2025 Micro-g NExT Challenge - Microgravity Operations - Soft Material Joining Devices

background

In space flight, soft materials such as textiles play an important role. On the International Space Station, a key function of soft materials is to provide thermal protection for sensitive equipment. In a series of extravehicular activities (EVA), astronauts may need a way to permanently join different parts of soft material together to protect the joints between pre-existing components and newly installed components. This requires a tool or tool kit that allows an astronaut to join two soft material parts together while only touching the outside of the material (i.e., the astronaut does not have access to the inside of the material). Find a reliable and ergonomic way toEVADuring this process two overlapping sections of soft material are joined together.

Target

Design aEVAA tool or tool set capable of joining two overlapping sections of soft material while only touching one side of the material. We would have preferred to design one tool that fully performed the function, but could use up to three tools to complete the task. If the design contains functional sharp edges, a means to prevent accidental user contact with the sharp edges must be included, such as a protective cover or retraction mechanism. The astronauts will operate the device while wearing spacesuits with restricted movement, so the ergonomics of its operation will need to be carefully considered during design. We will be working in the Neutral Buoyancy Laboratory (NBL) to test the functionality of the device you designed.

**hypothesis**

* we will be inNBLTest the device underwater. The selected team is responsible for its own testing plan,NBLWill be responsible for facility-related risks (e.g., drowning, barotrauma).
* We adjusted the weight of the test subject to near neutral buoyancy (simulating microgravity).
* The test subject's feet will be secured in a restraint to allow them to bear a small amount of load. They will have two hands free to use.
* To simulate a spacesuit, test subjects will wear a surface-supplied diving helmet andEVAGloves. Helmets limit peripheral vision, and gloves reduce finger dexterity.
* NBLThe water temperature of the swimming pool is86°F(about30°C), the depth is40feet (approx.12rice).
* We will provide a fabric tensile testing fixture with a frame, in addition to a second piece of free-floating fabric for connection testing.
* We will provide information on test fixtures and fabric types later/thickness of the file.

**Hardware requirements**

* A microgravity soft material joining device (or set of equipment) configured forNBLtest.
* NASATest fixtures will be provided including the soft materials to be joined. Details of the test fixture will be provided later.

**Require**

| **Requirement number** | **Minimum requirements** | **ideal requirements** |
| --- | --- | --- |
| **functional requirements** | | |
| 1 | You should provide a device or tool kit that can connect one layer of fabric to another layer mounted on the frame while only touching the outside of the fabric. |  |
| 2 | You must use no more than three tools to achieve this function. | We want you to use only one tool to achieve this functionality. |
| 3 | Tools or tool kits should not weigh more than10Pounds (Earth's gravity). | We want the tool or tool kit to weigh no more than5Pounds (Earth's gravity). |
| 4 | When stored, the device should be able to accommodate a12inchx 12inchx 12inches of space. If your solution includes multiple devices, all devices must fit into this space together. Note: The expanded device can be of any size as long as one person can operate it. |  |
| 5 | For linear drive mechanisms, the operating force should not exceed20 lbf（89 N). For rotating mechanisms, the operating torque should not exceed30 in-lb（3.4 Nm）。 |  |
| 6 | Tools must be manually powered only. |  |
| 7 | The equipment and its removable components shall1inch diameter tether attachment points. |  |
| 8 | The equipment needs to pass stress analysis with a safety factor of at least2.0. Submit a preliminary hand-calculated stress analysis of your proposed design. Stress analysis should include free-body diagrams, hypothetical traces, and equations. Finite element analysis (FEA) may be included but are not required. Normal operation should be assumed when performing stress analysis. The goal of the analysis is to identify the most critical components of the equipment (i.e., the part that fails earliest and has the lowest safety factor). Reports factors of safety based on design, selected materials, and operational input loads. Remember to consider the subcomponents of the mechanism. Note: If your proposal is selected, you will be required to provide additional stress analysis during the spring semester. | We want the equipment to also withstand any part of the tool30 lbfStress analysis of impact loading. Note: Although it is not a requirement, consider the effects of equipment falling under Earth's gravity when writing your hazard analysis. |
| 9 | The equipment and any components that become separated during operation must be sinkable in water. | We want the device to achieve neutral buoyancy in the water to simulate microgravity (i.e. neither sink nor float). |
| **Material requirements** | | |
| 10 | The device should useNBLApproval of materials in the materials list (see Proposal Guidelines document). These include metals, plastics, lubricants, coatings, foams and adhesives. for absenceNBLApproval of materials in the materials list, teams can apply for exemptions provided a reasonable basis is provided and approved. The proposed hardware design must specify all materials used. ordinaryPLANot available, toughPLAAcceptable. |  |
| 11 | all3DThe fill rate of the printed component is at least75%. This is to ensure3DThe print is strong enough and dense enough to sink in water. |  |
| **security requirements** | | |
| 12 | There should be no sharp edges on the equipment unless required for function. All functional sharp edges must be protected when not in use/Not accessible. | We wanted the device to meet challenging functions without sharp tools. |
| 13 | All functional sharp edges must be maintained at3inches“avoidance zone”outside, or away from the user's hands. Note: Your design may require some kind of tool to hold the second piece of fabric in place, or for the user to hold the fabric in place. Plan whether your device will be used with one or two hands, depending on your needs. |  |
| 14 | You should demonstrate the inherent hazards of the equipment in your proposal and follow upMicro-g NExTShown in submitted materials. If selected, please refer to the hazard analysis guidance in the proposal guidance document. |  |
| 15 | There must be no pinch points on the equipment. Pinch points that cannot be eliminated must beNBLLabeling guideline, which we will provide later. |  |
| 16 | Any uncovered holes or gaps in the equipment, other than tether points, must be smaller than0.5inch(1.27cm) or greater than1.4inch(3.56cm) to avoid getting your fingers stuck. Holes or gaps that cannot be eliminated must be removed in accordance withNBLLabeling guideline, which we will provide later. |  |
| 17 | Hazards that cannot be eliminated (such as functional sharp edges) must beNBLLabel guide marked as“don't touch”area, we will provide guidance on that later. |  |
| 18 | The area on the device for the user to hold must beNBLLabeling guideline, which we will provide later. |  |

**Other considerations**

* Consider what the astronauts will hold onto to stabilize the equipment during operation. The handle should be suitable for use with pressurized spacesuit gloves. NOTE: Smooth, rounded rod handles in spacesuit gloves can cause hand fatigue.

Consider operating while wearing a pressurized spacesuit. Anything that requires fine hand control or puts the astronaut in an unnatural position will be more difficult in a spacesuit.