Project 40 — 1/24 Scale Model V-2 Rocket/Tony Guyer

About the Model V-2 Rocket Project

Tony Guyer just completed this project and wanted to share it with our Sherline community. Here are the project details that Tony sent to us. "It consists of 1/24 scale model (about 2' high) of both the external rocket, as well as a second one, which shows all of the key inner components. The second item (internal components) were virtually all created with your CNC Mill and Lathe. Many parts were 3-axis milled. The internal components include the cross sections and longerons, which form the basic structure along with the propellant tanks, guidance section, turbopump, propellant distribution, servos, mechanical linkage, fins, steerable fin vanes, etc. Overall, there were approximately 750 parts to fabricate for this model. Research and design time spanned about two years, and fabrication and assembly about eight months."

On a side note, Tony says he corresponded with the US & Space Rocket Center in Huntsville Alabama, and they want to take his V-2 model on loan to display in their museum!

Following is Tony's complete write-up on his project.

1/24 Scale German V-2

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1/24 Scale German V-2 Project

Overview

This project involves the scratch-building of a German V-2 Missile. There are two models resulting from this project. The missile as seen when fully assembled and the second one reflects the inside structure and major components as seen when the outer skin is removed.

This project was chosen due to the major historical significance of the V-2 especially when viewed in terms of its importance to the genesis of space travel. The technology engineered into this machine was the basis in many aspects, for the Mercury Redstone Rocket which carried the first American Astronaut into suborbital flight.

There are many examples and models of the external appearance, but few or possibly none depicting the internal working parts.

Once the project was chosen, approximately 2 years of research including old actual design blueprints, many photographs, and a trip to the US & Rocket Space Center in Huntsville, Ala. to view and photograph an actual V-2.

Design of the model was developed in CAD and involved the the creation of approximately 750 parts. The majority of the parts were then fabricated utilizing Sherline's CNC Milling and Lathe machines. Another portion of the parts were created on a 3d Printer. Over 90% of the parts contained in the internal model are constructed from Aluminum.

The internal structure model does not show a warhead, as in the external one. This is primarily due to lack of available information, and likely there would not be many interesting details to show anyway.

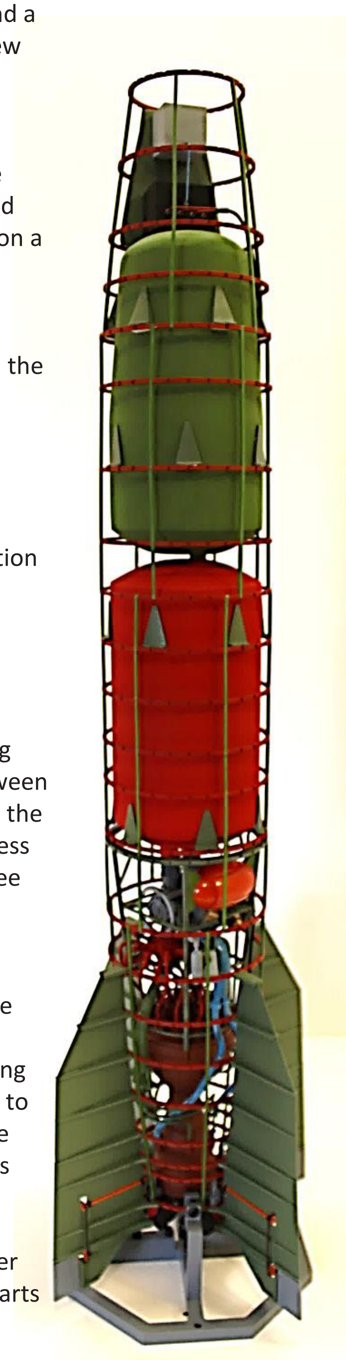
The following page identifies the major components of the internal model. Thereafter, details are provided on the creation of parts for the major components including the Propulsion System, Airframe Structure, and Guidance System.

2d vs. 3d Machining

Throughout this article, a distinction is made when machining operations are done in 3d instead of 2d. The difference between the two involves the fact that when a part is machined in 2d, the X, and Y surfaces vary in shape but are of a consistent thickness (Z-axis constant). With 3d machining, surfaces vary in all three axes.

Many parts of this model including much of the Fuel System, which was primarily cylindrical shaped pipes and tubing, were machined in a very high resolution 3d to achieve precise cylindrical shapes. As the resolution increases, each machining layer becomes less deep as does the step over distance (side to side), thus requiring longer machining times. Also, to achieve high resolution, smaller milling bits were used. In some cases 1/32" Ball Mills were used in this process.

For several of the 3d machined parts, 3 mils of depth per layer and 3 mils per step over were used. Some of the individual parts created for this model required in excess of 24 hours of machining time.



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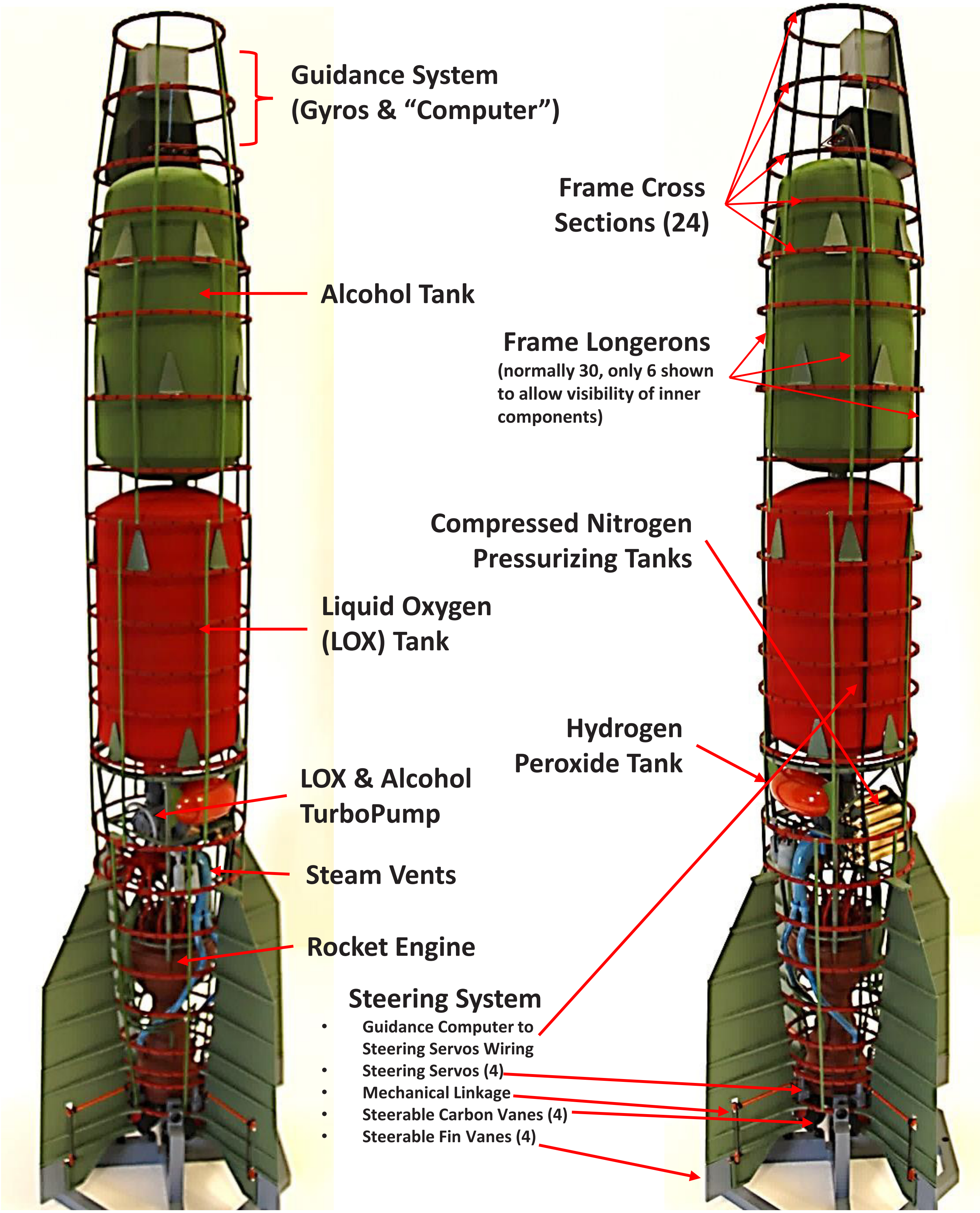
1/24 Scale German V-2 – Internal Structure



Notes:

1) Colors chosen for the internal model are not representative of an actual V-2, but were selected to more easily distinguish key components.
2) Warhead not shown since no detail could be found.

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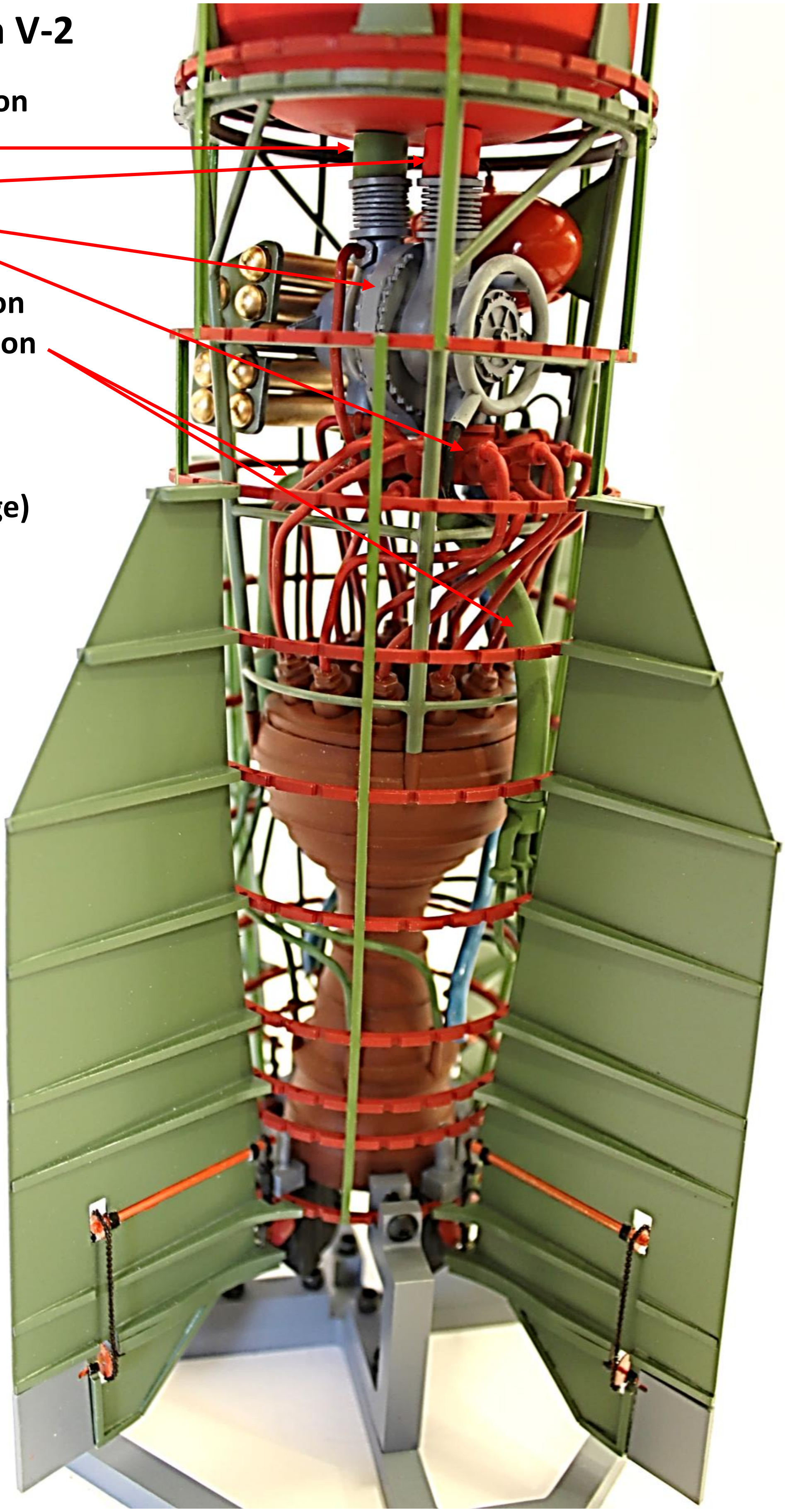
1/24 Scale German V-2

Propellant Distribution

- **Alcohol Inlet**
- **LOX Inlet**
- **Turbo Pump**
- **LOX Manifolds & Engine Distribution**
- **Alcohol Distribution**

(More detailed photos on next page)



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V2 Rocket Engine

Well - you can't have a Rocket without a Rocket Engine, so let's start there first.

The Rocket Engine shown in Figures 6-7 consists of 57 parts. The main portion of the engine was fabricated in two sections (Figs. 1, 2, &5) on a lathe using 1.75" Diameter 6061 Aluminum Solid Rod. Some additional milling was then required to accommodate the Alcohol Inlets and Turbo Pump Cage Attachments. The inside of the engine nozzle is tapered and was opened up using 3d milling. The top and bottom sections were then pinned and glued together.

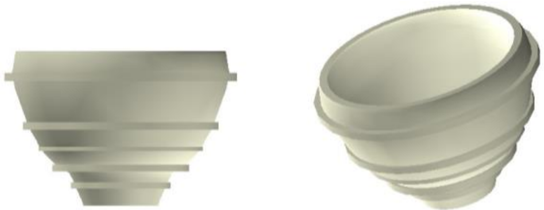

Figure 1 – Rocket Engine Top Section

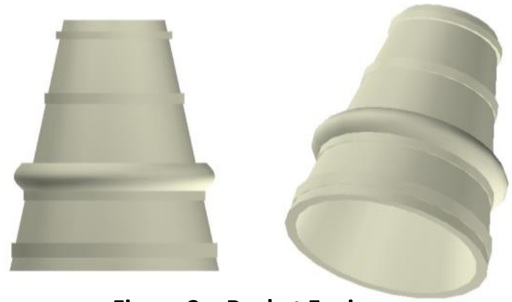

Figure 2 – Rocket Engine Bottom Section

Because of the contour, the Engine Cone (Fig. 3) was 3-Axis Milled (6061 Aluminum Sheet). Special tooling was used to set the cone at various incline angles to mill locations for the Burner Caps. Finally, the Burner Caps (Fig. 4) were milled from Aluminum.

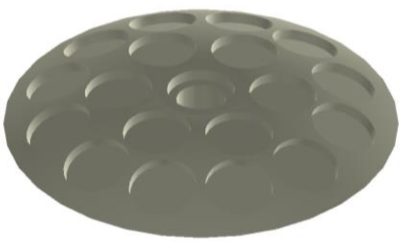

Figure 3 – Engine Cone

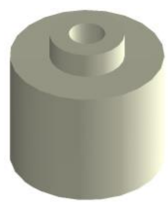

Figure 4 – Burner Caps

Figure 5 – Alcohol Inlets

Due to the tapering the Alcohol Inlets were also 3-Axis Milled.

Figures 6 & 7 show the full Engine Assembly.

Figure 5 – Rocket Engine Fabrication on Lathe

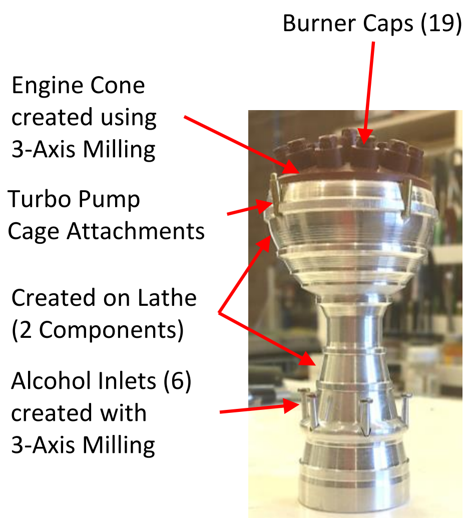

Figure 6 – Rocket Engine Components

Figure 7 – Rocket Engine Completed

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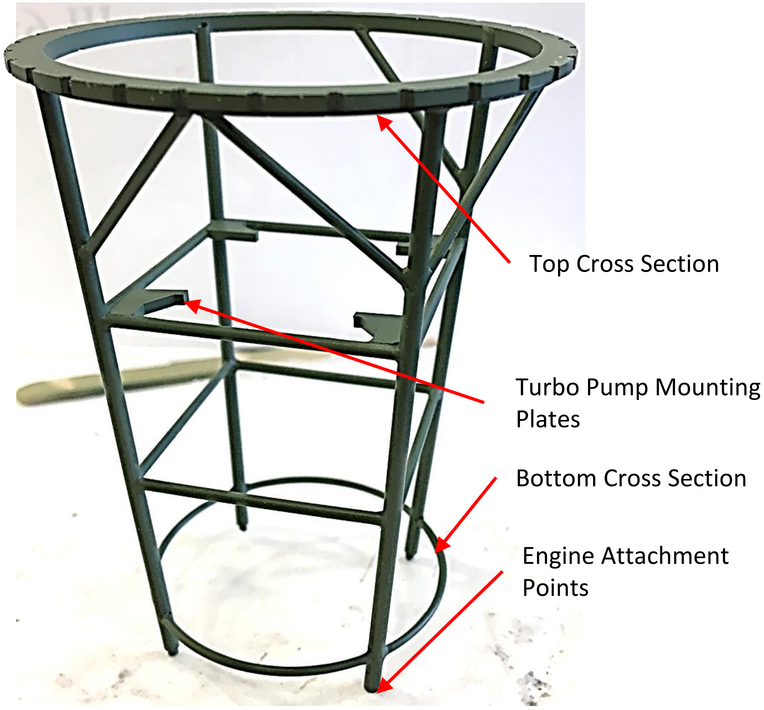

Figure 8 – Thrust Cage

<u>Thrust Cage</u>

The Thrust Cage shown in Fig 8 Attaches the Rocket Engine to the Missile Structure and also houses the Liquid Oxygen (LOX) and Alcohol Turbo Pump.

The top cross section was made similar to the other cross sections except out of thicker material. 3-Axis milling was used to create attachment joints for the vertical supports.

The bottom cross section is both ring shaped and round. This part was made by 3-Axis milling using a 1/32” Ball Mill.

The vertical supports were made from stock tubing with angled holes milled using special tooling to accommodate the horizontal supports.

Turbo Pump Mounting Plates were milled from Aluminum.

Figs 9 & 10 show the finished Thrust Cage-Turbo Pump-Rocket Assembly

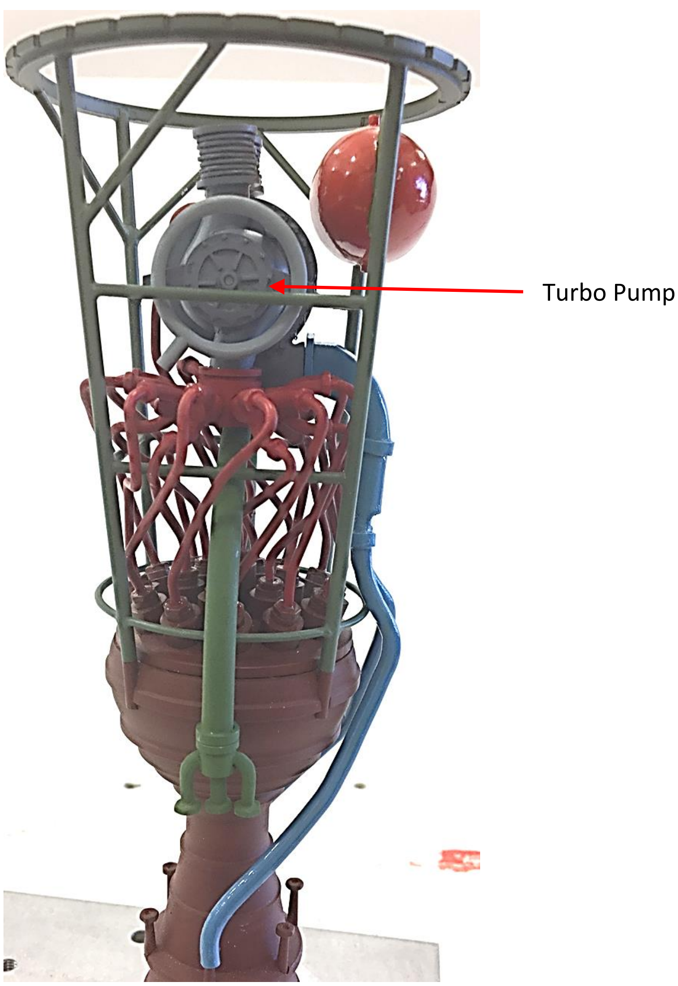

Figure 9 – Thrust Cage Assembly

Figure 10 – Thrust Cage Assembly

Turbo Pump

The Turbo Pump was built from 11 parts (Fig. 11/12).

The four pumps and center section were 3-Axis milled using 3/8” sheet Aluminum.

The core was produced by reducing 3/8” Aluminum rod to the correct diameter using a Lathe.

The bolt patterns were created by milling 0.02” aluminum using a 1/32” Flat End Mill (FEM).

Fig. 13 shows the beginning of assembly starting with the Core and Center Section. The completed assembly is shown in Fig. 14.

Although a separate component, the Steam Manifold shown in Fig. 14 is mounted to the Turbo Pump.   Due to the shape of this part being a toroid, 3d milling was used to create it from 1/8” sheet aluminum using a 1/16” Ball Mill.

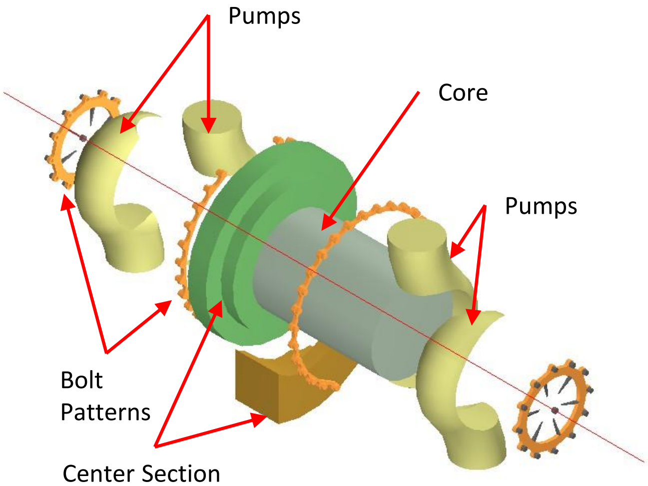

Figure 11 – Exploded View of Turbo Pump components

Figure 12 – Turbo Pump

Figure 13 – Start of Turbo Pump Assembly

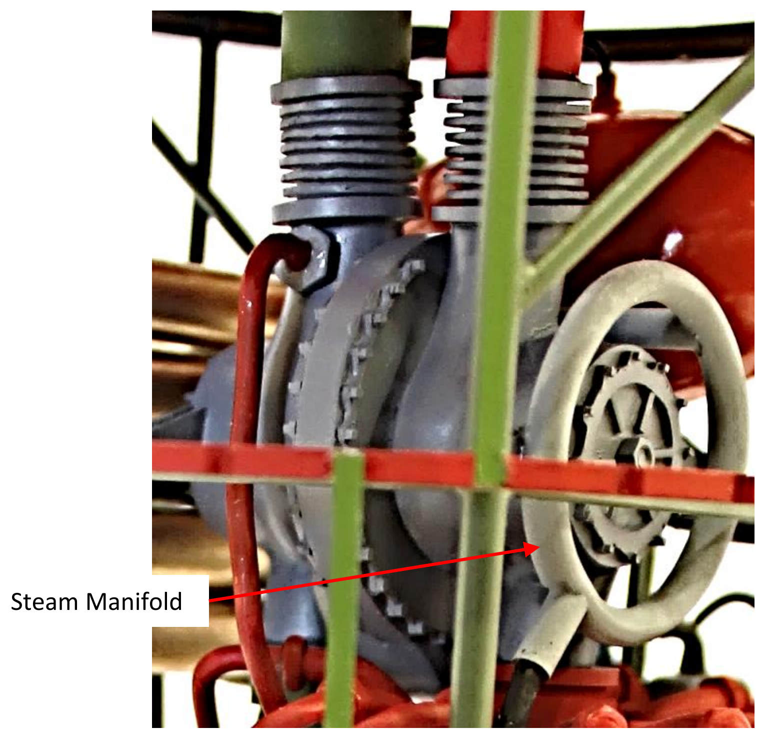

Figure 14 – Turbo Pump Completed Assembly

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LOX Distribution

The LOX Distribution system is connected to the output of the LOX Turbo Pump and disperses propellant through the Manifolds and tubing shown below into the 18 Burner Caps of the engine (Fig.17).

The LOX Distribution system consists of 43 parts shown in Fig. 15 below.

The primary manifold was created on a lathe from Aluminum Rod. The recessed holes to accommodate the Secondary Manifold were milled at 60 degree rotational angles.

The Secondary Manifolds were machined using a similar process.

The dispersion tubes were individually 3d Milled using a 1/32” FEM from 1/16” Aluminum Plate.

Fig. 17 shows the actual finished assembly.

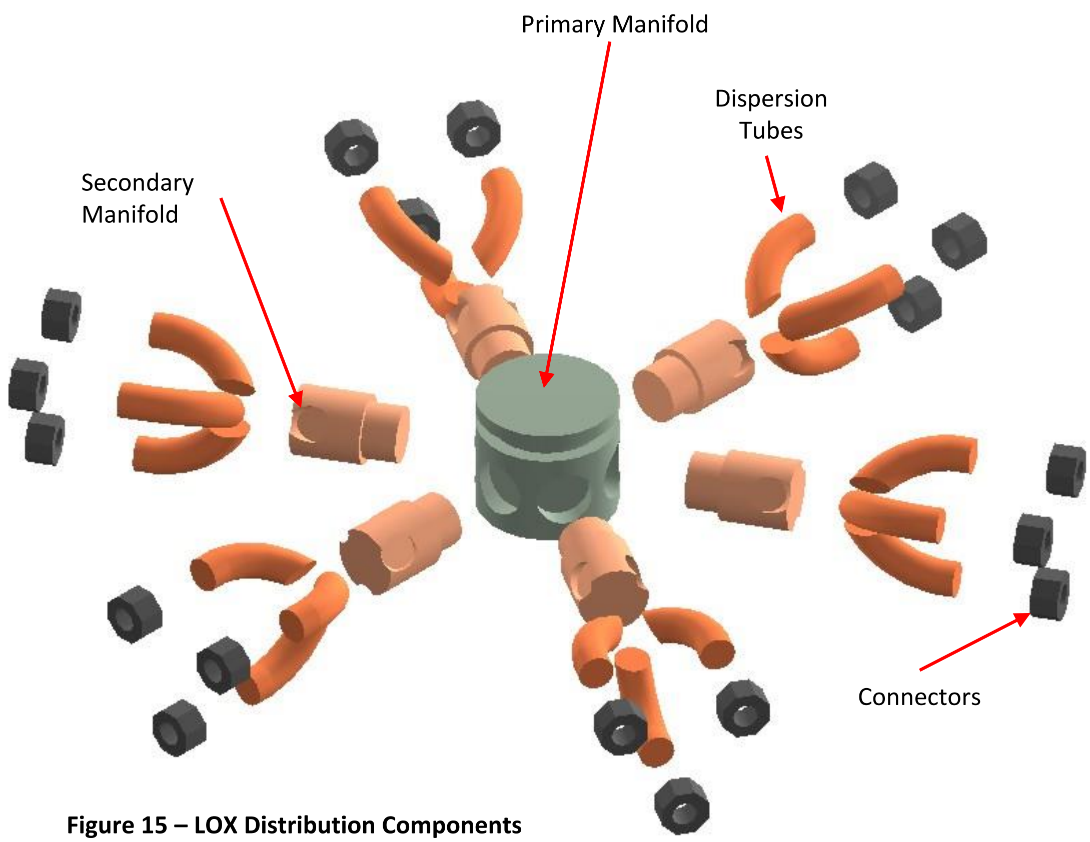

Figure 15 – LOX Distribution Components

Figure 16 – LOX Distribution Assembly

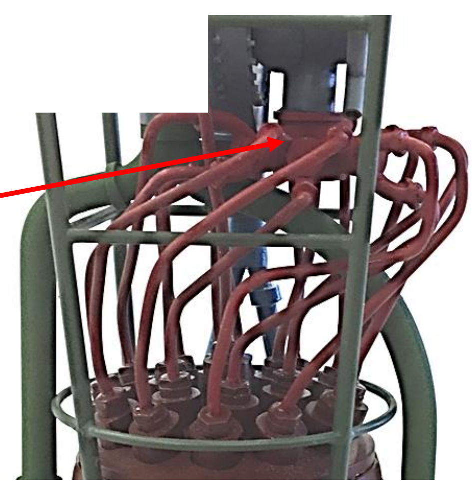

Figure 17 – Actual LOX Distribution Assembly

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Alcohol Distribution System

The Alcohol Distribution system is connected to the output of the Alcohol Turbine Pump (Fig 20) and disperses propellant through the plumbing shown below to the six Inlets on the Rocket Engine (Fig 21).

Due to the unusual and unsymmetrical shape and requirements for very precise placement, the Alcohol Main Tee was 3d Machined from ¼" Aluminum Plate using a 1/16" Ball Mill.

The two Manifolds were created from ¼" Aluminum rod on a lathe and then machined to accommodate the Outlets.

The Outlets were 3d Machined from 1/16" Aluminum Sheet with a 1/32" Ball Mill.

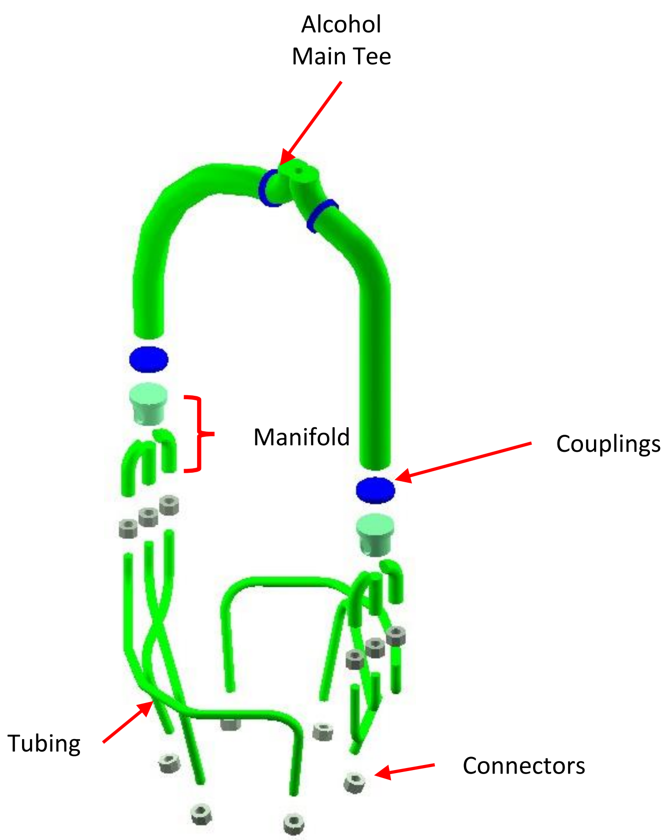

Figure 18 – Exploded View of Alcohol Distribution Assembly

Figure 20 – Actual Alcohol Distribution Assembly Upper View

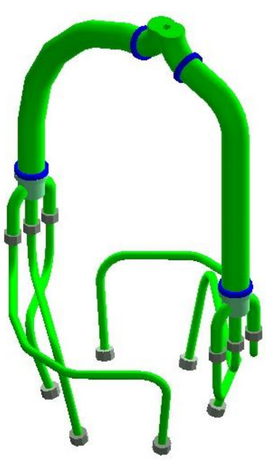

Figure 19 – Alcohol Distribution Assembly

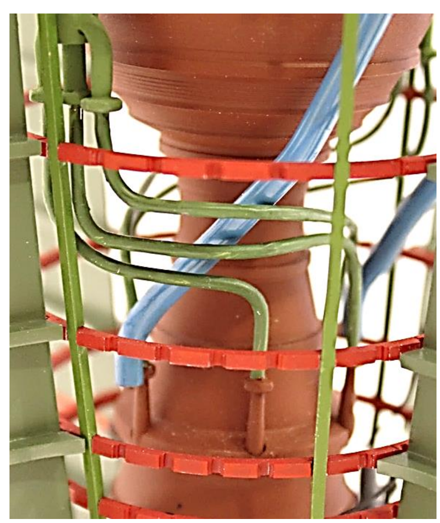

Figure 21 – Actual Alcohol Distribution Assembly Lower View

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V2 Framework

The V2 Framework consisted of 24 circular Cross Sections and 30 Longerons as depicted in one of four sections of the rocket shown in Fig. 22.

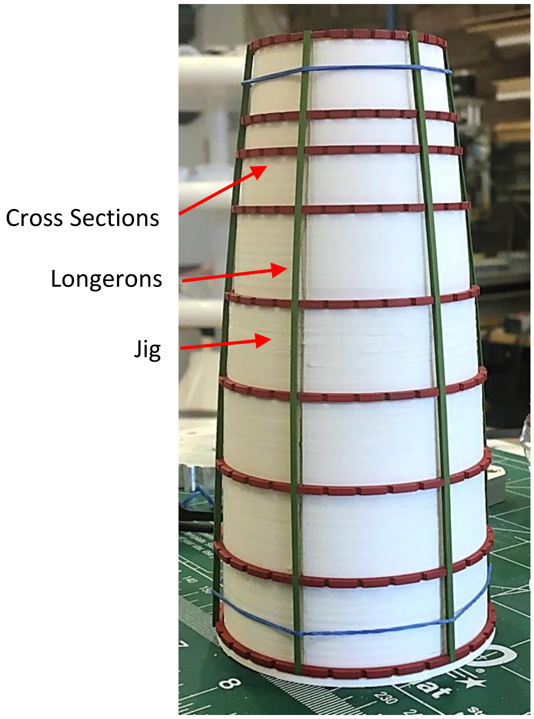

Figure 22 - Framework

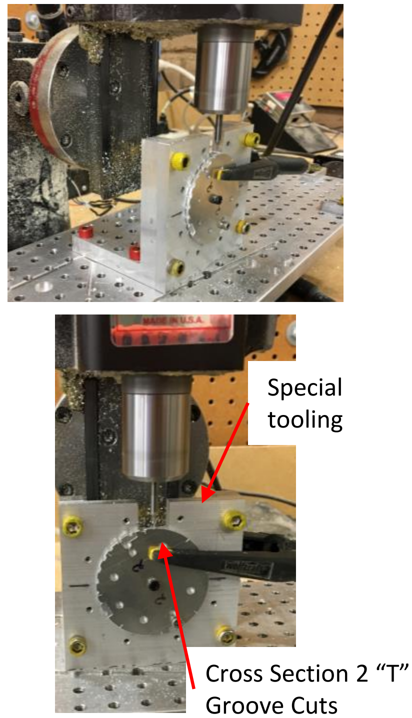

Figure 23 – Rocket Cross Section Fabrication

Figure 24 – Cross Sections after Step 2 completed

The Cross Sections, shown in Fig. 21,were fabricated from 1/16” 6061 sheet aluminum. Fabrication of each Cross Section was a 4-step process.

- Step 1 involved drilling a hole pattern in each disk which would facilitate accurate rotational placement for cutting the 30 “T” grooves in each Cross Section required for inlay of the “T-Bar” shaped Longerons. This also required some special tooling as shown in Fig. 23.
- Step 2 required cutting the Cross Sections to the correct diameters (examples in Fig 24).
- Step 3 was to cut 30 “T” grooves into each Cross Section as shown in Fig. 23 to the dimensions shown in Fig 25.
- Finally in Step 4, the inner portion of each Cross-Section was cut and removed leaving a finished Cross Section which was 0.0625” thick with a width of 0.125” all of varying diameters required to meet the shape of the rocket.

The Longerons were also milled from 0.0625” 6061 sheet aluminum. The cross-sectional shape of each longeron is shown in Fig. 25.

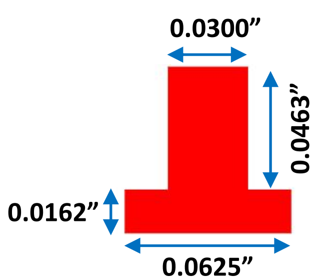

Figure 25 – Longeron Cross Section

After fabrication of the Cross Sections and Longerons, assembly of each of the four sections of the Rocket was accomplished by creating a jig for placement and alignment of the components. The jig was constructed using a 3d Printer and is shown in Fig. 22.

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Fins & Guidance

Key parts of the fin structure and guidance components are shown in Fig. 26 & 27.

The Fin Centers were machined from very thin 0.01" Aluminum sheet. Fin ribs and steerable fin vanes were machined form 1/16" Aluminum plate.

The mechanical portion of the Guidance System consisted of the Servos, Mechanical Linkages, Sprockets, Chains, Fin Vanes, and Internal Carbon Vanes which directed the rocket thrust.

The Servo Gearbox was machined from 3/16" Aluminum. Mechanical Linkages were machined from 1/32" Aluminum with a final thickness of 0.02" using a 1/32" FEM.

The sprockets were machined from 1/32" Aluminum sheet to a final thickness of 0.02" using a 0.025" FEM. An extremely small FEM was required due to the tooth density of the sprockets.

The Internal Carbon Vanes were produced on a 3d Printer

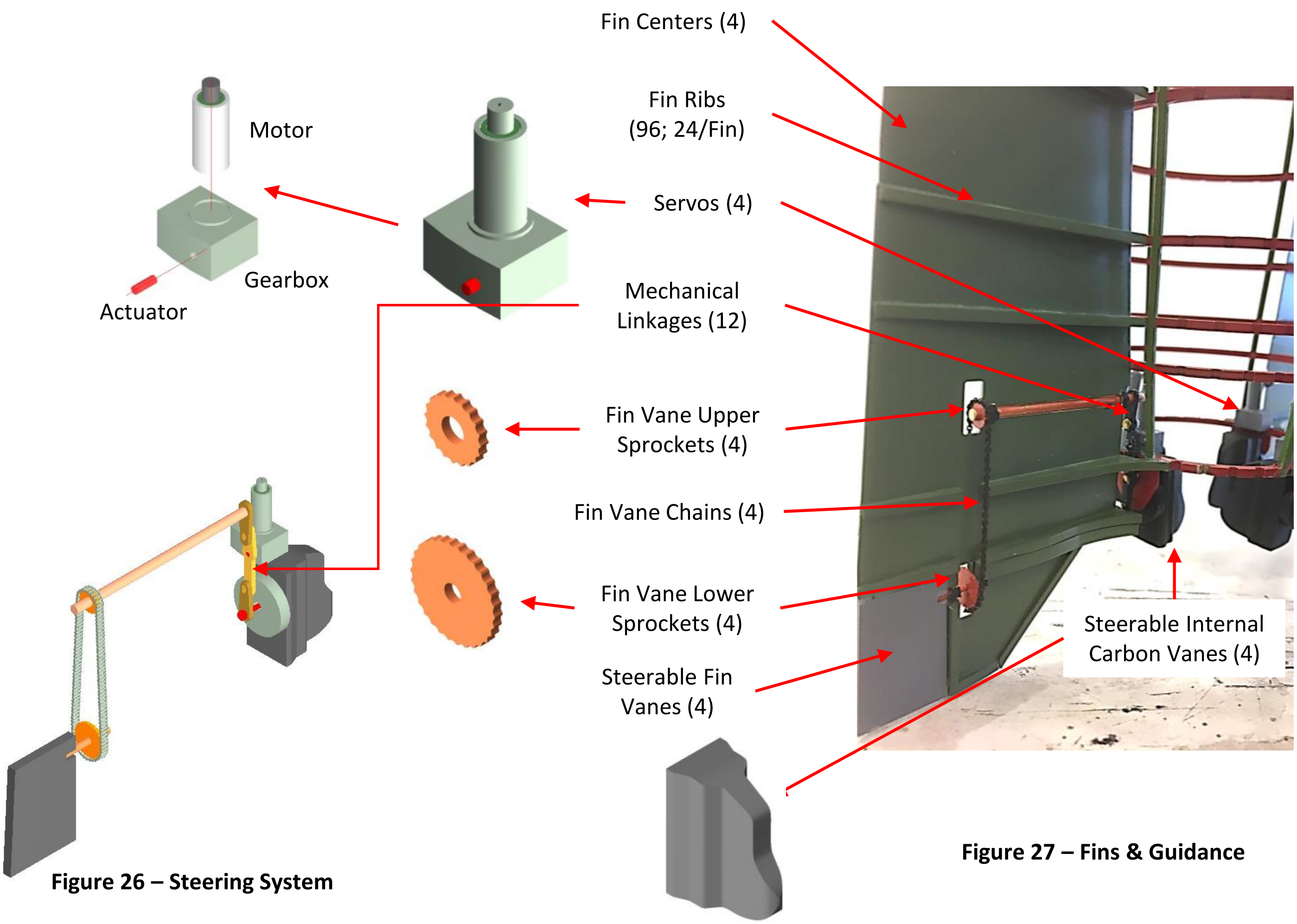

Figure 26 – Steering System

Figure 27 – Fins & Guidance