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Designing and Modeling of Saturn V base on Juno New Origins

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Abstract. Saturn V, utilized by NASA during the 1960s Apollo program, stands as a pivotal heavy-lift rocket in space exploration history. Its design and fabrication mark a significant chapter in spaceflight history. Through an amalgamation of Saturn V's authentic design parameters and Juno New Origins' sophisticated modeling tools, we proficiently resurrected this emblematic rocket system. This investigation delves into design methodology, model validation, and the advantages of Juno New Origins for Saturn V spacecraft modeling, offering a fresh vantage point for spacecraft design and simulation research. The modeling process spans four sections: S-IC, S-II, S-IVB, and supplementary modifications, exclusively utilizing Juno New Origins. Empirical evidence from user studies underscores the model's commendable quality and efficiency, bolstering its credibility within aerospace engineering. Evaluation outcomes reveal overwhelmingly positive sentiments regarding the model's performance, highlighting its efficacy in simulating diverse rocket interactions and its practical indispensability within aerospace engineering.

Keywords: 3D modeling; Saturn V; Juno New Origins.

1. Introduction

The Saturn V rocket was one of the most important achievements in the history of American aerospace in the 1960s. It provided the necessary propulsion and technical support for the Apollo moon landing program. However, accurately modeling Saturn V has been one of the challenges in aerospace engineering due to its complexity and massive size. In recent years, with the development of computer technology and the increasing improvement of simulation software, it has become easier and more effective to use computer modeling technology to research and analyze Saturn V.

In addition to being used in academic research and spacecraft design, Juno New Origins also have a wide range of application prospects. Especially in fields such as the film and television industry or toy companies, for jobs that require rocket models, Juno New Origins provides an easier-to-use, more cost-effective option. Through Juno New Origins, people can quickly create various types of rocket models and conduct virtual testing and demonstrations, thereby saving time and costs, and improving work efficiency and product quality. Therefore, Juno New Origins are not only important in the aerospace field, but also provide innovative and practical solutions to other industries.

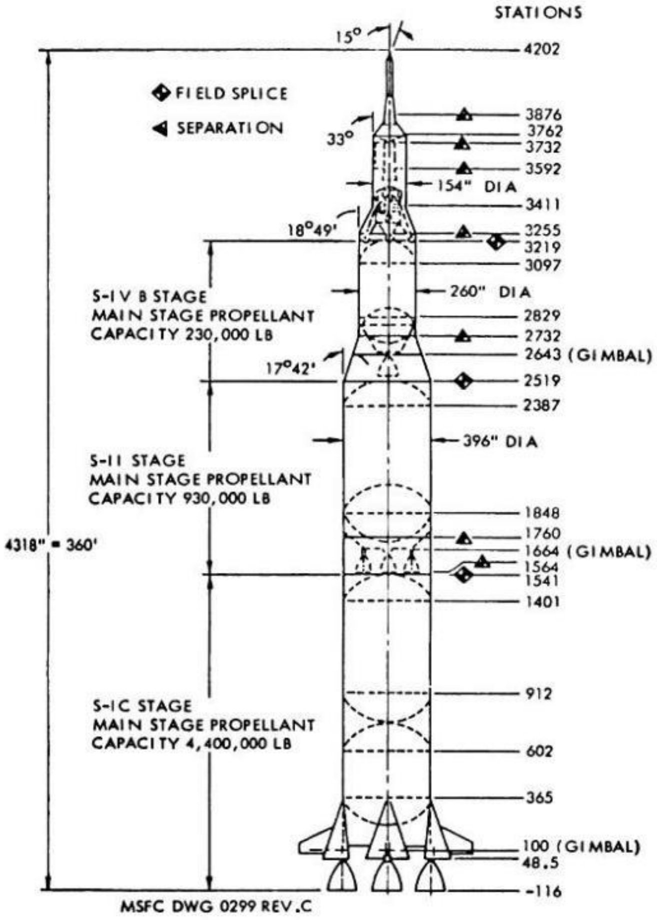
This research is to implement the modeling of Saturn V through Juno New Origins. Through the design drawings, the model is divided into four parts: S-IC, S-II, S-IVB and supplementary modification parts. After completing the modeling, the accuracy and time efficiency of the Saturn V modeled using Juno New Origins were compared with those modeled by other software.

2. The Design of Saturn V

This section serves as the cornerstone of the paper, outlining the fundamentals of constructing a Saturn V model and detailing the process using planar modeling-based software. In Juno Origins, various components have been carefully crafted to mimic the rocket's complex structure and functionality. Each component is calibrated in detail to ensure accuracy, with advanced capabilities to simulate complex phenomena such as phase separation and trajectory optimization, enhancing the realism of the final model.

The Saturn V modeling effort can be divided into several key parts. The first is the main thruster stage, which includes the five F-1 engines and their supporting structures. Next are the second and third stages, including the J-2 engines and corresponding propellant tanks. Finally, the modeling work included painting the rocket's skin. By modeling these key components, it is possible to create a comprehensive and accurate model of the Saturn V rocket that resembles the appearance and performance of the actual rocket.

In this article, Juno New Origins, as a software platform focused on spacecraft design and simulation, provides researchers with a convenient and powerful tool to design and model various types of rocket systems. Compared with traditional modeling software, Juno New Origins has an intuitive user interface, rich functions, and easy-to-use operation methods, making the spacecraft design and simulation process more efficient and flexible (Figure 1).



Saturn V Reference Dimensions

Fig. 1 The scale blueprints used for reference (Picture credit :Original)

2.1. S-IC

Liquid oxygen was used as the oxidizer in RP-1 fuel, which made up the majority of S-IC's mass upon launch (Figure 2) [1]. At sea level, it delivered 7,750,000 lbf (34,500 kN) [2] of thrust. The S-IC stage weighed roughly 303,000 pounds (137,000 kg) dry at launch, and 4,881,000 pounds (2,214,000 kg) total mass when fully fueled.

Five F-1 rocket engines are needed for the first stage. Choose the cylinder as the tank in the "Add" option, add it to the layer, then modify its height and width with the arrows. The stage measured 33 feet (10 m) in circumference and 138 feet (42 m) in height.

Then add five F-1 rocket engines and four wings. Now add an engine to the bottom of the cylinder you just modeled, and then use the Symmerty Mode function to model four more engines. The same goes for the wing modeling. After splicing the first wing surface to the rocket column, use the Symmerty Mode function to model the other three wing surfaces.

Mode: Disabled

Symmetry is currently disabled for this part

Symmetry Mode can be enabled for parts connected to the side of a fuel tank. It will dynamically create clones of the part around the circumference of the fuel tank.

Quick Mirror is useful for airplanes that may not have a central fuel tank to use as a symmetry root.

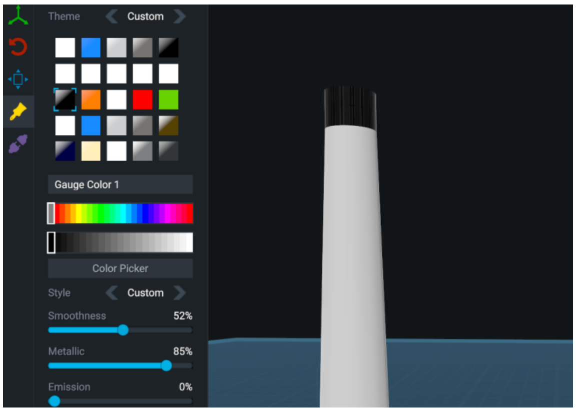
Fig. 2 S-IC (Picture credit :Original)

2.2. S-II

The S-II stage featured five Rocketdyne J-2 engines arranged similarly to the S-IC. It utilized four outer engines for control and ran on liquid hydrogen and oxygen. When fully fueled, it weighed 1,060,000 pounds (480,000 kg), with a dry mass of approximately 80,000 pounds (36,000 kg). In vacuum conditions, the S-II stage provided 1,100,000 pounds-force (4,900 kN) of thrust to propel the Saturn V through the upper atmosphere.[3].

The S-II has the same height and diameter as the S-IC. [4][5]Therefore when adjusting the cylinder height and diameter of the tank, it was also set to be 81.6 ft (24.87 m) high and 33 ft (10 m) in diameter (Figure 3).

In this process, use the Paint Tool to change the color and surface material of the cylinder. Set the color of the upper and lower circles to black, and adjust the Smoothness value to make the material close to a metallic texture.



Theme: Custom

Style: Custom

Smoothness 52%

Metallic 85%

Emission 0%

Fig. 3 S-II (Picture credit : Original)

2.3. S-IVB

The two tanks were kept apart by a shared bulkhead in the S-IVB. Its height was 58.6 feet (17.86 meters) and its diameter was 21.7 feet (6.604 meters). The S-IVB stage, while not as aggressively mass-efficient as the S-II, still boasted significant efficiency in its design [6]. When fully fueled, it weighed approximately 262,000 pounds (119,000 kg) and had a dry mass of about 23,000 pounds (10,000 kg). Sharing fuel with the S-II, it was equipped with a single J-2 engine [7].Aero Spacelines Pregnant Guppy, a cargo plane, could only carry the S-IVB rocket stage, which was the only one of the Saturn V's smaller rocket stages[8].

Next, add Command/Service Module (CSM), Lunar Module (LM), and Escape Tower (LES). The command module is the place where astronauts reside and work during most of the Apollo missions. While the service module houses the main engine, electrical and life support systems, and other systems required to support the command module, it also measures the vehicle's attitude and acceleration. The lunar module is specifically designed for lunar landing and return to lunar orbit. It consists of two parts: the descent module and the ascent module. The escape tower is not a component for the entire flight, but a system designed to protect the safety of astronauts in the event of launch failure. Shortly after confirming the launch safety, the escape tower will be abandoned.

In Add Part, select Command Chip, Command Disc and Nose Cone to model respectively. The CSM and LM are modeled with reference to the drawings, but it is worth noting the modeling of the LES (Nose Cone), because this is the top part, so its diameter must be small enough. Here you can use the Part Shape Tool to make more subtle adjustments to each Corner.

Supplementary and modified parts

The S-IC stage featured five Rocketdyne F-1 engines arranged in a quincunx pattern. While the central engine remained fixed, the four outer engines were equipped with gimbals for hydraulic steering control[9,10]. To improve accuracy, modifications were made to the engine modeling, including the addition of cones above the engines to match the prototype's shape. Additionally, the engine color was changed to gray and the material to metallic using Paint Tool.

Moreover, the words "United States" were added to the rocket fuselage. This is achieved through the label in Add Part. After adding label, in Part Properties, enter "United States" and change the font type, color and size.

3. Result

3.1. Results Display

After the modeling process is done, Juno New Origins supports models to be exported as .obj file for further utility. A simple online 3d viewer, Creator3D, is used to demonstrate the result as shown in Figure 4 .

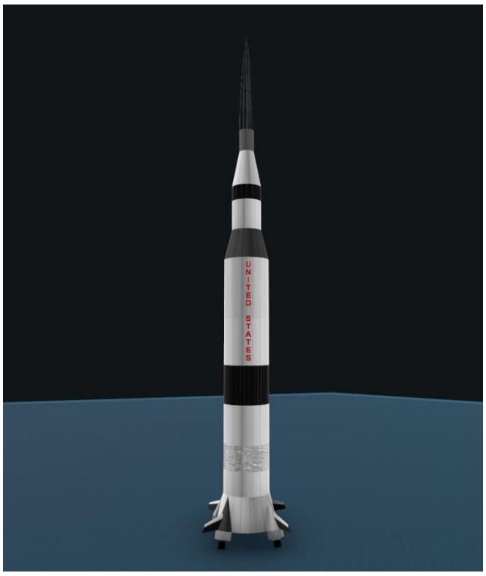


Fig. 4 Results Display (Picture credit :Original)

Comparing the result to the blueprint, above methods ensure the model is visually matching the blueprint of Saturn V Importing a scaled blueprint in Juno New Origins as a reference makes accurate ratios between each part and positions of intersections accessible. It saves approximately 6 hours of work compared to tradition modelling methods, which requires measuring the data manually from the blueprint. Modeling through Juno New Origins does not require manual measurement of data. It only needs to modify the height, width, diameter or the value of each corner of the added structure to achieve more accurate modeling (Figure 5).

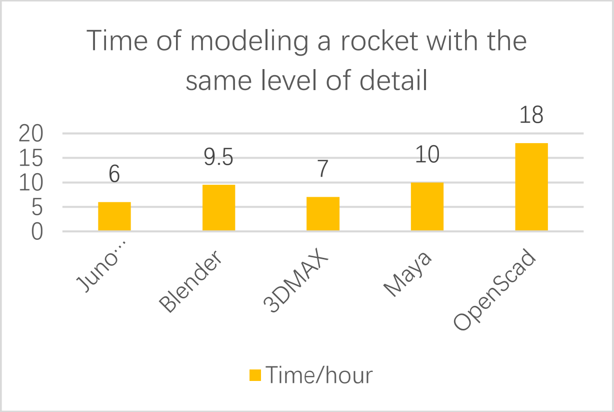


Fig. **5** Time of modeling a plane with the same level of detail (Picture credit :Original)

3.2. Evaluation

A study was conducted to assess the overall quality of the model compared to a realistic rocket in terms of appearance, details, and time efficiency. To ensure the study's validity, 30 subjects were divided into three groups: 10 with experience using Juno New Origins, 10 with experience in modeling with other software, and 10 with no modeling knowledge. Each group was presented with the blueprint, the model, a real-life picture of Saturn V, and the time required to model the rocket. Next, on a scale of 1 to 5, they were asked to rank each aspect; higher ratings denoted greater satisfaction (Figure 6).

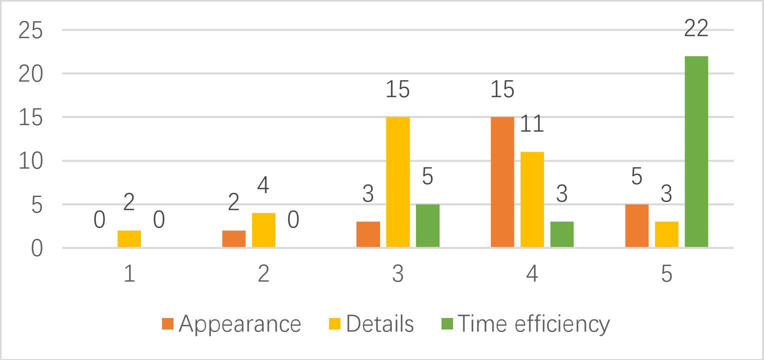


Fig. 6 User study (Picture credit :Original)

overall scores fall in the high range (3 to 5), that implies a decent quality of this model. Time efficiency, as expected, receives the highest comment, as 22 out of 30 subjects vote full marks. Subjects tend to acknowledge that this model has a pleasing appearance, but they find its details less impressive. This shows that Juno New Origins is efficient in modeling, but it is not flexible enough and lacks pertinence in detail construction.

3.3. Limitations

The user study revealed predominantly positive feedback on the model's performance, yet highlighted several areas for improvement. Specifically, while the model effectively achieves its primary objective of simulating interactions with various rockets against a realistic backdrop, it falls short in providing detailed internal representations of the rockets. Although the methods employed in this study demonstrate commendable efficiency gains, the model's inability to furnish internal details remains a notable limitation.

Moreover, feedback from a subset of 20 subjects experienced in modeling indicates a lack of unanimous enthusiasm towards adopting this modeling approach in their future work. Notably, only half of these participants expressed a willingness to prefer this method over others. The primary deterrent appears to be the trade-off between efficiency and freedom in modeling. While the proposed method significantly reduces workload, alternative approaches are perceived as better equipped to accommodate a broader spectrum of modeling requirements.

Consequently, future enhancements should prioritize augmenting the versatility of this method to address a wider array of modeling demands. Such improvements are pivotal in bolstering the model's appeal and adoption within the modeling community, thereby fostering its broader applicability in research and practical endeavors.

4. Conclusion

In conclusion, this paper delineates a comprehensive methodology for designing and modeling the Saturn V rocket using the Juno New Origins software platform. Leveraging its advanced tools and intuitive interface, we have achieved a notable level of efficiency and precision in recreating this iconic spacecraft system. The design process, model verification, and advantages of Juno New Origins in spacecraft modeling have been meticulously expounded upon, offering invaluable insights into spacecraft design and simulation research. User studies affirm the model's overall high quality, particularly emphasizing its appearance and time efficiency. The considerable reduction in modeling time compared to conventional methods underscores the practical significance of Juno New Origins in aerospace engineering and associated domains. Nonetheless, it's essential to acknowledge the identified limitations, such as the absence of detailed internal representations and the inclination towards modeling freedom among seasoned practitioners.

While Juno New Origins presents discernible efficiency enhancements, its specialization in modeling planes imposes certain constraints. Looking ahead, there lies potential to build upon this research to devise innovative methodologies that augment model intricacy without sacrificing efficiency. This may entail adapting existing tools or formulating new techniques tailored specifically for spacecraft modeling. By tackling these challenges head-on, we can further propel our capabilities in aerospace design and simulation.

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