3D Printing In Space

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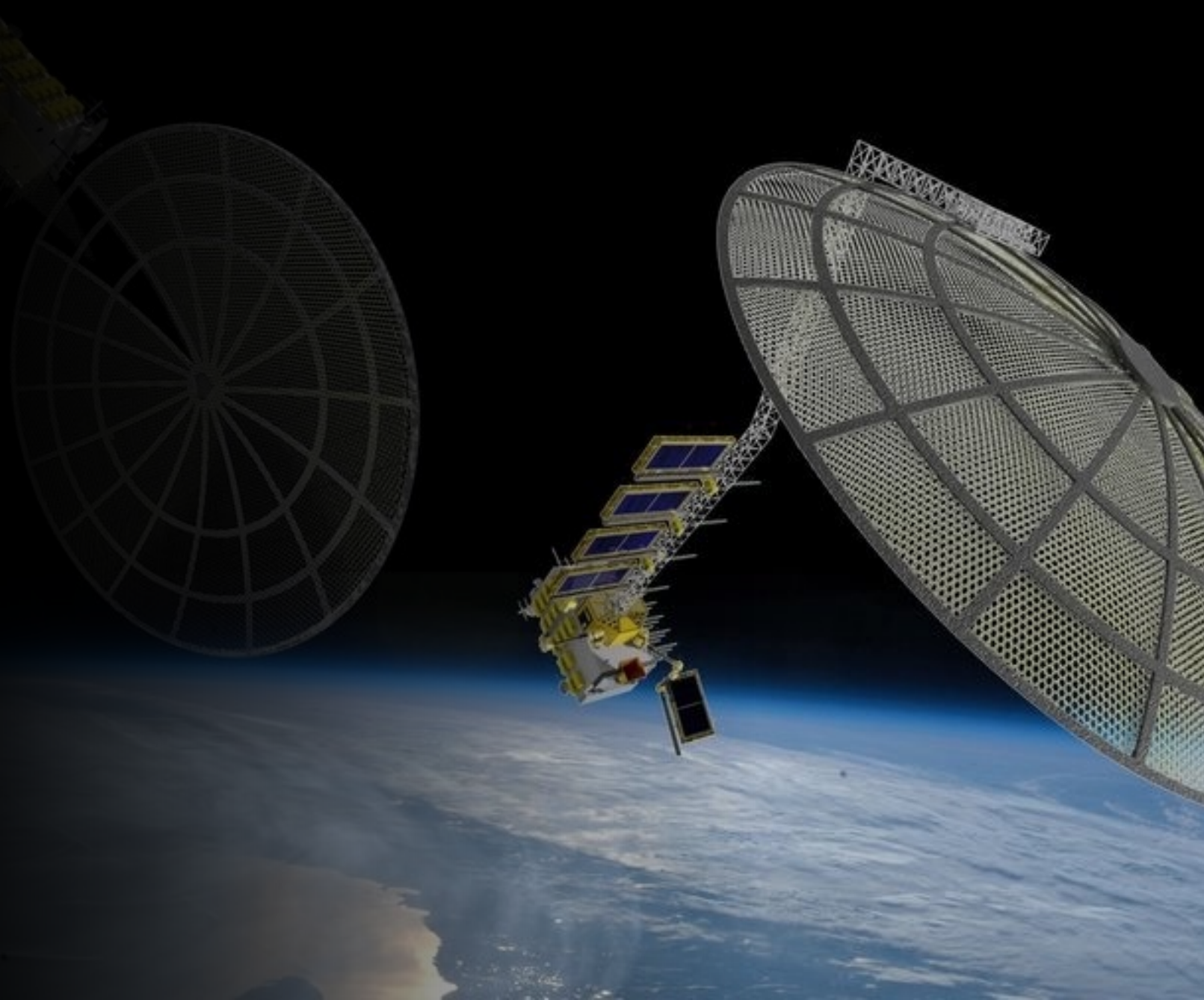


Companies Interested

NORTHROP GRUMMAN

ARTEMIS
3D SOLUTIONS

Costumer Request

- 3D printing in space is still in infancy, despite major advancement on earth in recent years. The OSAM2 mission led by Redwire with NGC support, is investigating the ability to print thermo plastic beams in space, but that effort is a small step, and the practical use of polymers in space is still uncertain. Possibly leveraging off the UTEP Keck Center's advanced additive manufacturing capability, this project will investigate printing metallic objects in space based on current planned ideas and possible alternatives they may derive.

Introduction

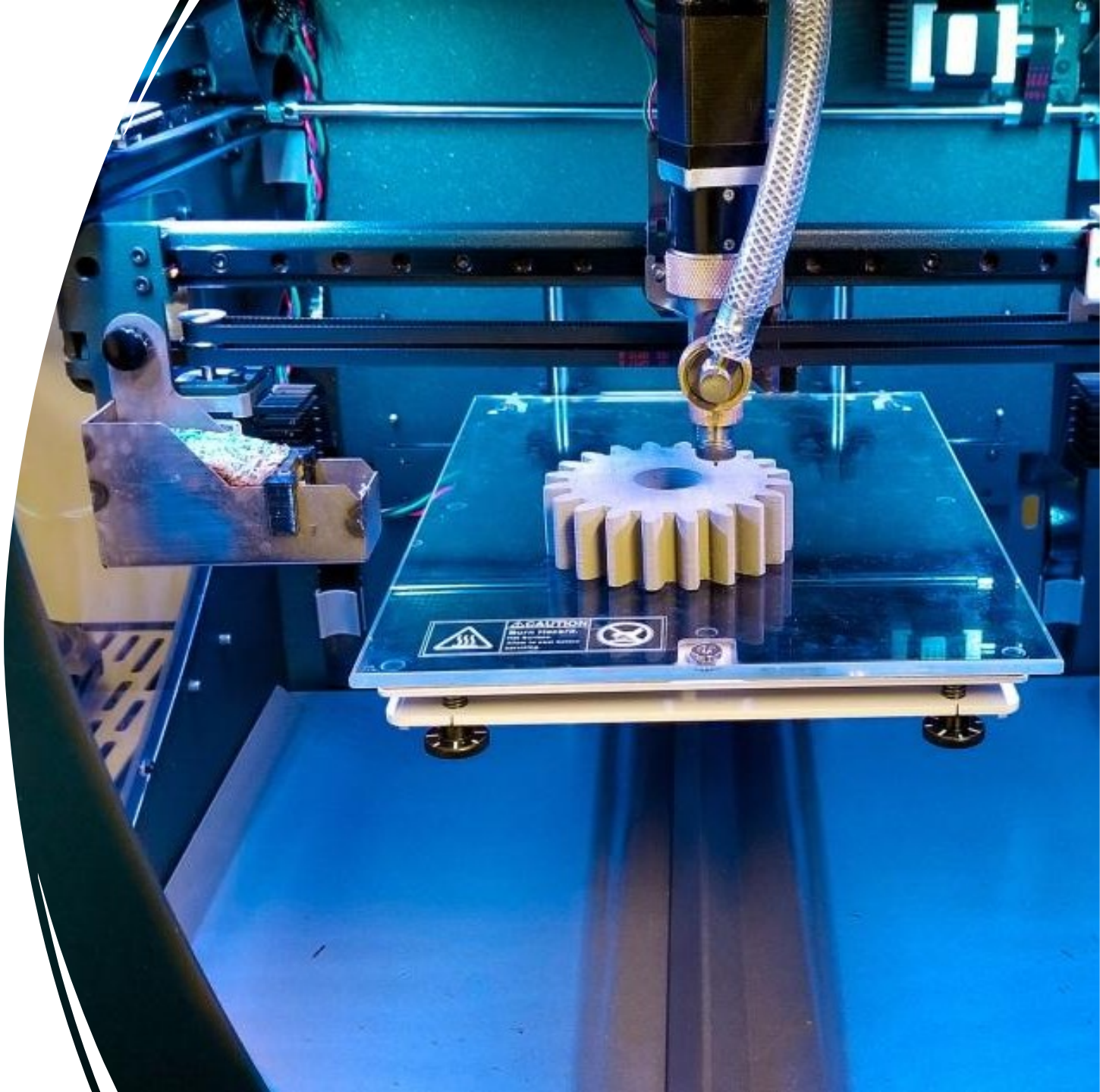
- 3D printing technology has revolutionized manufacturing on Earth, and now it is also playing a crucial role in space exploration. The University of Texas at El Paso's Department of Industrial, Manufacturing and Systems Engineering has conducted research on 3D printing in space, leading to significant advancements in engineering design and collaboration.

Robo Satellite

- The principal function of the satellite will be, to fix or assist damaged satellites.
- When a satellite is damaged and no longer working, is easier to send a new one rather than send it back to earth and fix it.
- For the closer satellites, it will fall out of orbit and burn up in the atmosphere. Further satellites are instead sent even farther away from Earth.

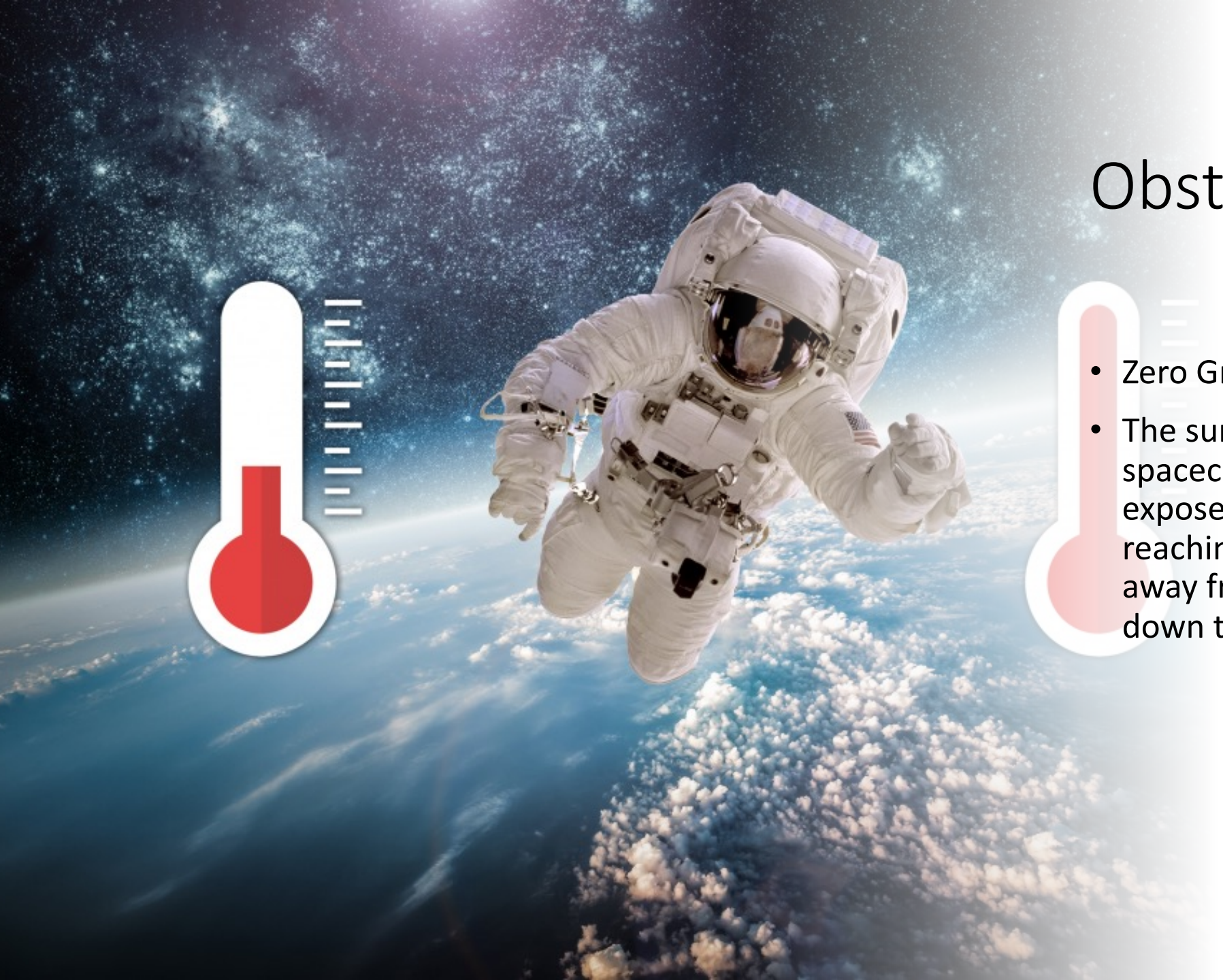
How the satellite will work

- The satellite will have a 3D printing machine to print the broken pieces of the damage satellite.
- Essential pieces of the satellite are the priority to fix.



Reason of the project

- This job is one of the most dangerous for astronauts because astronauts are outside the spaceship, and it is what keeps them safe.
- There are many variables or possibilities for something to go wrong risking astronauts' lives.
- Every time there are more satellites on orbit.
- There are 29,000 pounds of hardware spares/replacement units on the International Space Station waiting to be send back to earth and another 39,000 pounds on the ground ready to fly when needed.



Obstacles

- Zero Gravity in space.
- The sun-facing surface of a spacecraft on Low Earth Orbit is exposed to temperatures reaching 140 °C. Surfaces facing away from the sun are cooled down to -100 °C.

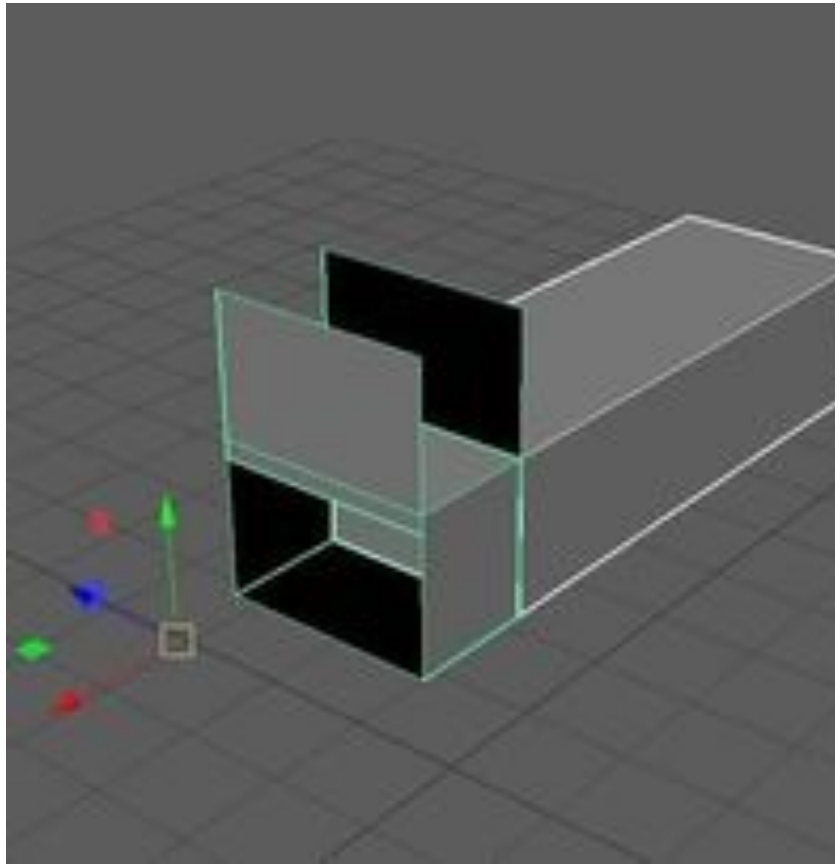
How a 3D printing machine works in space

- Analysis revealed that microgravity had no engineering-significant effects on the process, demonstrating that a 3D printer works normally in space.
- There is enough pressure that the filament is squished into the previous bed.
- Astronaut Samantha Cristoforetti working on the 3D Printer aboard the space station.

Design

- Satellite design, 3d machine inside, two robotic arms, doble door, **Thermal control systems**

- The protective box would have two sections, the interior compartment will carry the printer.
- In the second section, there will be two robotic arm that will help remove the parts from the printer. When the part has been taken, the door of the printer compartment will close, and a second door will open that will take the parts to the outside to use them, without compromising the 3D machine



Filament

- Z-PEEK is one of the strongest polymers on the planet.
- This material has withstood extreme temperatures.
- The material has been successfully tested in space environment on Low Earth Orbit and beyond.
- Z-PEEK has strength-to-weight ratio comparable to stainless steel.

Key Properties	Metric	Imperial	Test Method
Tensile Modulus	3720 MPa	540 ksi	ISO 527
Tensile Elongation	28%	28%	ISO 527
Flexural Modulus	2700 MPa	392 ksi	ISO 178

Outgassing Properties		
TML (%)	0.31	ECSS-Q-ST-70-02C
CVCM (%)	0.000	ECSS-Q-ST-70-02C
RML (%)	0.14	ECSS-Q-ST-70-02C

Extruder Machine

- Using recycled material for printer feedstock could save future long-duration exploration missions from having to carry a large supply of material for 3D printing.
- Recycling also could make use of material that otherwise would represent a nuisance or a trash disposal issue on these missions.

Satellite parts

- Satellites have to be light, as the cost of launching a satellite is quite expensive and based on weight. To meet these challenges, satellites must be small and made of lightweight and durable materials.

Insulation

- We will be dealing with temperature changes, and UV rays from sun. For this we designed a protective box lined with Muti-Layer Insulation (MLI).
- A satellite's thermal system protects its sensitive electronic and mechanical components and maintains it in its optimum functioning temperature to ensure its continuous operation.

Multispectral Cameras

Standard cameras, like those in cell phones, are optimized to take pictures that represent, as close as possible, what the eye can see. These cameras make use of a color filter array, known as a Bayer filter mosaic, with a Red, Green, and Blue (RGB).

Satellites use cameras to gather spatial and spectral data of the earth, identify structures, objects and features within the data. The goal is to recognise, classify and quantify changes. These changes may be of a spatial or spectral nature.

Antenna

- These components receive and transmit signals between Earth and the satellite.
- Signals in the higher end (X-, Ku-, Ka-, and V-bands) of this spectrum have more power; therefore, dishes as small as 45 cm (18 inches) in diameter can receive them.
- **Ku-band**, which offers higher transmission power over smaller geographic areas and can be received with smaller ground equipment.
- The lower orbit significantly reduces the delay that is created as the signal travels between Earth and the satellite.

Guidance and stabilization systems

The tracking telemetry and control system (TT&C) is a two-way communication link between a satellite and the station on ground. This system allows the ground station to control the satellite.

For low-Earth orbit spacecraft, GPS receivers are now the primary method for performing orbit determination, replacing ground-based tracking methods. Onboard GPS receivers are now considered a mature technology for small spacecraft

Propellant

It will have a 4 propellant for better maneuverability.

The propellants use Hydrazine fuel, this is special due to the combustion do not oxygen.

This fuel do not get affected with temperature changes

Housing

- These components protect the sensitive satellite components from the harsh conditions in space.
  - Satellites are usually made to be extremely light weight and use materials such as titanium and aluminum. Additionally, alloys such as nickel-cadmium or aluminum-beryllium, to increase the resistant of the material.

Batteries used in space

- There are two types of Batteries, primary and secondary
- Primary Batteries are less expensive and for satellites with short life.
- Secondary Batteries are composed of different quimics, increasing the reliability and making them rechargeable
- Nickel-cadmium (NiCd) nickel-hydrogen (NiH2), lithium polymer (LiPo), and lithium-ion (Li-ion) cells are used as secondary batteries in space applications.

Solar Panel (PUMA)

- PUMA (Planar Unfolding Modular Array), is a high-heritage, rigid-panel solar array scalable from 200W to over 10kW per wing, suitable for small or large satellites. PUMA arrays benefit from compatibility with all solar cell types, high recurring production rates, and interchangeable standard parts and designs.

Transponders

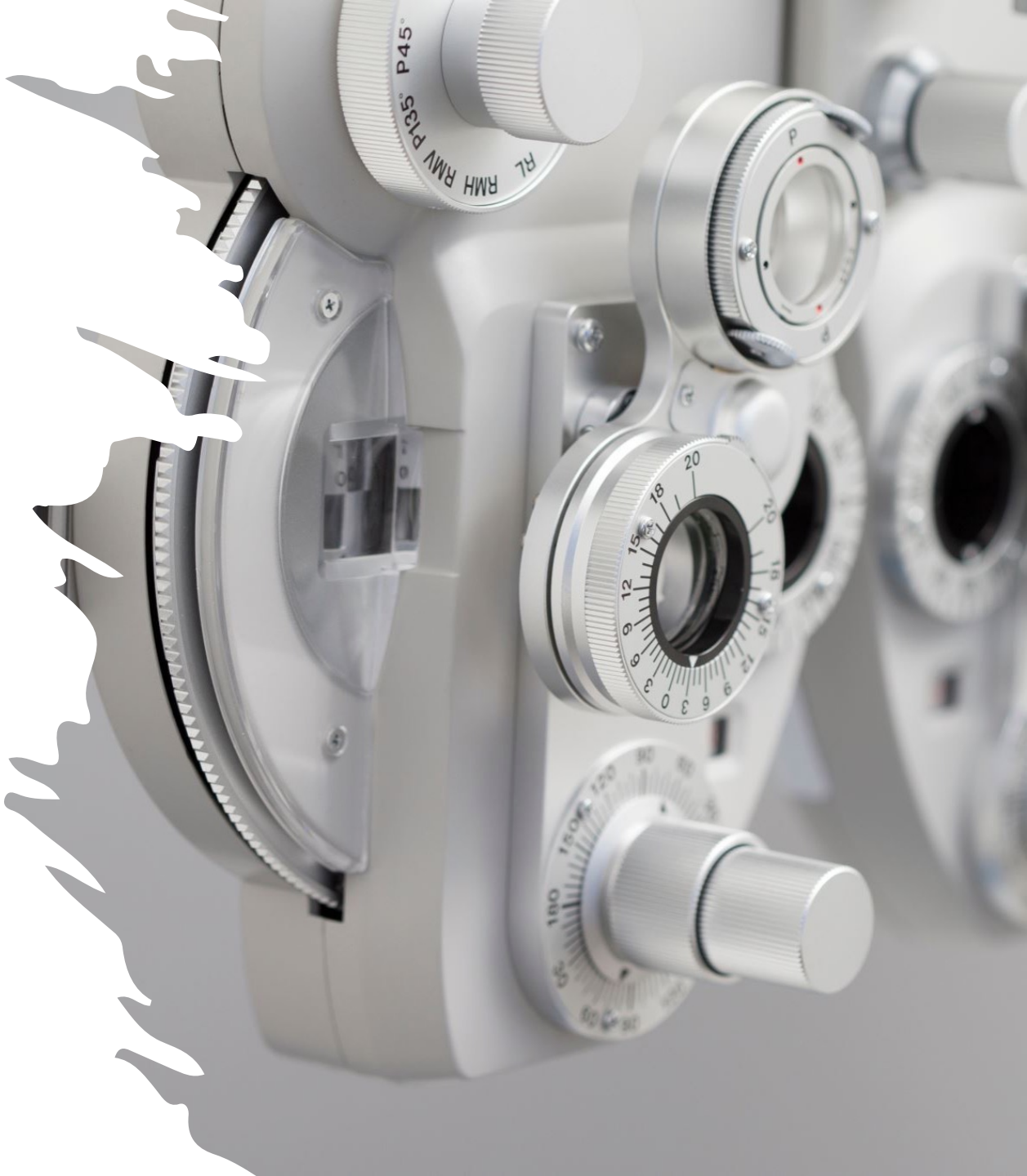
- These components convert incoming signals and amplify outgoing signals. Satellite transponder is a series of interlinked devices that form a single communication channel between transmitter and receiver.
- A transponder is an electronic component of a satellite that shifts the frequency of an uplink signal and amplifies it for retransmission to the earth in a downlink. Transponders have a typical output of 5 to 10 watts.

Sun Sensors

- Sun sensors are used to estimate the direction of the Sun in a spacecraft body frame.

Inertial Sensing

- Inertial sensors include gyroscopes for measuring angular change and accelerometers for measuring velocity change.



Verification

With all this new adjustments and this new technology implemented, we reduce the Risk of astronauts going out of the spacecraft, and the design will keep the machine and filaments properly protected for better durability.

The cost of fixing satellites will impact a lot because before, damage satellites will just get disposed and now they will get fix.

Time reduction improved, before for fixing a Satellite, a group of astronauts had the arrenge a high cost and risk mission, now Robo Satellite will do it.

International Space Law

Space activities are for the benefit of all nations, and any country is free to explore orbit and beyond.

There is no claim for sovereignty in space; no nation can “own” space, the Moon or any other body.

Weapons of mass destruction are forbidden in orbit and beyond, and the Moon, the planets, and other celestial bodies can only be used for peaceful purposes.

Any astronaut from any nation is an “envoy of mankind,” and signatory states must provide all possible help to astronauts when needed, including emergency landing in a foreign country or at sea.

Signatory states are each responsible for their space activities, including private commercial endeavors, and must provide authorization and continuing supervision.

Nations are responsible for damage caused by their space objects and must avoid contaminating space and celestial bodies.

Conclusion

- In conclusion, 3D printing in space is a collaborative and innovative endeavor that poses challenges and opportunities for the future. The University of Texas at El Paso's Department of Industrial, Manufacturing, and Systems Engineering's research has made significant contributions to advancing 3D printing technology in space, leading to improved engineering design, effective communication, collaboration and teamwork, and the acquisition and application of new knowledge. The findings presented in the poster demonstrate the potential for 3D printing technology to play a critical role in future space exploration.

Costumer Review

- "I have had this company for five years and the work only keeps increasing. I know that I don't have much time to make comparisons, but what I am sure of, is that if the 3D machines demant on earth is increasing, why not in space?"
- It is a very complete proyect, congratulation please let me know if you are going to keep working on it, or if there will be a way to buy part of the pattent.

CEO: Raul Grageda