National Aeronautics and Space Administration

Environmental Testing of Flight Hardware in the 25 ft. Space Simulator at JPL in a Manual Mode

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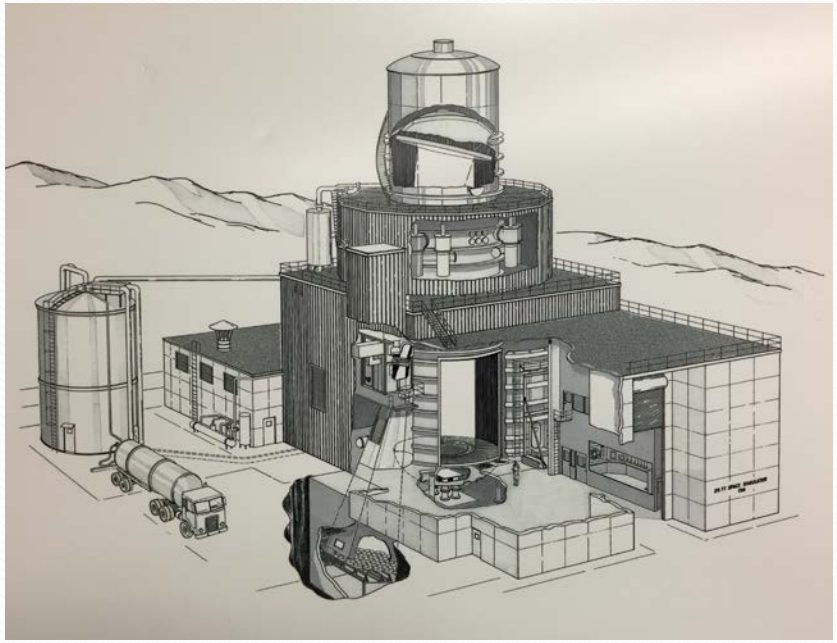
CHAMBER HISTORICAL PREFACE

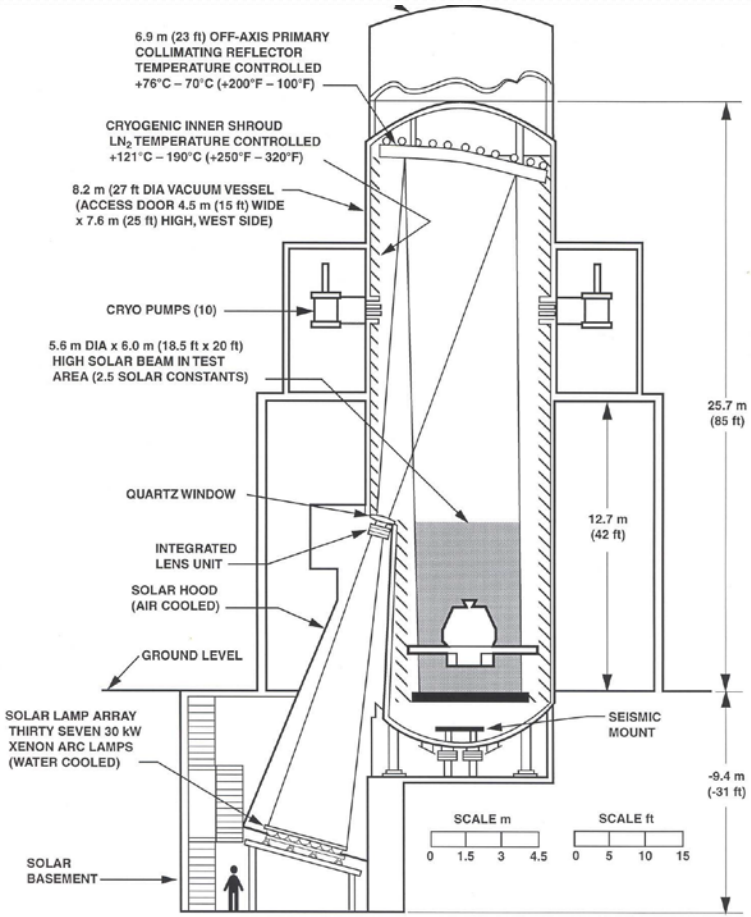


Credits: NASA/ JPL-Caltech. *Artist rendering of 25ft Space Simulator circa 1967*

- Nearly 60 years ago, JPL's focus shifted for a Lab that produced missiles to one that developed lunar and planetary spacecraft.
- JPL recognized the necessity of having a large thermal, vacuum chamber with solar simulation capabilities.
- The 25 ft. Space Simulator has undergone several renditions of improvements to maintain its adaptability to ever-changing Flight Project Protocols, performance requirements, and reliability needs.

25 ft. Space Simulator Information

- Chamber Size: 27 ft. dia. x 85 ft. high
- Access Door: 15 ft. wide x 25 ft. high
- Minimum Operating Pressure: 1 x 10 -6 Torr (90 min)
- Off Axis Solar: (37) 25 Kilowatt Xenon Lamps
- Maximum Solar Beam Diameter: 18.5 ft. Dia



Credits: NASA/ JPL-Caltech. *25 ft. Space Simulator Facility Diagram*

25 ft. Space Simulator Vacuum System

Ingersoll-Rand Two Stage Axial Compressor

Credits: NASA/ JPL-Caltech. *Axial Compressor*

Mechanical Pumping Plant

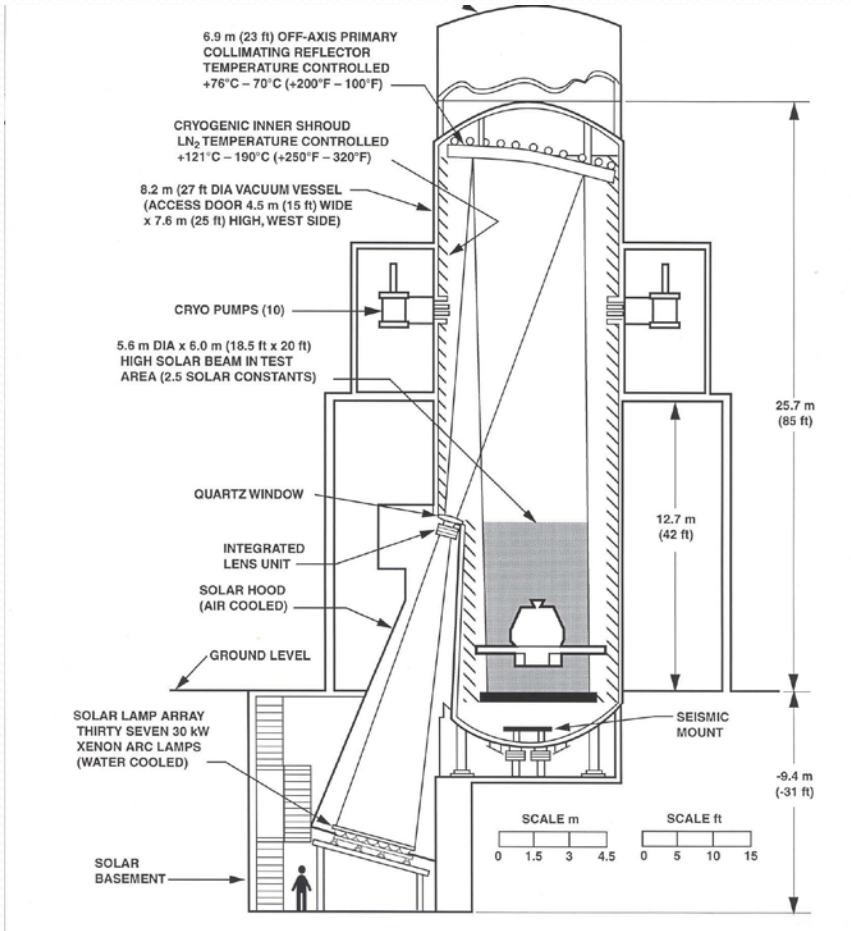
Credits: NASA/ JPL-Caltech. *Mechanical Pumping Plant*

25 ft. Space Simulator Thermal System

Credits: NASA/ JPL-Caltech. *25 ft. Space Simulator with Access Door Open*

- Thermal Shroud Capabilities
  - -190 degrees Celsius (flood mode)
  - + 100/ -140 degrees Celsius (recirculating mode)
- Liquid Nitrogen Usage Rate
  - 1,000 to 2,000 gallons per hour

25 ft. Space Simulator Solar System

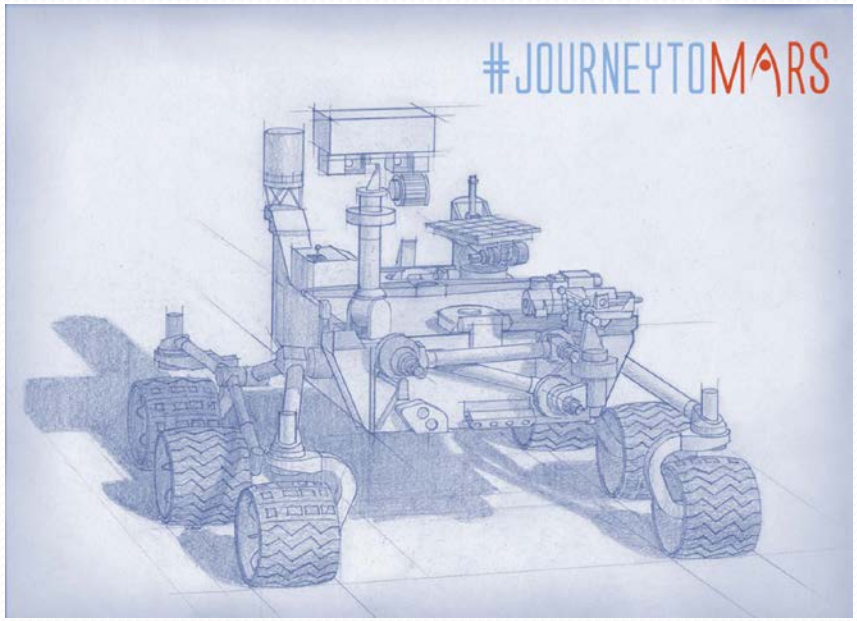


Credits: NASA/ JPL-Caltech. *25 ft. Space Simulator Facility Diagram*

- Off Axis Solar Simulator
  - 37 Xenon Arc Lamps (25-30 kw)
  - Integrated lens unit
  - Quartz penetration window (2" thick and 27" dia.)
  - 23 ft. (7-m) mirror
  - Maximum beam size = 18.5 ft.

Mars 2020

- JPL is planning to embark upon another mission to the red planet in the year 2020.
- Currently, the working name given to this sophisticated next generation rover is Mars 2020.
- This rover will boast a multitude of newly developed instruments to aid in the scientific study of Mars; one of the instruments was tested at JPL's 25 ft. Space Simulator in Pasadena, CA.



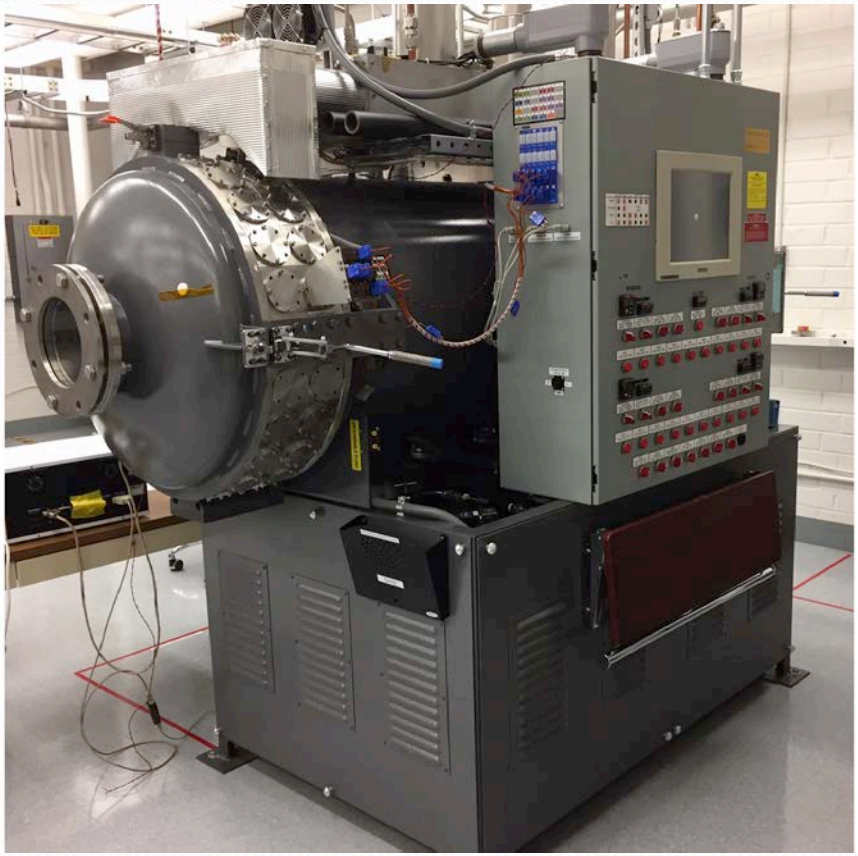
Credits: NASA/ JPL-Caltech

The Problem

Credits: NASA/ JPL-Caltech. *25 ft. Space Simulator Control Console Circa 1994*

- Under normal circumstances, the 25 ft. Space Simulator would have been the ideal facility to conduct these series of tests.
- Timing was bad, as the entire circa-1994 GE Fanuc PLC control system used to operate the 25 ft. Space Simulator was in the middle of a much needed, large-scale upgrade in an effort to modernize the chamber's control system.
- During this refurbishment a group of engineers expressed their desire to utilize the 25 ft. Space Simulator to aid in the research and development of their instrument.

The Solution



Credits: NASA/ JPL-Caltech. *ETL's Small Thermal-Vacuum Chambers*

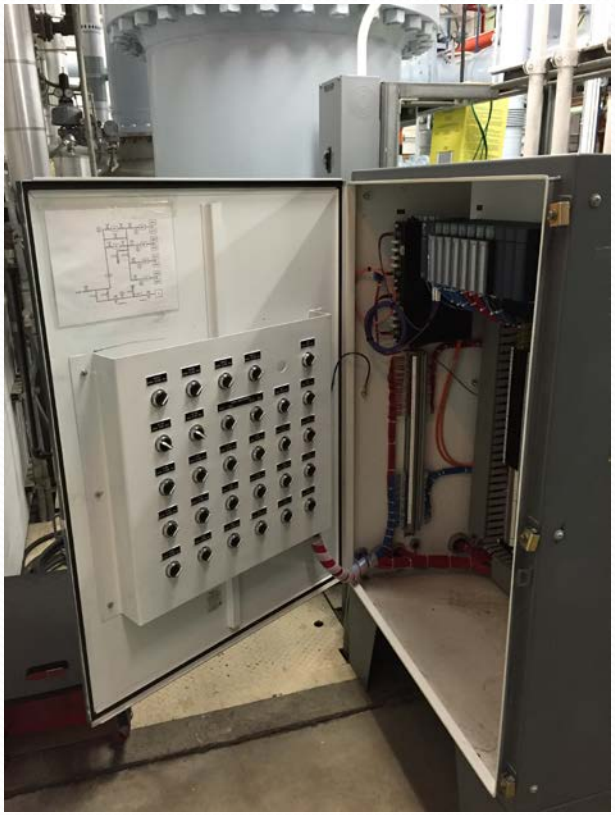
- A common Human Machine Interface (HMI) in the 1990's for chambers was a personnel computer.
- A significant difference of opinion between ETL members resulted with a compromise that developed the Hand/ Off/ Auto (HOA) switches.
- ETL set precedent of equipping all of its newly refurbished vacuum chamber control systems with redundant Hand/ Off/ Auto (HOA) switches.

Pandora's Box

Electrical Cabinet with Door Closed

Credits: NASA/ JPL-Caltech. *25 ft. Space Simulator Facility Electrical Cabinet*

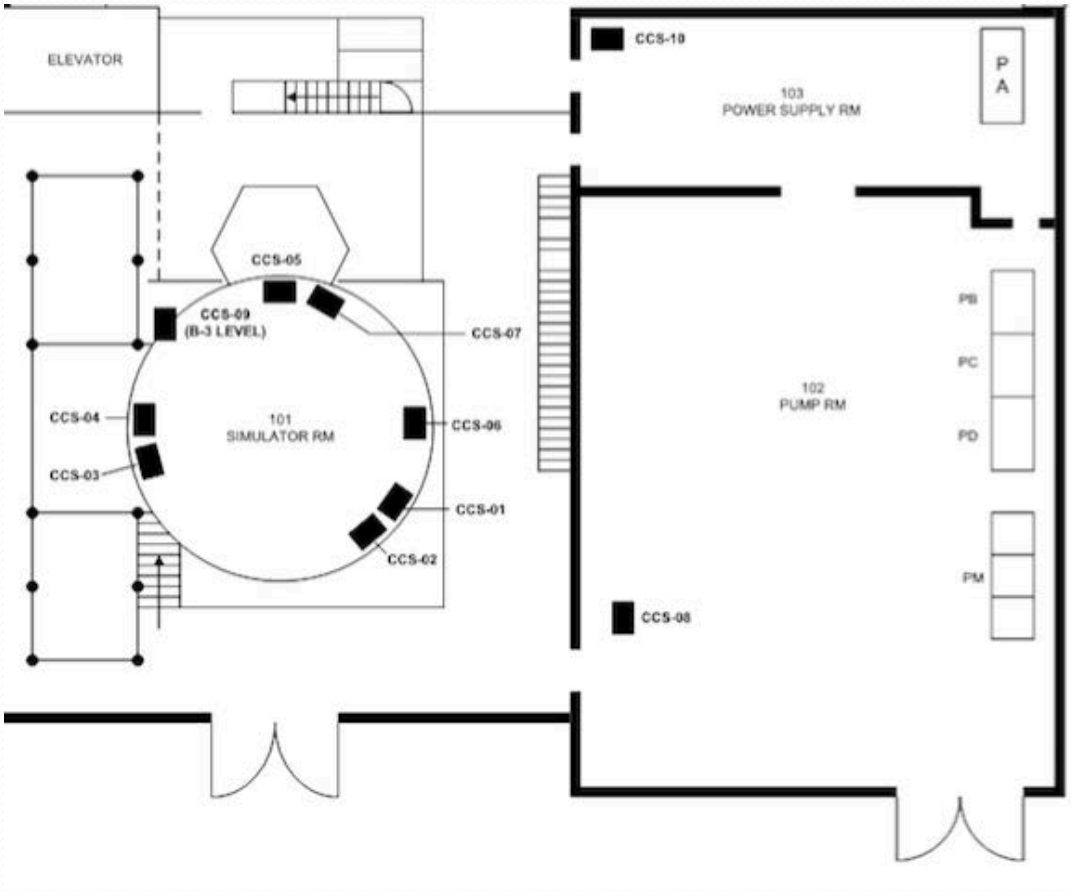
Electrical Cabinet with Door Open Revealing HOA switches



Credits: NASA/ JPL-Caltech. *25 ft. Space Simulator Facility Electrical Cabinet*

The Challenges

- Modify existing pump down procedure to accommodate a manual mode of operation.
- Electrical cabinets with HOA switches are distributed irregularly throughout facility.
- Process required constant uninterrupted communication.
- Original overlapping pump-down process presented complications for sustaining audible communication
- Difficult for field operators to conceptualize mechanical pumping plant.



Credits: NASA/ JPL-Caltech. *25 ft. Space Simulator Facility Electrical Cabinet Locations*

Solutions to Our Challenges

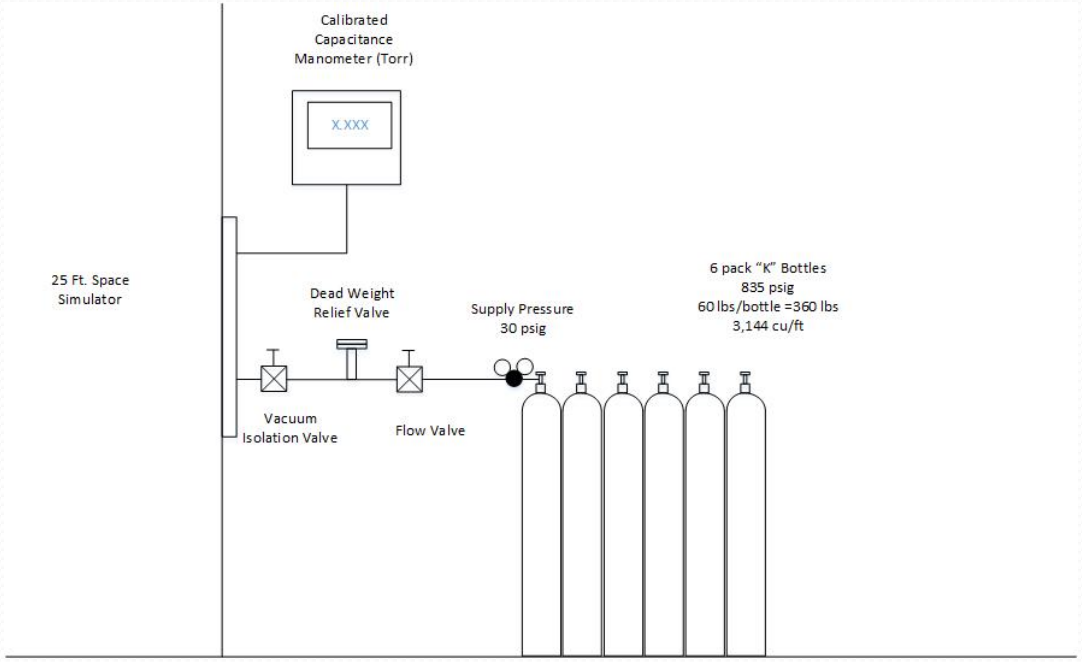
- Abandoned the overlapping pump-down process.
- Provided visual representation for both pressure and mechanical pumping plant.
  - Installed analog pressures gauges as needed
  - Posted a mechanical pumping plant schematic in all electrical cabinets.
- Equipped field operators with radio headsets designed to function in high-noise applications.
  - Similar to headsets used by race car pit crews
- Finalized manual mode pump-down procedure with 81 steps.

Credits: NASA/ JPL-Caltech. *Field Operator Utilizing HOA*

Partial Backfill

Our team assembled a simple manual backfilling system to create the CO_2 atmospheric pressures of 7 Torr found on Mars.

Credits: NASA/ JPL-Caltech. *CO2 Backfilling System*



Credits: NASA/ JPL-Caltech. *CO2 Backfilling System Diagram*

Test Parameters

1. Evacuate chamber to 500 milliTorr.
2. Partially backfill chamber with CO_2 to 5 Torr.
3. Evacuate chamber again to 500 milliTorr (Removing lingering water vapor).
4. Partially backfill chamber again with CO_2 to ~ 7 Torr (Customer provided exact final pressure).

This entire process took roughly 3 hours to complete.

SUMMARY AND CONCLUSION

- Our team performed a total of 38 successful runs utilizing the manual mode operation.
- Our team effectively met the projects criteria by replicating CO_2 atmospheric pressures found on Mars (7 Torr).
- Tests were completed on schedule ensuring the instrument would be a strong candidate to be integrated with JPL's next-generation rover.
- The instrument team was able to advance onto the next phase of the project.
- Our team proved that even with limited operational capabilities, a large vacuum chamber is critical for JPL mission success!

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Acknowledgments

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