MACHINA LABS

CASE STUDY

NASA TOROIDAL TANK CASE STUDY

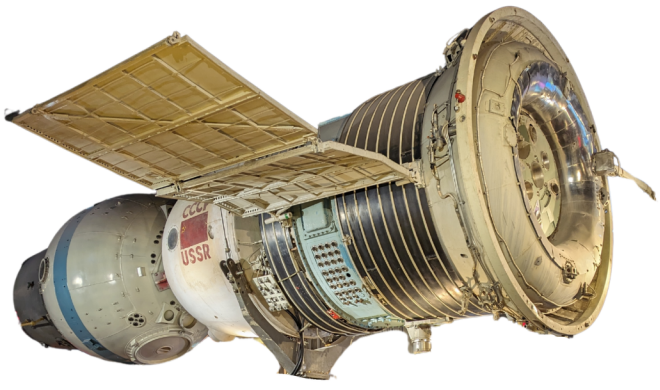
UNLOCKING AEROSPACE MANUFACTURING WITH THE AI-DRIVEN ROBOCRAFTSMAN

Artist rendering of the Blue Moon lander. Image Credit: Blue Origin / NASA

/ BACKGROUND

Since the 1960s, NASA and other space agencies, including the Soviet Space Program and the European Space Agency, have explored toroidal (donut-shaped) fuel tanks for spacecraft and lunar landers. These tanks offer volume-efficient storage of propellants and integrate seamlessly with other spacecraft components.

The extreme complexity of manufacturing toroidal tanks led NASA to abandon the concept due to the skilled manual labor and specialized tooling required to manufacture these tanks. To overcome this challenge, **NASA selected Machina Labs and its AI-driven RoboCraftsman™** manufacturing platform for the production of a toroidal tank.



A toroidal tank displayed on a high-fidelity model of the USSR Soyuz 7K-OK, which flew from 1967-1971. Photo Credit: National Space Centre, United Kingdom.

/ SOLUTION

Machina Labs used the RoboCraftsman to fabricate the toroidal tank panels without molds or dies, eliminating the most significant barrier to scalable production. The process included:

- **RoboForming™**: The platform shaped Aluminum Alloy panels with precision, using an initial material thickness of 0.125 in (3.175 mm)
- **RoboScanning**: Integrated laser scanning ensured quality control and accuracy before post-processing
- **RoboTrimming & Drilling**: Each panel was machined to remove excess material. Heat-treatment was completed separately on this project
- **Assembly & Welding**: The final tank assembly consisted of 32 distinct panels with 2 unique geometries (inner and outer)

/ BENEFITS SUMMARY

- **87% Cost Savings –** $100,000 per tank compared to $1.5 million estimated with traditional manufacturing
- **Production Speed Increased Up to 75% –** Completed tank production in 12 weeks instead of the typical 10 to 19 months using conventional manufacturing processes

/ RESULTS

Toroidal Tank Panels Delivered to NASA

Material: Aluminum Alloy (AA5052-H32)
Starting Material Thickness:
0.125 in. (3.175 mm)
Inner Diameter: 11 ft. 3 in. (3.4 m)
Outer Diameter: 14 ft. 7 in. (4.4 m)
Assembly Completed: June 2024

Photo Caption: On the right, is a photo of a 2nd toroidal tank that is now on display at Machina Labs LA factory.

The RoboCraftsman platform eliminates the need for costly custom dies and molds, drastically reducing upfront tooling expenses. By automating and simplifying traditionally labor-intensive processes, Machina Labs streamlines production and enhances efficiency. Its adaptability ensures scalability, making it a viable solution for various aerospace applications beyond toroidal tanks. Looking ahead, future iterations of RoboCraftsman will integrate robotic welding, paving the way for fully autonomous tank and aerospace stucture production.

Most notably, the platform delivers unmatched cost and time savings, reducing manufacturing costs by **87% from $1.5 million to just $100K per tank, while accelerating production by up to 75%**, cutting timelines from 10 to 19 months to just 12 weeks. By demonstrating that AI-driven robotics can manufacture toroidal tanks at scale, Machina Labs is reshaping the future of aerospace structures and enabling groundbreaking advancements in space exploration.

Why It Matters: This project not only revives a promising fuel tank design for NASA and the space industry but also highlights the advantages of AI-driven robotic manufacturing in space exploration, aerospace, and defense. By enabling rapid iteration, reducing costs, and promoting agile production, **flexible factories equipped with RoboCraftsman represent the future** of advanced manufacturing.

/ TIMELINE OF EVENTS

STEP 1

/ Machina Labs responded to a NASA published study to make metal parts in space.
/ Initial contract was proposed and accepted

STEP 2

/ Machina Labs formed multiple parts (from adjacent application spaces) and shared results with NASA
/ Marshall Space Flight Center engaged to understand the types of parts that were needed.
/ Two tanks as parts were scoped (sphere and small toroid)

STEP 3

/ NASA shared toroidal designs, first attempt to form was unsuccessful
/ Machina proposed a new spherical design, 3 of the 4 hemispheres passed dye-penetrant testing, multiple hemispheres completed pressure testing
/ Machina completed subscale toroidal tank, pressure-tested it, and submitted to NASA MSFC

STEP 4

/ Machina Labs recieved a contract to produce a full-scale toroidal tank for NASA

STEP 5

/ Machina Labs completed 2 sets of toroidal tank panels.
/ One set was delivered to NASA to weld and assemble onsite.
/ The second set was welded and assembled at Machina Labs using a NASA provided fixture.