National Aeronautics and Space Administration

Modular Tool Concept Eighth International TWI EWI Seminar 2016

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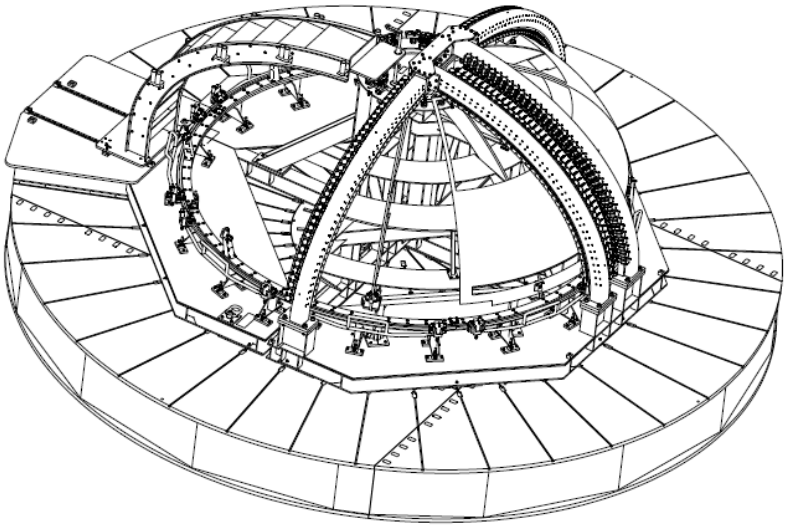
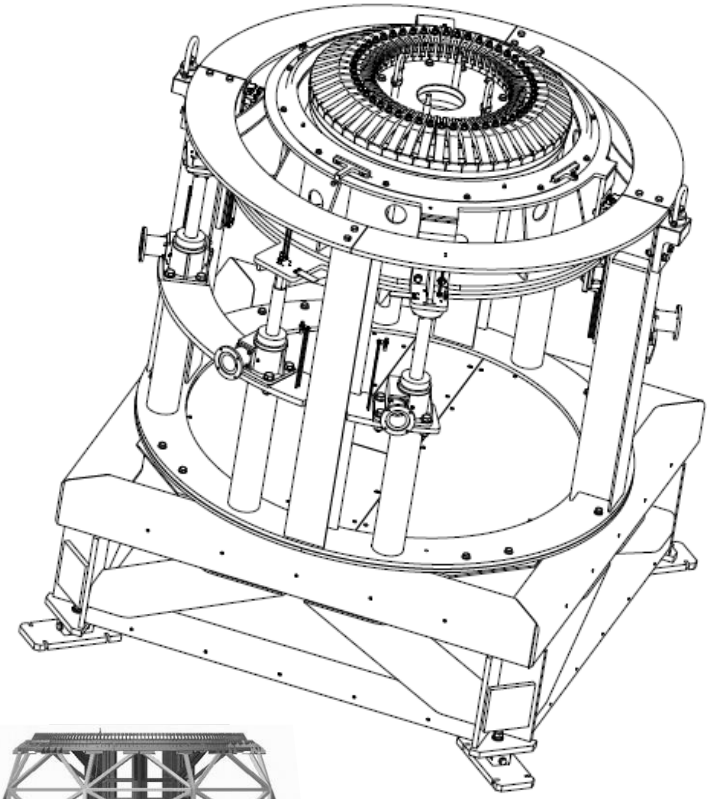
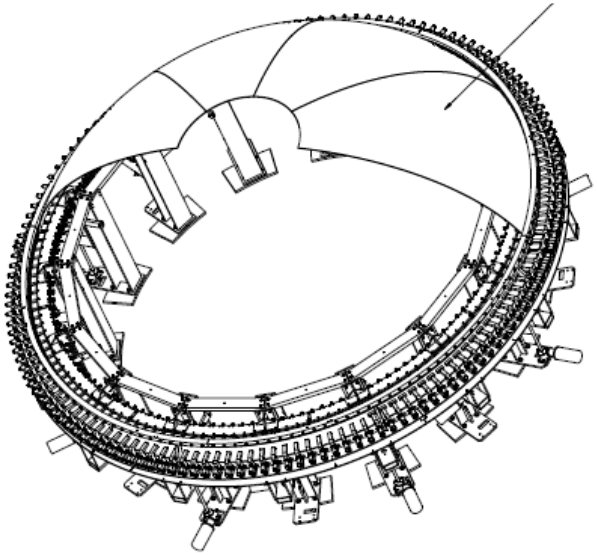
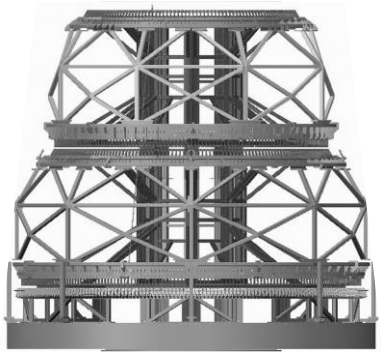
Traditional Tooling



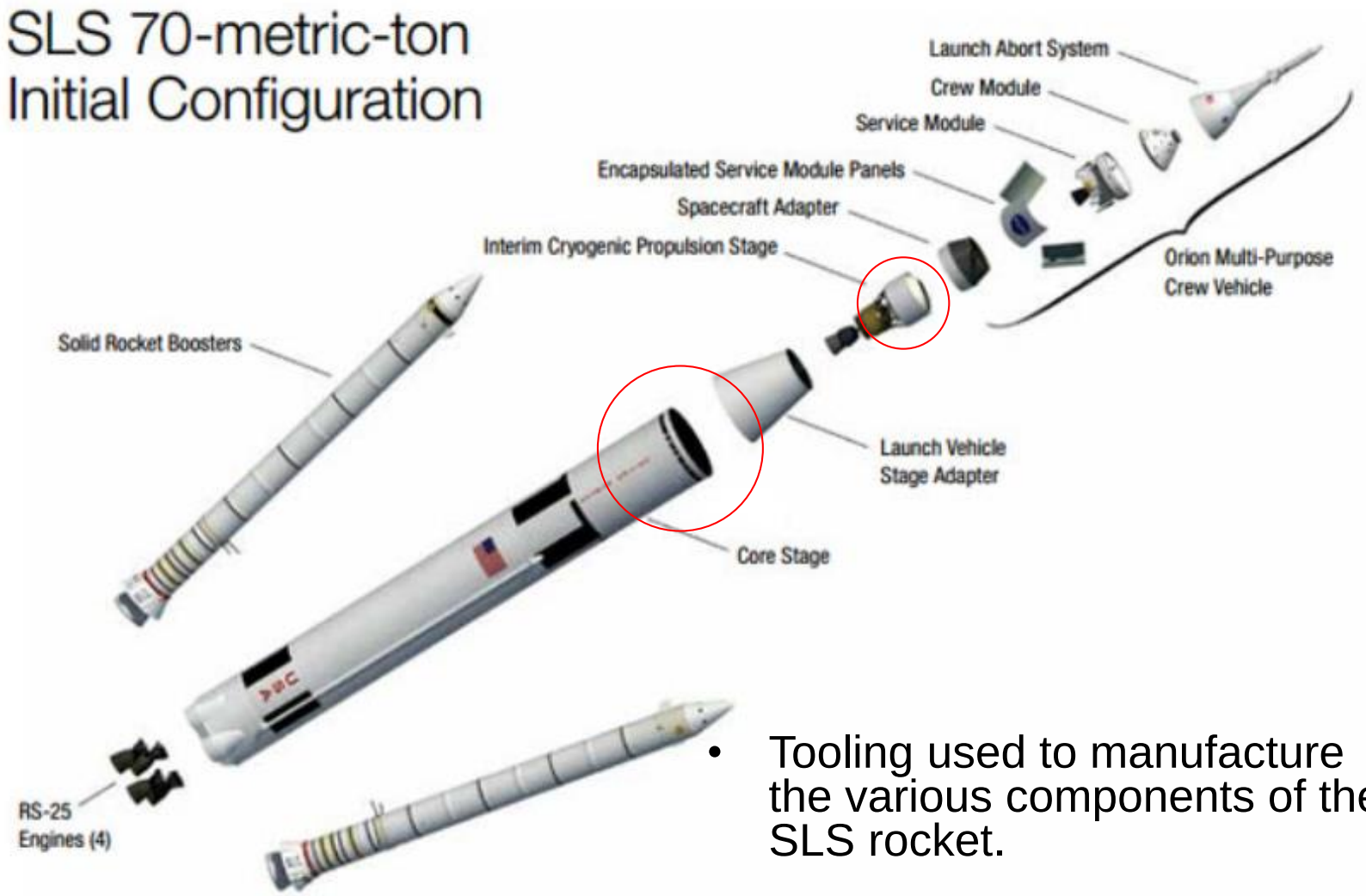






Traditional Tooling is complex, bulky, expensive and configuration specific.
Requires long durations to design, fabricate and assemble.

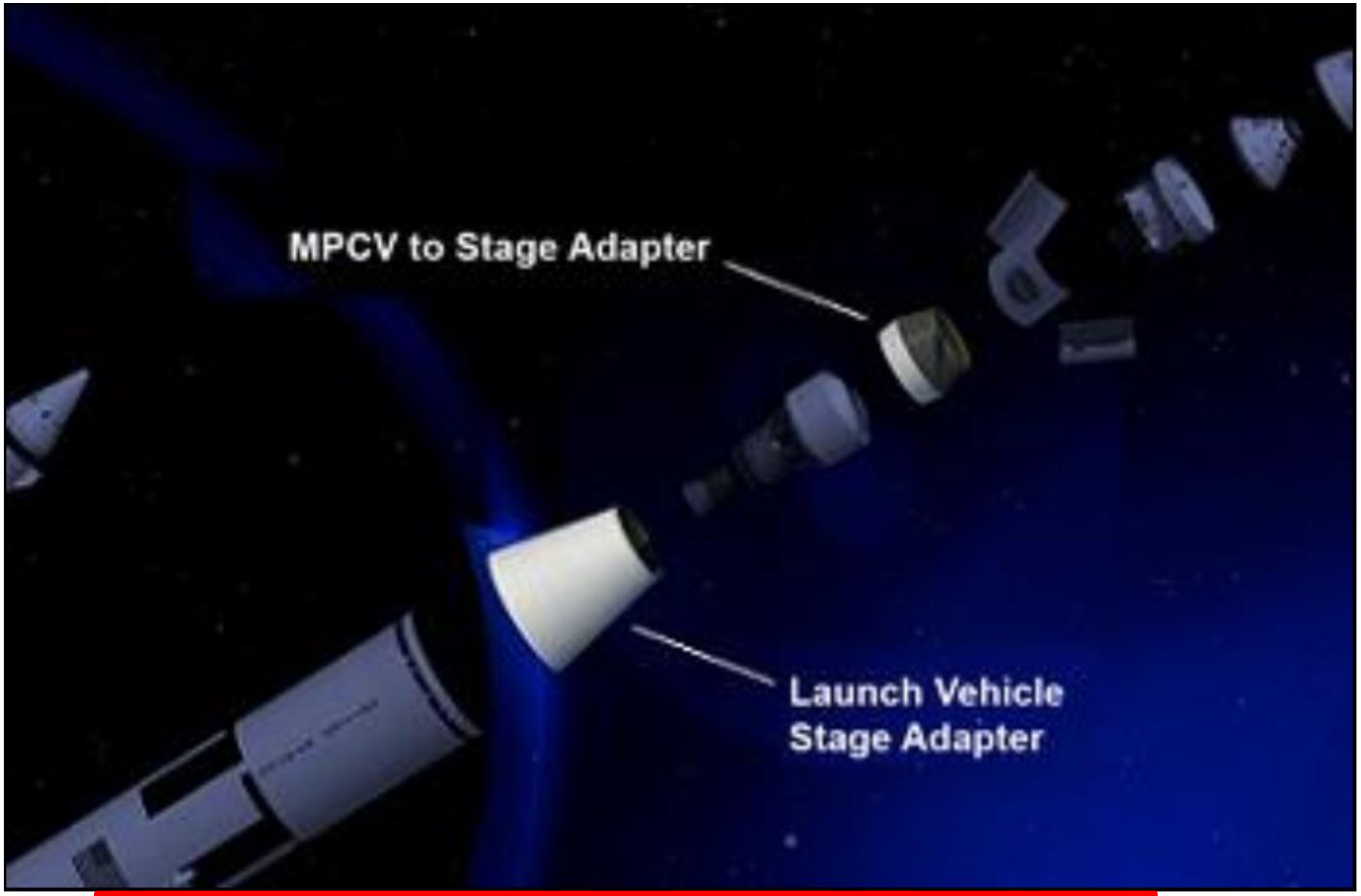
SLS Components



- Tooling used to manufacture the various components of the SLS rocket.

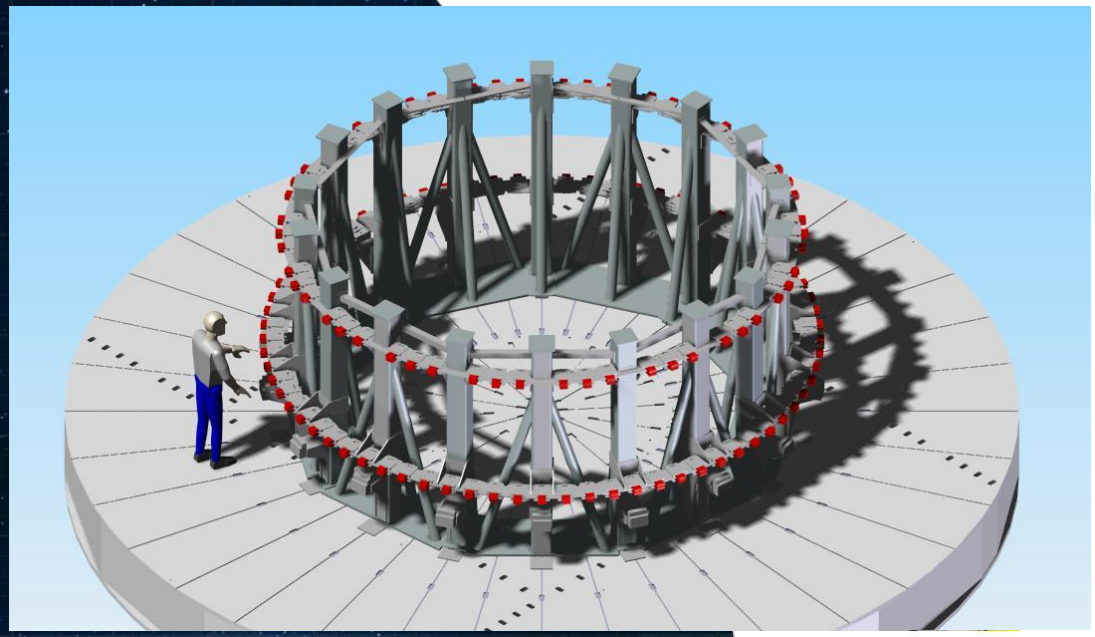
Different components with unique geometries require one-off traditional tools

MSA & LVSA



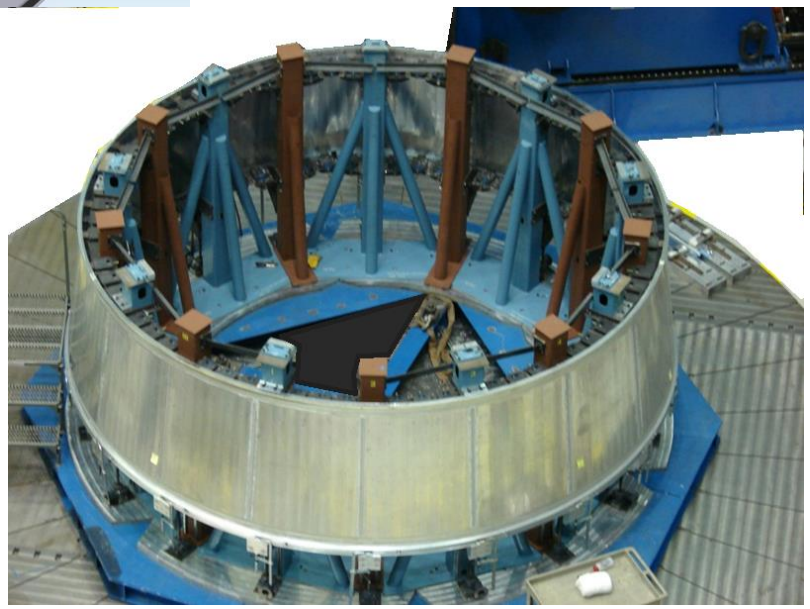
Products manufactured at NASA's Marshall Space Flight Center

SLS: MSA weld fixture

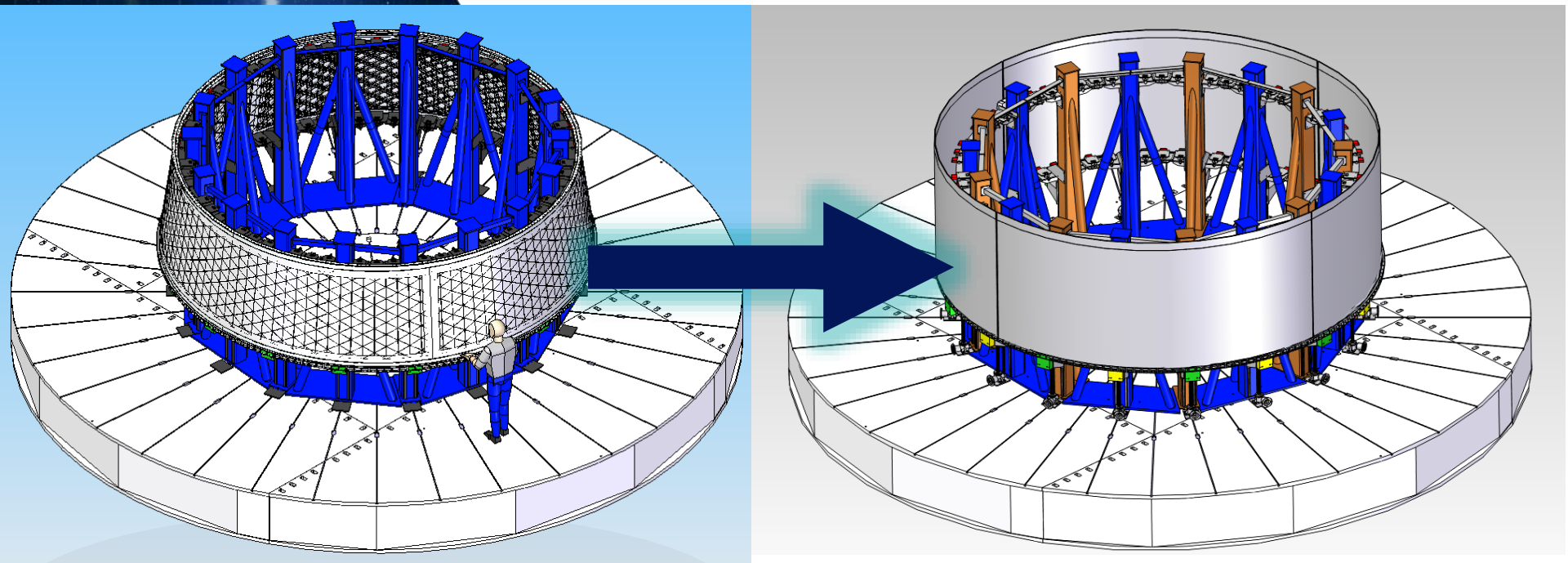


- Conical Shape
- Top 5.5 Meter diameter
- Bottom 5 Meter diameter

- Used Traditional Tooling approach but with minimal budget and schedule.
- Still exceeded budget
- Still required excessive schedule



SLS: MPCV Simulator

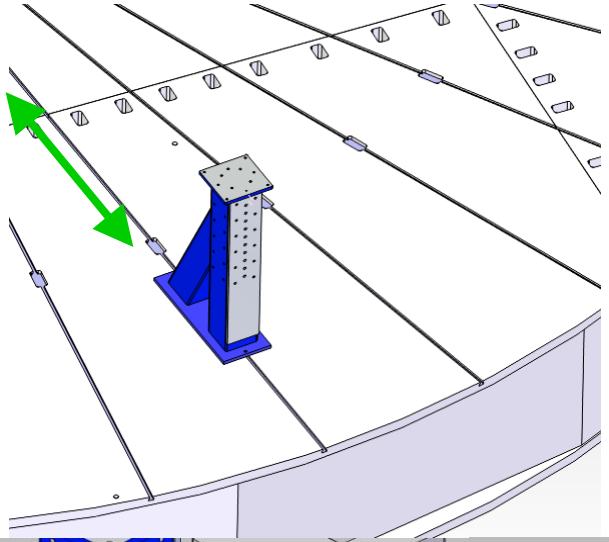


MSA
Conical

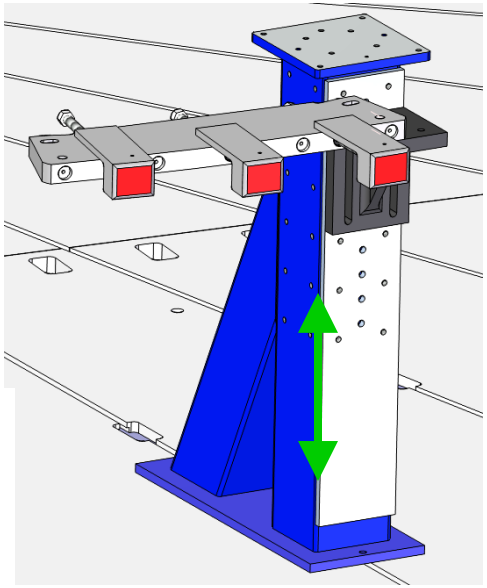
MPCV-S
Cylindrical

A simple change in component geometry requires a completely new traditional tooling

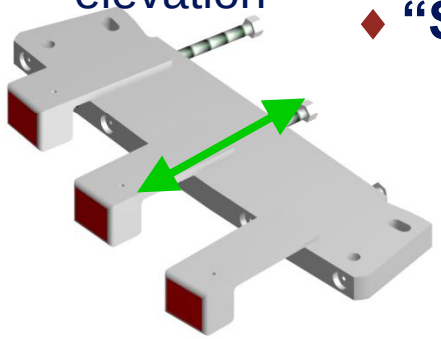
Modular Concept



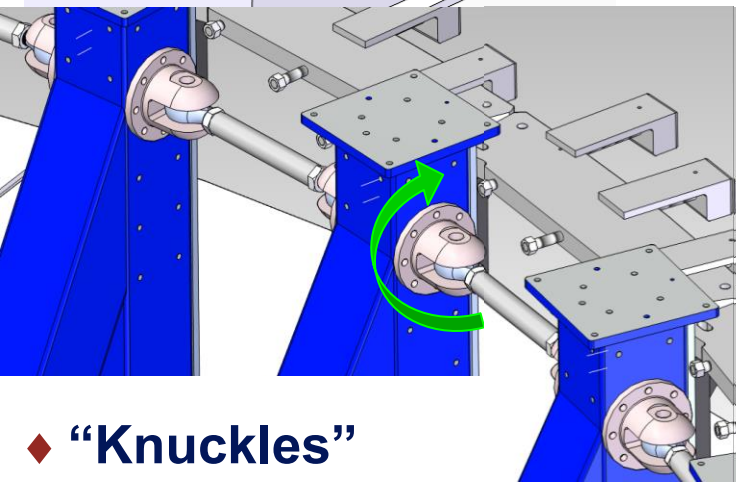
- **"Tombstone"**
  - Slides along the Turn Table's slots to provide the backbone support at a specific radius



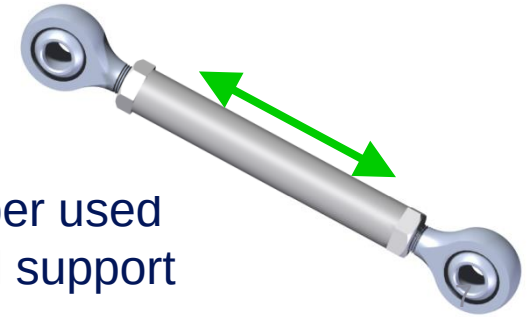
- **"Shelves"**
  - Provides a stiff circumferential platform at a specific elevation



- **"Shoes"**
  - Pads used for rounding the article driven by threaded rods within the "Shelves"

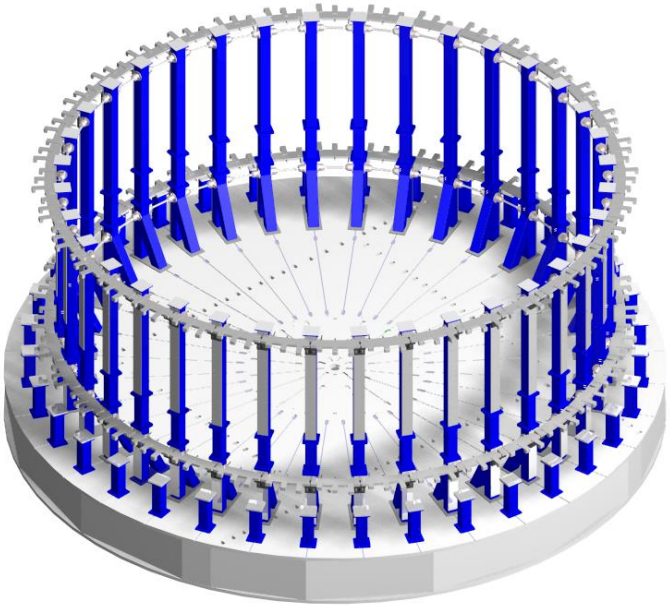


- **"Knuckles"**
  - Clevis devices used for pinning Turn Buckles, capable of pivoting 45 or 90 degrees

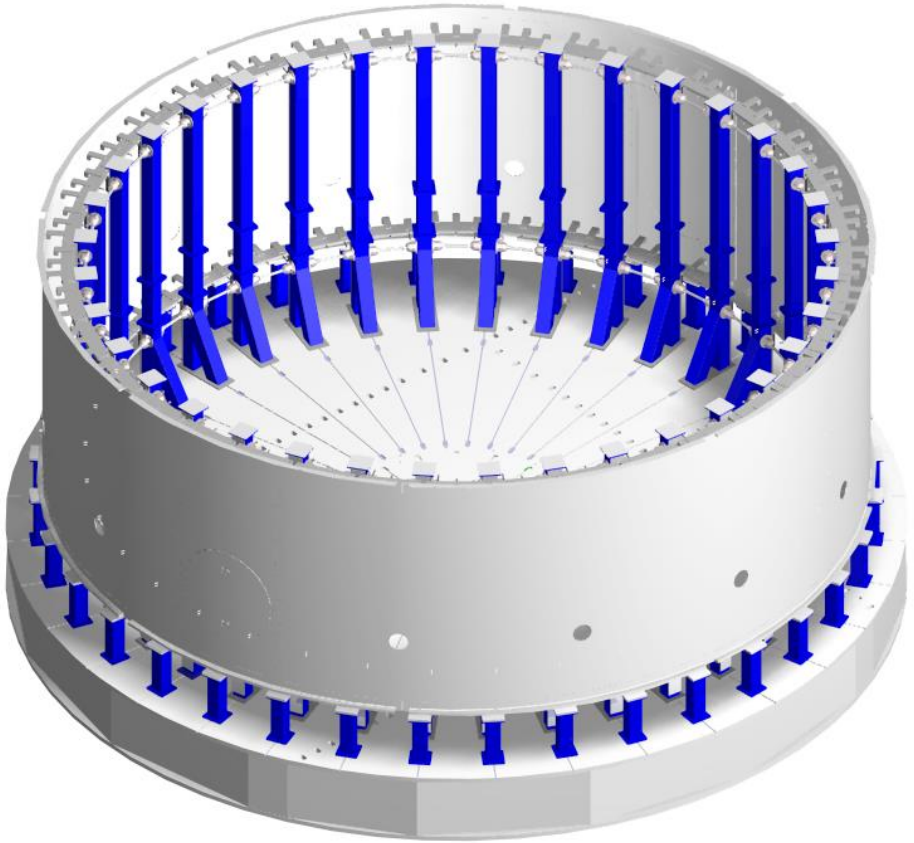


- **"Turn Buckle"**
  - Compression member used to provide additional support

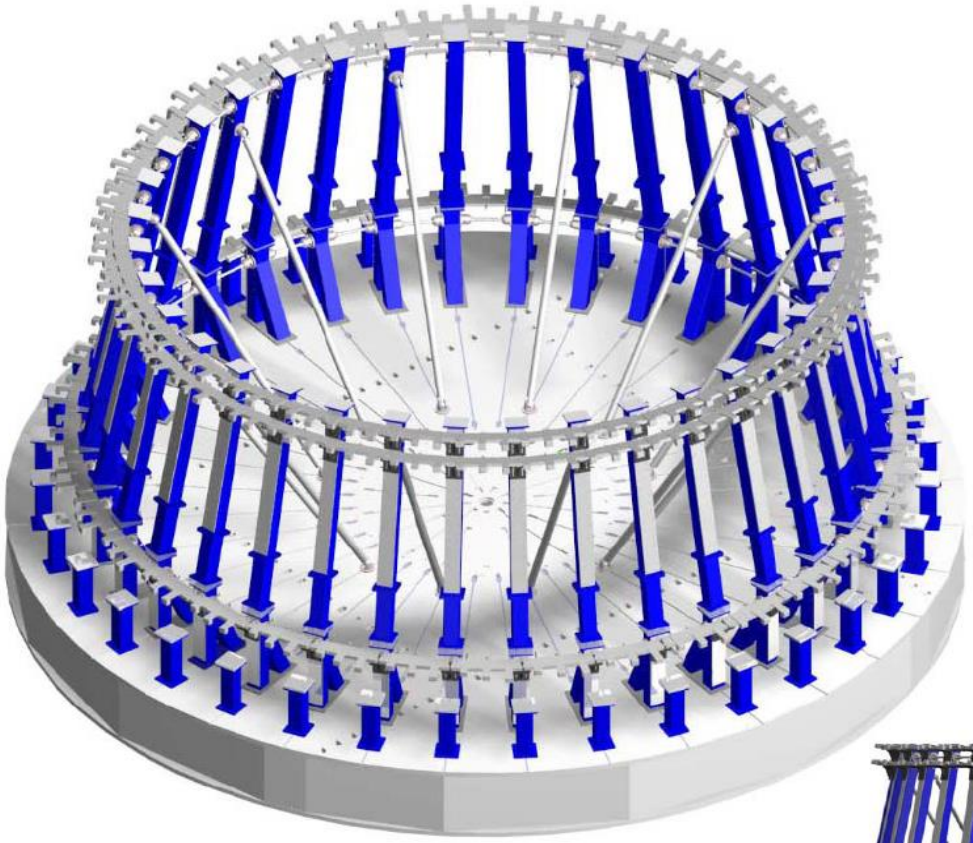
SLS: Core Stage Simulator Fixture

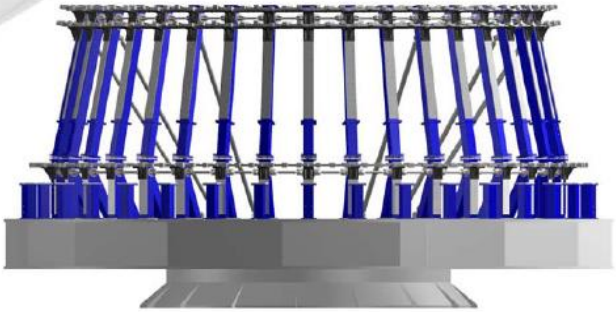


- Cylindrical
- Diameter 8.4 meters
- Height: 4 meters



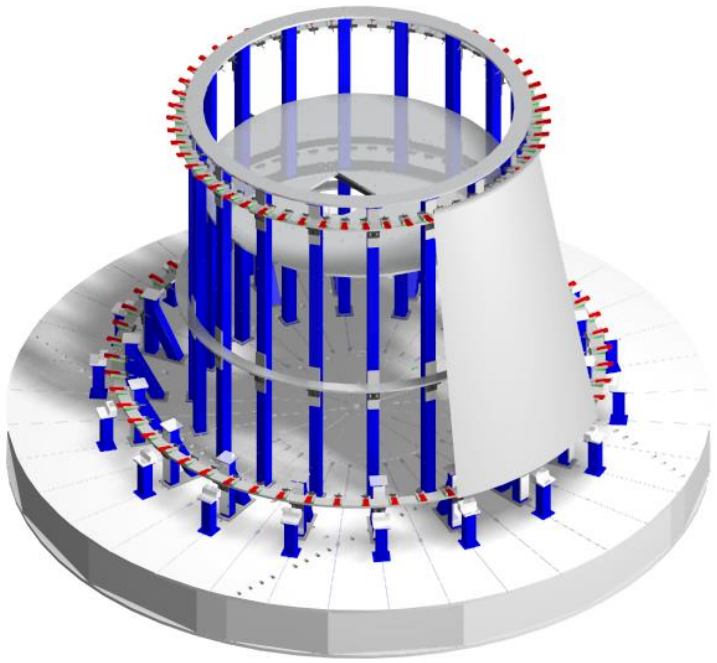
Modular model concept

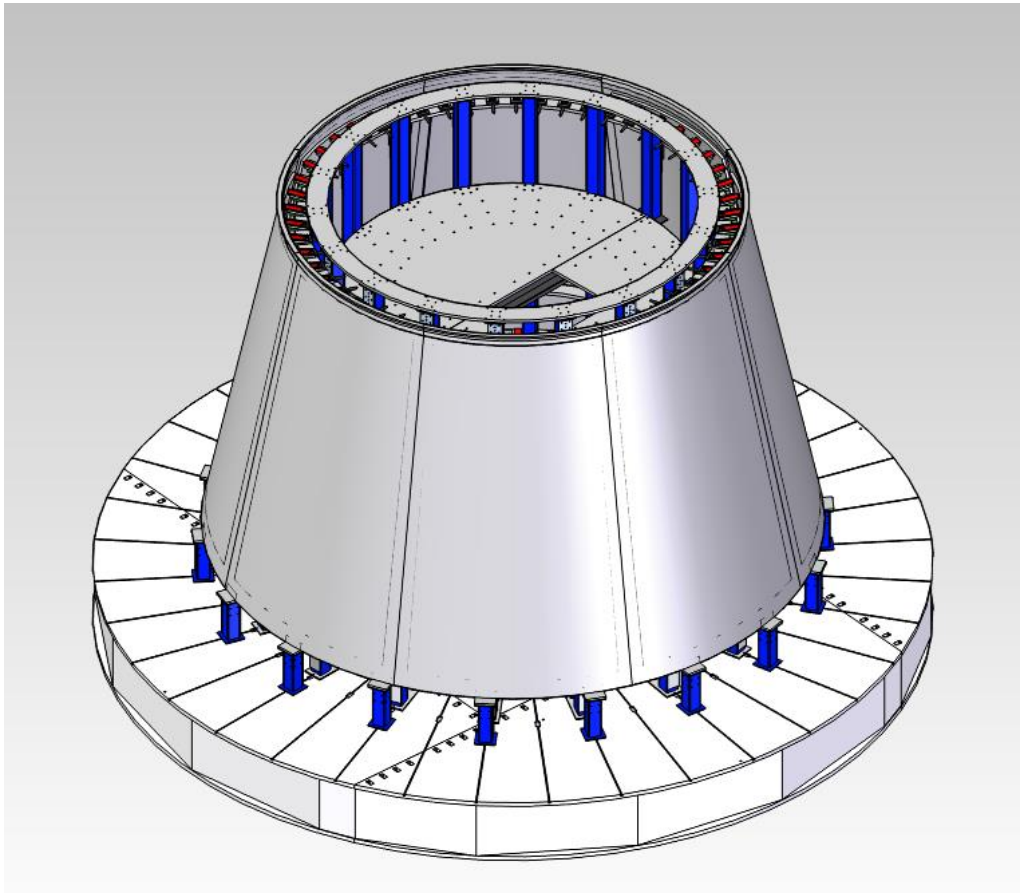




Modular Tooling can adjust to various configurations
Offering multiple solutions to fixture issues

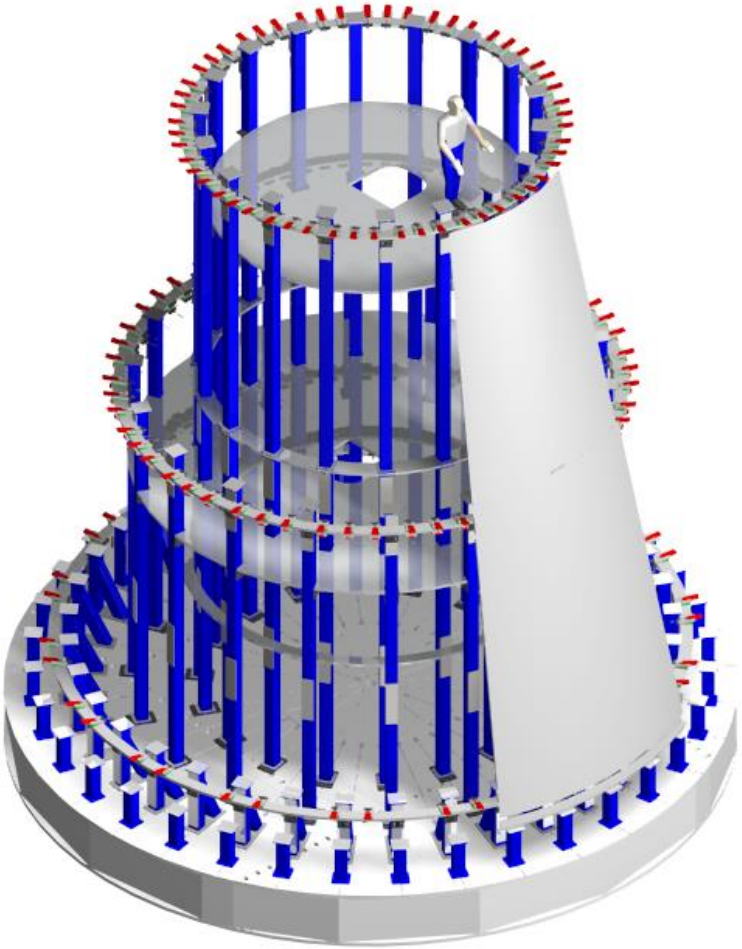
SLS: LVSA Fixture Configuration 1

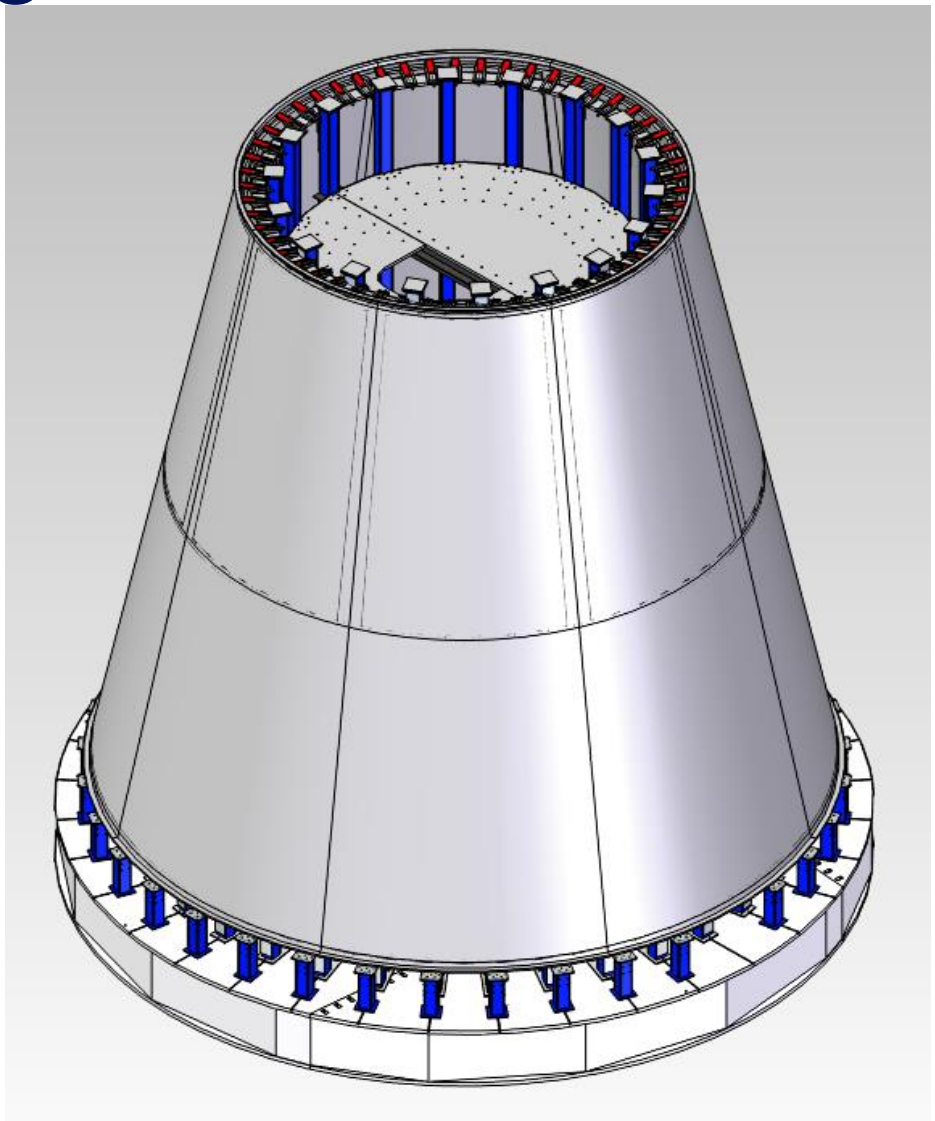




- Conical
- Diameter: 8.4 to 7 meters
- Height: 4.5 meters

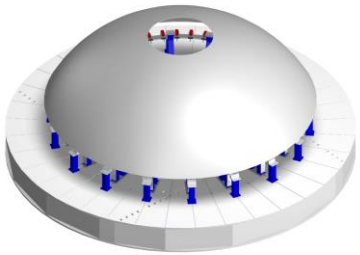
SLS: LVSA Fixture Configuration 2



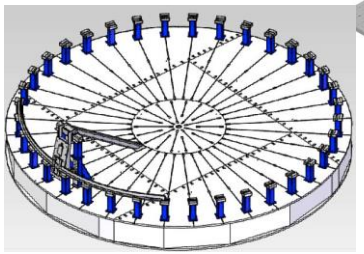


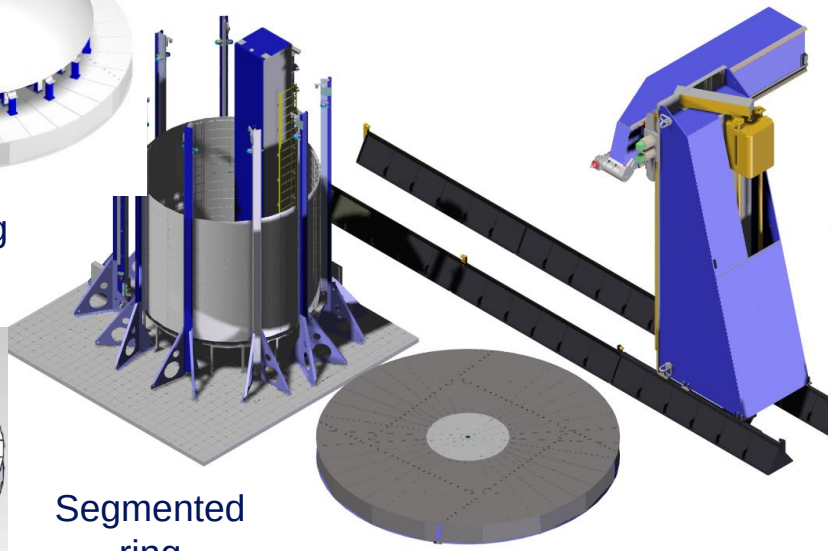
- Conical
- Diameter: 8.4 to 5.5 meters
- Height: 9.1 meters

Expanded Capabilities

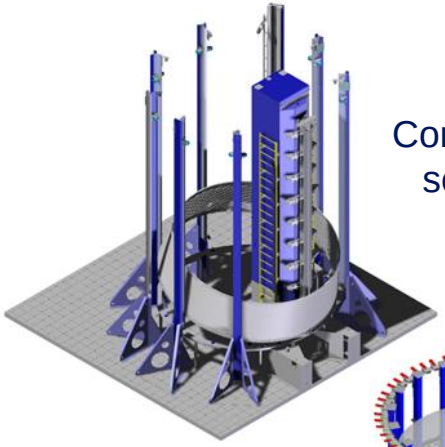


Caps & Y-ring to Domes

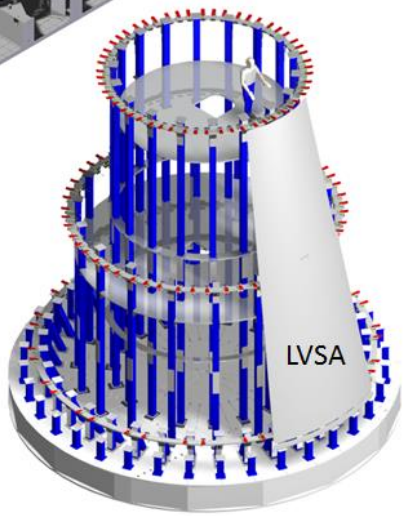




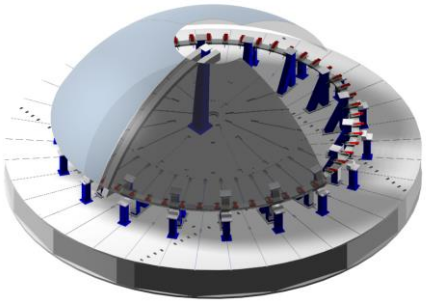
Segmented ring



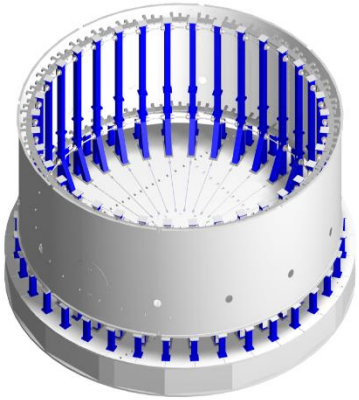
Cone to cone segments



Cone barrel to barrel



Gore to gore segments



Flange to cylinder

Modular tooling can accommodate multitude platforms (longitudinal, circumferential, complex curve, and circular)

Summary

1st Time Use				
Fixture Method	**Cost (Unit)**	**Time (Months)**		
		Design	Fabrication	Assembly
Traditional	10x	3	3	3
Modular Fixturing	1x	1	1	0.25

2nd Time Use (different configuration)				
Fixture Method	**Cost (Unit)**	**Time (Months)**		
		Design	**Fabrication**	**Assembly**
Traditional	10x	3	3	3
Modular Fixturing	0.05x	0.25	0.50	0.25

Modular Tooling saves time and money
Summary table reflects actual costs and schedules observed during SLS manufacturing

The journey to Mars
begins with…

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