**Project Title**

Connect-Two

**High Level Summary**

Connect-Two is a docking mechanism for in-space assembly of spacecraft modules. This is a particular challenge for large-scale missions. We tackled this by constructing an innovative model based on the mechanics of quick release connectors (Action Sealtite, 2020). The factors considered include building materials, pressure requirements and minimization of moving parts. This has the advantage of making the process of assembly rapid, safe and cost-efficient.

**How this project addresses this challenge**

Modern technologies and research are increasingly dependent on space-based technologies. While the space environment proves advantageous for numerous reasons ranging from lack of atmospheric interference to clearer observations, a major drawback is the limitation of the dimensions of the satellite. The increasing complexity of recent space missions often results in the requirement of larger equipment size. This poses transportation challenges to move infrastructure in space via single rocket launches.

Placing larger satellites such as the James Webb Space Telescope amongst others has the added risk of overshooting launch vehicles’ capabilities and increases the risk of damage. Current assembly techniques involve highly complex robotic arms. However, although robotics and in-person assembly may achieve the accuracy needed, they significantly increase costs and result in higher risk factors.

The future leans on in-space assembly techniques and transportation of parts with multiple launches to minimize risk and resources. Our solution to this is deploying an autonomous docking mechanism consisting of the ‘guest’ and ‘host’ component with minimal mechanical modules to avoid complications. We have used a locking system, a pressurized system and bearings in our model.

**How we developed the project**

Must see: website link here.

Upon evaluating some leading techniques and innovations involving the use of electromagnetic docking systems and complex autonomous robotics, we deduced that while precise, these approaches can prove exceedingly costly in case of equipment damage

Connect-Two is a model inspired by the widely used tool for fluid transport – the quick release connector. In a nutshell, it consists of two components: a ‘guest’ module which latches onto the ‘host’ module. This is facilitated by a locking system assisted by clamps and airlock pressure valves. Our low complexity approach minimizes the need of human/intricate robotics interactions and hence increases robusticity while reducing the threat of equipment damage. These are the components of the system: host lock module (female), guest lock module (male), airlocks and a latching system.

* 1. Guest Module

In order to correctly position this with respect to the host, we have implemented the use of RF beacons which provides only a tentative position orientation. For the final precise orientation, we can implement technologies similar to the ISS (host) sensors, such as the system applied when docking a Soyuz module. Four monopropellant thrusters (such as ones with hydrazine) are used to obtain the required alignment.

* 1. Host Lock Module

As the guest module approaches and slides into the host, the clamps are retracted to allow the guest to fit. Once the widest region (cross-section width) of the guest passes the bearings’ site, the clamps return to their original position, preventing the module from sliding back out (see animation). The clamps are coated with vulcanized-rubber for effective sealing, allowing pressurization of the host chamber to take place if necessary. In case of pressurisation failure

* 1. Pressure Systems (for manned and material transport missions)

Upon the successful clamping of the quick-release connector, the pressure systems are activated. This incorporates the use of nitrogen gas due to its inert physical characteristics. Inserting nitrogen would allow for checks to verify that no gaps are present between the guest and host modules. To prevent the addition of excess nitrogen which may compromise the stress structural integrity, the nitrogen insertion system is coupled with a nitrogen removal valve placed adjacent to it.

This pressure system is particularly applicable to applications involving human life to ensure depressurizing is not a threat, where it is known that there will be motion between the connected module and manned regions of the host module. In the absence of human interaction, this system may be discarded entirely.

* 1. Release

To release the guest module, the host chamber is depressurized and the clamps may be retracted using a simple hydraulic system. Thrusters can then be activated to propel the guest away from the host module.

**How we used space agency data**

We used data from NASA reports and webpages, as well as ESA’s materials database. Some of the key considerations identified when designing this system incorporate the following (Brennan, Walbolt, & Biferno, 2020):

1. Materials

In order to select the appropriate materials for the components, we identified some key specifications. Both the host and guest modules must be strong and resistive to damage upon contact. They must be made of a suitable material to avoid damage from the harsh conditions in space, namely a temperature of about 283 K at the Earth’s outer orbit that can reach a minimum of 2.7 K in outer space. Meteoroid impact and space-radiation damage should also be prevented (Patel Nagaraja, 2001). This results in the different regions of the modules being composed of various materials:

* + Aluminium alloy 1000 series

Location: Host and guest main bodies

Advantages: Strong and impact resistant, does not rust and can withstand low temperatures. It has a relatively low density hence does not add significant weight to the structure (ESA, s.d.).

* + Vulcanized rubber

Location: Entirety of clamp surface

Advantages: Ensures an airtight fit that allows pressurization of the host chamber with gas, preventing leaks. Its operational temperature ranges between 173 K and 573 K, proving an ample margin for operations away from the Earth’s orbit (Space Materials DataBase, s.d.).

* + White ceramic plasma electrolytic oxide coating

Location: Coating of the whole guest and host surfaces

Advantages: This prevents cold welding between the modules, has good operability even at low temperatures thanks to thermal controlling, has good adhesion and low absorptance. It resists harsh space conditions, providing a thermal shield on the external surface. It is also suitable for complex geometries which increases the range of missions it can be applied to (Keronite, 2020).

1. Costs

Compared to missions involving robotic arms, complex electronic systems or manned assembly, the Connect-Two solution has significantly lower costs and associated risks. NASA estimated expenditures up to $17 billion to assemble the ISS, which could be significantly lowered with our solution (BBC, 1998).

**Solution demo (link to video)**

Concept animation: Video link here.

**References**

Concept:

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**Tags**