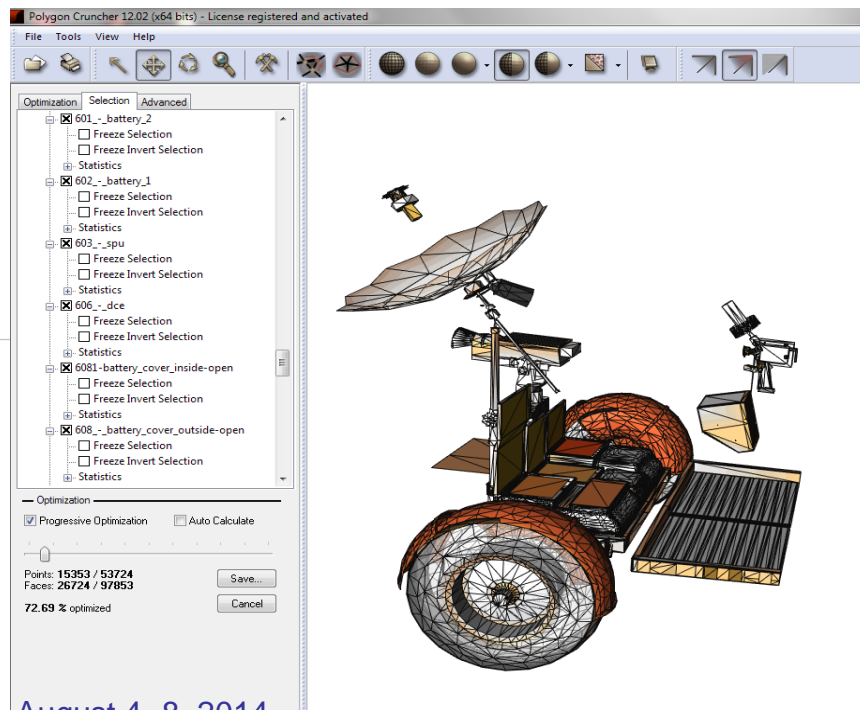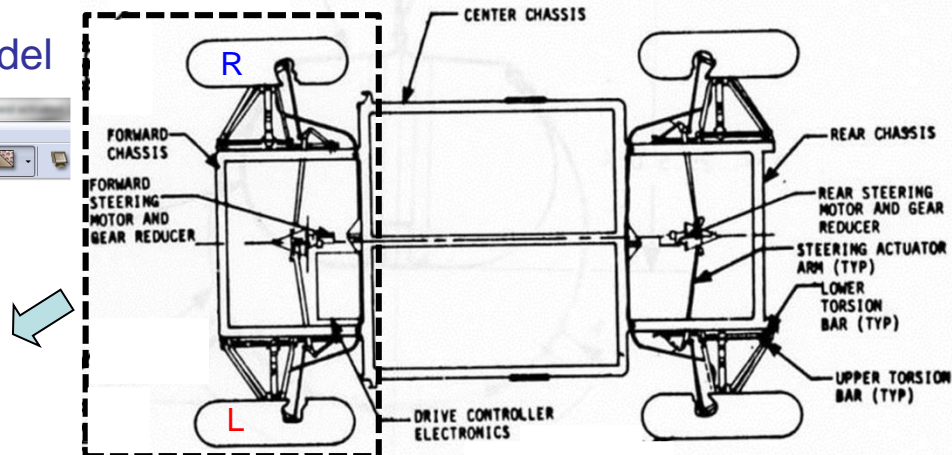

(1) 3D Web Browser Used to Select Forward Chassis Model Nodes

(2) Polygon Cruncher Used to Reduce Number of Triangular Polygons

Triangular Polygons Converted to TRASYS Trapezoids

Input

Output

③ IVREAD Converts Reduced Polygon "Faces" and "Vertices" to ".obj" Readable Ascii Format
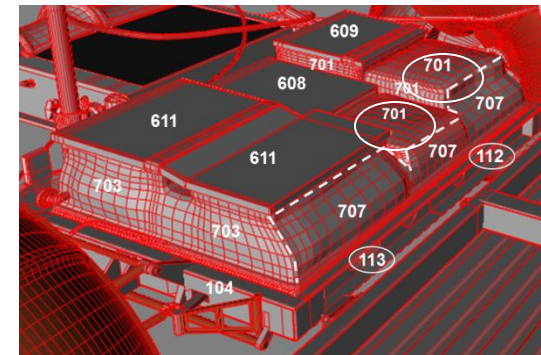
Forward Chassis Surface Model

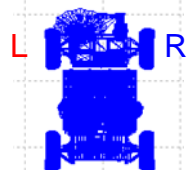④ CONVERT Provides TRASYS Trapezoids for Calculating Radiation Conductors, and Correspondence to Combine Polygons for Surface Nodes Heat Rates, and Areas,

Allows Mirroring for Symmetrical Mobility Subsystems and Coordinate Rotations for Variable Solar Orientation
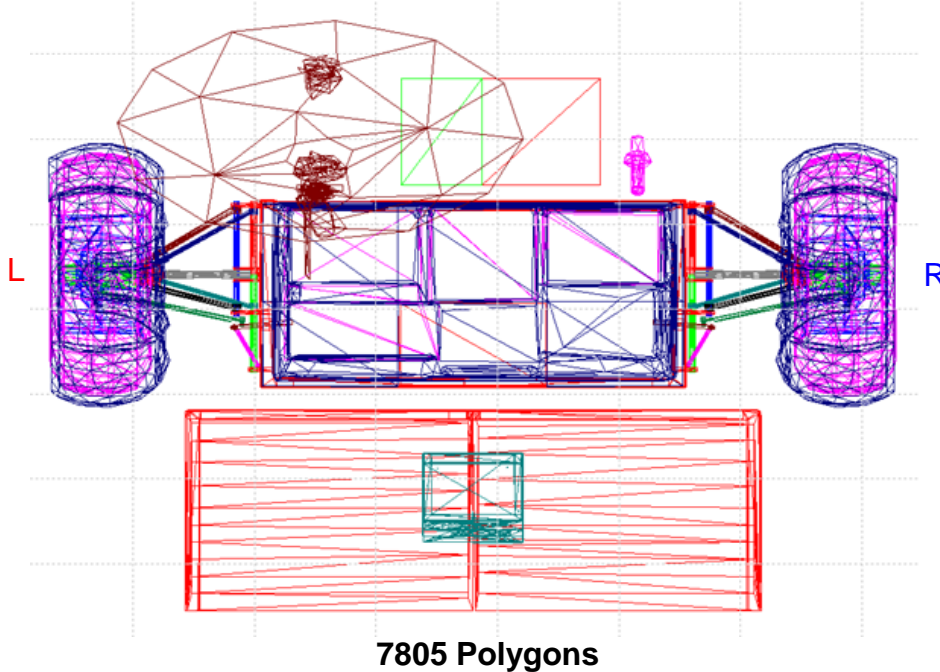
- Surface Plot Programs Provide Visual Verification for R/C Processed Forward Chassis Surface Nodes

L   R

7805 Polygons

⑤ Polygon Faces and Vertices using PGNUPLOT

Rover   Lunar Module (LM)

(233,856 Polygons crunched to 2000)

Left Side Iso View

⑥ Converted Surface Trapezoids using TRASYS PLOT
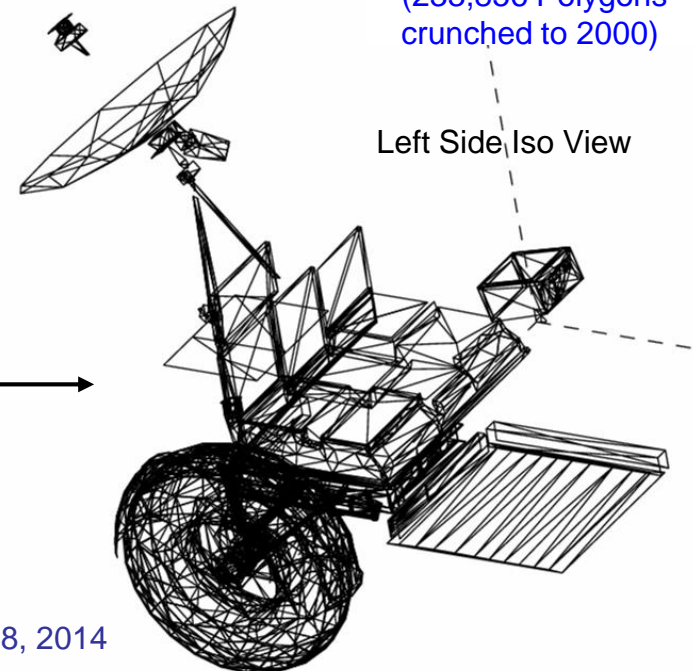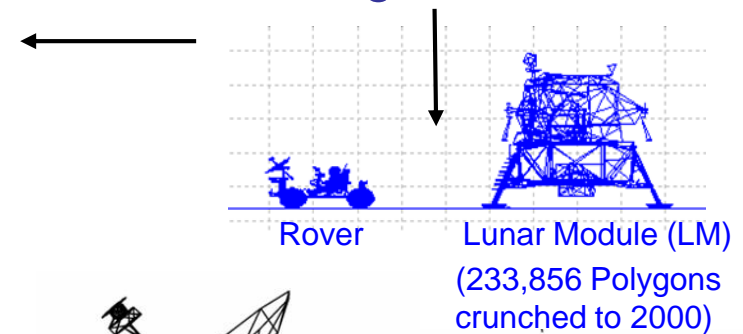
- TRASYS Calculated Forward Chassis Node Heat Rates Verified

Left Side Nodes (open covers)

Lunar Surface

Sunrise

Lunar Noon

Sunset

Right Side Nodes (open covers)

Sunrise

Sunset

Radiator Nodes (open covers)

Radiator Nodes (closed covers)

Sunrise

Sunset

SURFP subroutine used for heat rates with all surfaces dust covered ($\alpha_s = 0.9$)

Sunrise

L R

Rover

Sunset
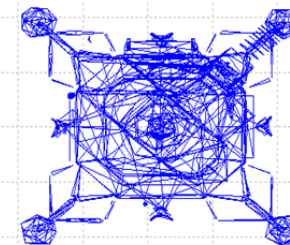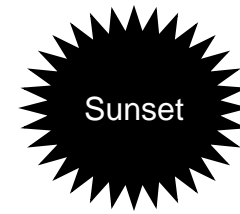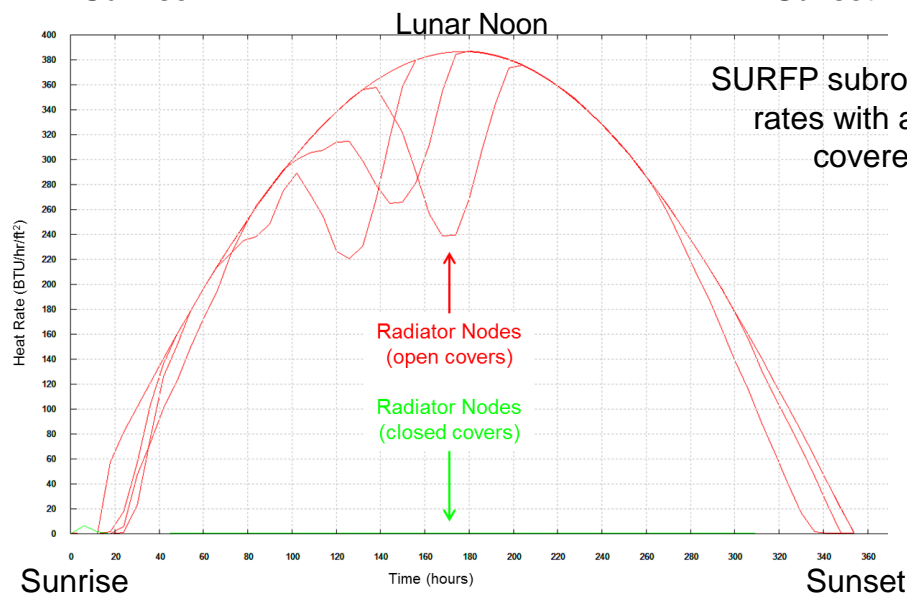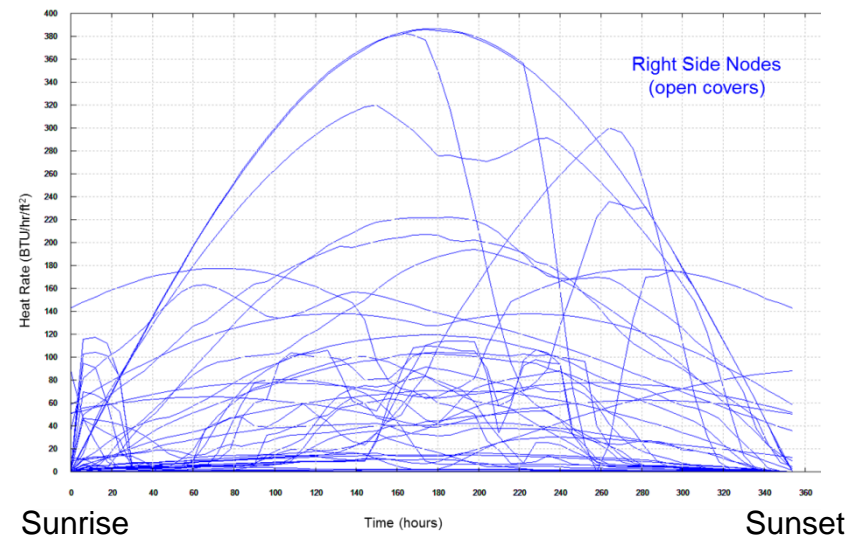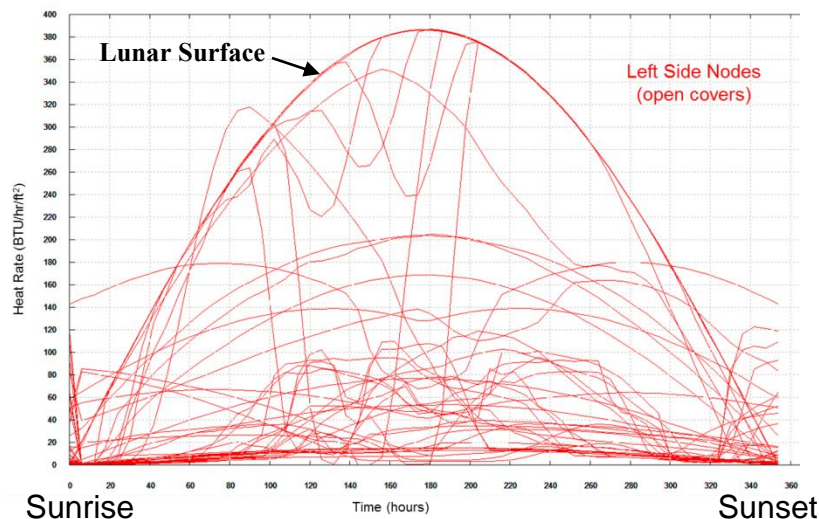
Lunar Module (LM)

⑧ • Next Step is to Compile SINDA Model to Compare with 19 Node Mission Model
  - Recently Used for NASA Nightrover Centennial Challenge for Energy Storage

Apollo 17 Last EVA and After

Future Plans for LUROVA

- Use Successful R/C Process to Add Rover Center and Aft Model Sections
- Complete Interactive SINDA Thermal Model for Book and DVD Simulation
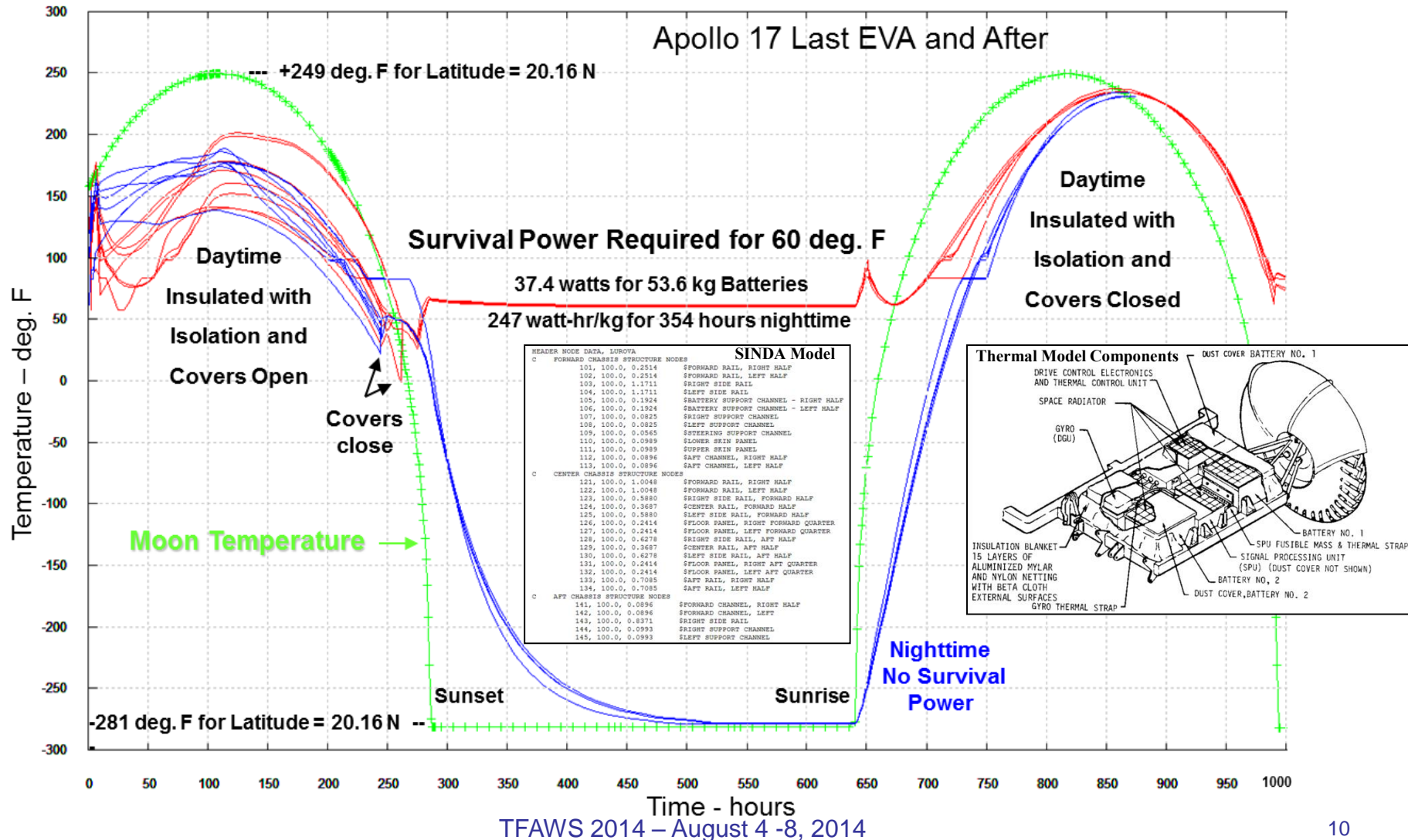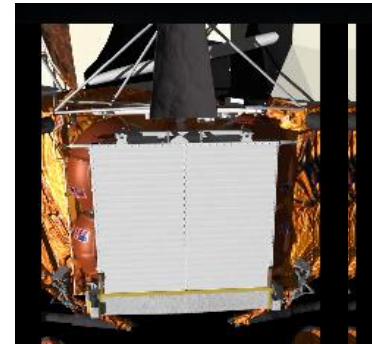 - Driving with Astronauts, and Parked with Covers Closed/Open and LM
- Use R/C Process for LM/CSM Transportation Phase Model

Passive Thermal Control (PTC) "Barbeque" Rotation (3 revs/hr) 2
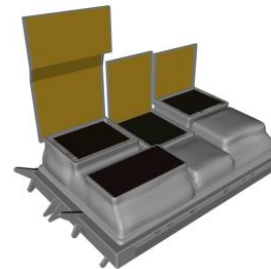
338,417 Polygons

PTC - Solar Heating Simulation 3

- Expand "Additive Manufacturing" 3D Model for Student Awards

NASA/MSFC Sponsoring 3D Printer for ISS Experiments

Printed Rover Forward Chassis Model Created Using MSFC 3D Printer

- Continue STEM Student Lectures and Support to Human Exploration Rover Challenge (formerly Moonbuggy Races)