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COSMIC

CONSORTIUM FOR SPACE MOBILITY AND ISAM CAPABILITIES

2026-27 COSMIC CAPSTONE CHALLENGE (C3) INFORMATION PACKET

The COSMIC Capstone Challenge is presented to college students who are invited to develop conceptual missions & designs for spacecraft operations in orbit or on the lunar surface. Six challenge tracks are offered in 2026-27: (1) Orbital Manufacturing and Assembly; (2) Lunar Operations; (3) Orbital Servicing; and (4) Construction; (5) In-Space for Earth; and (6) Architecture of Autonomous Space Clusters.

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REVISION AND HISTORY PAGE

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Contents

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The COSMIC Capstone Challenge (C3) has been developed over several years with contributions from dozens of students, professors, mentors, and judges. Below are some of the key contributors expected for the 2026-27 edition of C3.

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1. Executive Summary: The 2026-27 COSMIC Capstone Challenge

The COSMIC Capstone Challenge (C3) is presented to college students who are invited to develop conceptual missions and designs for spacecraft operations in orbit or on the lunar surface. Six challenge tracks are offered in 2026-27: (1) Orbital Manufacturing and Assembly; (2) Lunar Operations; (3) Orbital Servicing; (4) Construction; (5) In-Space for Earth; and (6) Architecture of Autonomous Space Clusters.

2. Description

The Consortium for Space Mobility and ISAM Capabilities (COSMIC) was established in 2023 by NASA in response to the In-space Servicing, Assembly, and Manufacturing (ISAM) National Strategy. COSMIC members from industry, academia, and government support work in five focus areas, including Workforce Development. COSMIC holds the C3 design competition to inspire and prepare the next generation of engineers, artists, and visionaries to contribute to ISAM. C3 takes place over the course of an academic year **for students studying at U.S.-based colleges and universities** (though the C3-Cluster track is exclusive to U.S. persons). Challenge statements for the six tracks, which can be adapted for in- and out-of-class options, are below:

Track 1 Challenge: Orbital Manufacturing and Assembly (**C3-Manufacturing**)
Design a payload to be hosted aboard Arkisys's Bosuns Locker that would demonstrate a chain of 3 or more operations providing a capability important for orbital manufacturing or assembly.

Track 2 Challenge: Lunar Operations (**C3-Lunar**)
Design a payload to be delivered by Astrobotic's Griffin lander that can prepare the lunar surface for a Fission Surface Power reactor with humans residing within 1km. Prototype required.

Track 3 Challenge: Orbital Servicing (**C3-Servicing**)
Using Northrop Grumman's Mission Robotic Vehicle (MRV) and Mission Extension Pod (MEP) as a fixed servicer capability, design and analyze candidate on-orbit attachable components (OACs) that the MRV could use to alter a client spacecraft already on-orbit in geostationary orbit (GEO) or cislunar space.

Track 4 Challenge: In-Space Construction (**C3-Construction**)
Design orbital or lunar surface infrastructure element(s) and outline the mission describing construction using autonomous robotic technologies.

Track 5 Challenge: In-Space for Earth (**C3-Return**)
Design a manufacturing payload hosted by Dispatch's Free Flyer 1 reentry vehicle to produce materials in space with properties that are impossible to achieve on Earth.

Track 6 Challenge: Architecture of Autonomous Space Clusters (**C3-Cluster**)
Develop an architecture and key elements that would enable a cluster of vehicles that would autonomously perform important functions in orbit or on the lunar surface (U.S. persons only).

Many C3 entrants will be students in their senior design class, often known as capstone classes. C3 projects can also be pursued by a group of students pursuing independent study, a team of students in a lab, or a student club. Teams can also be formed across universities.

3. Objectives

C3 was developed in response to the ISAM National Strategy calling for the development of ISAM capabilities and promoting workforce development**.** Engineers have worked to identify and advance technologies important for servicing, assembly, orbital manufacturing and lunar operations. Many of these have been demonstrated terrestrially and on orbit, paving the way for larger, more complex payloads which are in the various stages of development. Conceptually designing such payloads is one objective for C3. These projects do not stand alone; the hope is that some of these projects develop into funded missions, and the successful missions help pave the way for the future of ISAM operations.

The goal for each challenge is to engage in **the early design work necessary for a complex ISAM mission** that could be ready for launch in 3-5 years. C3 is primarily a conceptual design challenge, distinguishing it from competitions that focus on building a product for demonstration or creating detailed design work sufficient to begin manufacturing. While a prototype is required for the Lunar track, final evaluation is driven by the conceptual design, which is the starting point for ambitious space missions. Some concepts may be continued post-competition, either by the entrants themselves or other entities (academic, industrial, or government). Mentors, judges, guest speakers, and other COSMIC members may offer guidance on how work can be extended.

4. How to Participate

The must-read parts of this packet are Sections 5-10, which describe the six program tracks, and Section 11 regarding deliverables and evaluation criteria. Other sections contain important information about dates, expectations, references, administrative items, and judging scorecards.

Teams interested in participating must register online at https://COSMICspace.org/C3. Early registration is encouraged, as C3 is limited to 100 teams. After registering, teams are assigned a mentor from industry, government, or a nonprofit research institution engaged with ISAM. Mentors will provide guidance to the students through weekly meetings, identifying problems and guiding students toward solutions. C3's timeline includes recommended milestones and four deliverables: a mission statement, a midterm pitch-style briefing, and a presentation (virtual or in-person) in mid-April at the C3 Final Showcase with an accompanying technical paper. Scoring is based almost entirely on the final presentation (a required 24-minute briefing with four minutes of questions), so crispness is essential.

For more information or to register, visit: https://COSMICSpace.org/C3 or contact C3-COSMIC@aero.org.

5. Track 1 Challenge: Orbital Manufacturing & Assembly (C3-Manufacturing)

Design a payload to be hosted aboard Arkisys's Bosuns Locker that would demonstrate a chain of 3 or more operations providing a capability important for orbital manufacturing or assembly.

5.1 Motivation

The Bosuns Locker is a part of Arkisys's on-orbit 'Port Module' architecture for hosted payloads and ISAM activities. The Arkisys Port Module enables experiments, replacement spacecraft components, and ISAM modules to be attached and detached via physical interfaces post-launch. The Port Module is a long-duration spacecraft platform that supplies data, power, thermal, momentum, and other services for up to 60 payloads at any one time, in various orbits. The Port Module includes robotics to enable payloads to be manipulated, moved, and even modified through physical connectable interfaces. Bosuns Lockers are enclosures built to have physical interfaces that "connect" to the Port Module and can be manipulated by the onboard robotic arm to move around as needed.

Payload developers who do not want to build their own containment or experimental enclosure for their payload can use the Arkisys Bosuns Locker as a modular payload containment unit. The Bosuns Locker enables developers to focus on their specific payload; it only encloses their payload through electrical and structural modularity but enables in-space manipulation compatible with the Arkisys Port architecture for post launch connectivity. The Bosuns Locker design includes sensors to support and monitor a payload's performance over time and can be placed on any face or surface of the Port Module as needed for experimentation. Additionally, a payload within a Bosuns Locker can be interacted with (e.g., material extraction, resupply, etc.) by using custom panels.

5.2 Definitions

- An **operation** is defined as an action or set of actions performed by a single device. Examples of operations are listed below.
    - Polymer extrusion
    - Moving a part
    - Generating or receiving a diagnostic signal
    - Cutting, bending, grabbing, or dispensing
    - Growing inorganic crystals (e.g., semiconductor applications)
    - Mixing chemical or biological agents (for biological or physical science applications)
- A **capability** is a chain of operations that, when performed together, perform a useful function. Examples of capabilities are listed below.
    - Extruding polymer, moving the nozzle on a gantry, and removing finished part from a build plate
    - Generating an ultrasound signal without contact, listening for the signal after it passes by an inspection target, and interpreting that signal to evaluate the target part

    - More broadly, capabilities could be inspection, manufacturing, assembly, or other tasks necessary for orbital manufacturing
    - Manufacturing semiconductor crystals that would be returned to earth
    - Performing a life-sciences experiment
- The **Bosuns Locker Max**
    - Available volume: 15.75 in x 15.75 in x 35.45 in
    - Payload mass capability: 250 kg
    - Peak available power: 500 W, up to one hour
    - Sustained available power: 100 W
    - Thermal Load: 25W through contact with each interface (50 W total)
        - Any additional load must be rejected through the panels to the space environment.
    - Links to the CAD and the ICD are available in the Reference section.
        - Editing panels for input/output of produced goods (when applicable) is permitted.
- **Autonomous** means it should operate on its own with limited remote commands.
    - Since the phrase "limited remote commands" is subject to interpretation, teams should describe and justify their expected level of remote interaction. Initiating a sequence, confirming alignment before operation, interrupting an operation, or proceeding to the next step are clear examples of "limited remote commands."

5.3 Requirements for Conceptual Design

- The payload should be designed for Arkisys' Bosuns Locker Max.
- It needs to demonstrate three or more operations to demonstrate a capability important for orbital manufacturing.
- The payload should be designed to operate semi-autonomously with limited remote commands.
- Key design elements:
    - The payload design should consider the entire mission lifecycle starting from launch.
    - Consideration should be given to known loads and environmental factors; this includes operating in vacuum, operating in microgravity, how it will be operated, and designing to survive launch loads.
    - The team should describe the expected operating duration.
    - The design should be captured using CAD software that can display essential views required to explain the process and concept of operations for this design.
    - A rough bill of goods required to build and integrate the payload should be included in the C3 Final Showcase presentation.
    - Analysis is required to sufficiently determine if a design is feasible and can meet the Arkisys Bosuns Locker specifications.

5.4 Recommended Majors

For single-major teams, this project works best with teams of aerospace or mechanical engineers; interdisciplinary teams of combined engineering majors would also work very well. Other STEM majors outside of engineering are free to participate within the challenge; however, they must consider how to gain or leverage others with engineering expertise to fully satisfy the requirements of this challenge. Teams of eight or more students are not eligible for prizes in Track 1.

5.5 Exemplar Projects

Below are ideas to help inspire your team as you select a project. Teams may directly follow the example or adapt as they see fit.

Manufacture an end effector for a robot arm. Teams will determine a useful type of end effector that could be manufactured in space for use by a robotic arm already in space. Teams should identify which robot arm they are developing for and specify how the end effector could be used.

Populate blank Printed Circuit Boards (PCBs). This is the logical next step following the production of PCBs using the PCB maker proposed by the winning C3 entry from 2025-26. Teams will propose methods to retrieve electrical components from inventory (including PCBs, resisters, transistors, etc.) and install them using robotics and electrical joining techniques.

Assemble a CubeSat-class satellite from pre-made panels. Teams will need to select an appropriate capability for the CubeSat and create conceptual designs for each components or modules. The components will need to be stored within the Bosuns Locker and assembled inside or outside the volume using a method the team chooses.

6. Track 2 Challenge: Lunar Operations (C3-Lunar)

Design a payload to be delivered by Astrobotic's Griffin lander that can prepare the lunar surface for a Fission Surface Power reactor with humans residing within 1km. Prototype required.

6.1 Motivation

NASA and industry interest and investment in developing lunar surface infrastructure is present and growing. Basic lunar surface infrastructure is needed for many desired functions, whether it is to support a lunar surface water economy, for the production of propellants for in-space refueling, or to provide test facilities for technology development and demonstration. This challenge is targeted specifically at preparing for a Fission Surface Power reactor. Likely infrastructure needs to include basic utilities such as **power**, **communications**, and **navigation**, as well as constructed infrastructure such as **landing pads**, **protective shelters/storage facilities**, and **towers**. Power, communications, and navigation technologies are currently being developed and are making good progress; the next step is the development of technologies for the autonomous robotic construction of landing pads and shelters in the near term, as NASA aims to establish continuous operations on the lunar surface. Teams may reference NASA's Moon-to-Mars architecture and stated goals for the development of a Moon Base to understand key objectives of lunar infrastructure. C3 concepts and designs could shape the future of these plans, and great ideas proposed by strong teams could be extended beyond C3.

6.2 Definitions

- The **Griffin lunar lander** (Detailed information from Astrobotic)
    - Griffin is a medium-class lander with flexible mounting options to accommodate a variety of rovers and other large payloads.
    - While the maximum payload mass is 625kg, the maximum available payload mass for C3 is 200kg. The available volume is no more than ¾ of total volume, which you can segment as desired. Payload volume dimensions are shown below.
    - The Griffin lander will act as a base station for the C3-Lunar missions, and that consumes about 400kg. Its capabilities include: 5kWe solar power; inductive charger for wireless charging; battery for 80W (70W for lander systems + 10W for construction systems) over 100 hours to survive "lunar night" (8kWh); 5G relay @ 60Mbps; and comms to Earth.

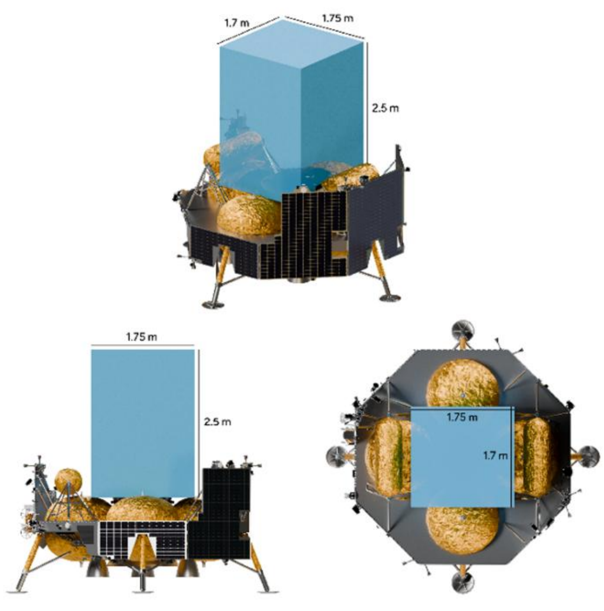

Figure 1: Payload volume for Griffin lander (Courtesy NASA).

- **Fission Surface Power reactor**
    - It is a compact nuclear microreactor designed to provide continuous, sun-independent electricity for planetary exploration, such as on the Moon or Mars.
    - You may use the Design Summary on page 3 from "A Summary of NASA Architecture Studies Utilizing Fission Surface Power Technology" as your

reference design. Within this reference design, you may trade the shielding options for the FSP as shown in Figure 6 from that reference.

- **Prototype**
  - A hardware assembly that demonstrates one or more key elements of the proposed design
  - The prototype may focus on the novel elements of the design or the whole thing.
  - Prototypes should be functional but do not need to be designed to survive launch or the operating environment.
  - Prototypes will be evaluated based on function, scale, completeness, and degree of difficulty as described in the evaluation section.
  - There will be an optional demo day for C3-Lunar teams **the week of April 5, 2027**, at the Lunar Regolith Terrain (LRT) Field at NASA MSFC.

- **Infrastructure**
  - A permanent facility or capability at a lunar outpost that supports other operations; several examples are provided in the motivation
  - "Hard" infrastructure you would need to build a city, mostly focused on fixed structures (other examples include robotic repair stations or recycling depots)
  - Manufacturing, servicing, or assembly capabilities that may be important for future lunar base operations

6.3 Requirements for Conceptual Design

- The payload should be designed to fit within the designated mass and volume available on the Griffin lunar lander; the payload may be stationary or mobile.
- It needs to create infrastructure important for a permanent lunar outpost or enable its maintenance.
- The payload may be designed to operate with various levels of human engagement. That could include full autonomy with limited remote commands, remote operation, local operation by an on-surface astronaut, or cooperative operation with an astronaut.
- Key design elements:
  - The payload design should consider the entire mission lifecycle starting from launch.
  - Consideration should be given to known loads and environmental factors; this includes operating in vacuum, operating in lunar gravity, designing to survive launch and landing loads, operating during day or night, and ensuring it can meet the Griffin specifications
  - Description of how the payload will be operated, how long it will operate, where it will operate, how it will interact with the Griffin lander, and how operations during both lunar day and night will be managed
  - The design should be captured using CAD software that can display essential views required to explain the process and concept of operations for this design
  - A rough bill of goods required to build and integrate the payload should be included in the C3 Final Showcase presentation

- Teams should be very clear on how their design will help prepare the surface for the fission reactor. For some projects, such as clearing and leveling the surface for placement, will be largely self-evident. For other projects, teams may need to identify the connection between their design and how it would support the reactor. So if a team is proposing to manufacture on the surface, they should identify how those products would support the reactor or the nearby infrastructure.

6.4 Recommended Majors

It is important to consider that for this track a prototype is required, so a larger group and resources like a makerspace would be helpful for this track. For single major teams, this project works best with teams of aerospace, electrical, or mechanical engineers; interdisciplinary teams of combined engineering majors would also work very well. Other STEM majors outside of engineering are free to participate within the challenge, however they must consider how to gain or leverage others with engineering expertise to fully satisfy the requirements of this challenge.

6.5 Exemplar Projects

Below are ideas to help inspire your team as you select a project. Teams may directly follow the example or adapt as they see fit.

Friction Stir Deposition. Develop a concept for a payload that would demonstrate the bobbin friction-stir deposition process in the lunar environment. Identify how those parts would be useful for the establishment and operation of a fission reactor and its associated infrastructure.

Develop protective structure for astronauts. Teams will design a system that fits within a lunar lander to develop berm-like structures to protect astronauts from the harsh moon environment.

Inspect structures manufactured on the Moon. Berm-like structures, rails, roads, and landing pads would all be manufactured on the moon and need to be inspected. Teams should design a system that can inspect one of these structures and should describe how their system's inspection process works.

7. Track 3 Challenge: Orbital Servicing (C3-Servicing)

Using a Northrop Grumman Corporation (NGC) Mission Robotic Vehicle (MRV) and a Mission Extension Pod (MEP) as a fixed servicer capability, design and analyze candidate on-orbit attachable components (OACs) that the MRV could use to alter an already on-orbit in GEO or cis lunar, client spacecraft. Research past spacecraft failure mods and determine if a replacement or upgraded system can be integrated onto the client utilizing the NGC servicing vehicles.

Consideration can also be given to an orbiting persistent platform as a base where a client satellite would come to be repaired, upgraded, refueled, or be attached to temporarily, with the intent to extend their operational lifespan, restore functionality, or enable mission flexibility with enhancements. The OAC(s) should exploit cutting-edge automation, robotics, or repair technologies to provide hands-free servicing solutions. A successful challenge response will define between one and five different OACs that would require the MRV to execute a modification to the client with emphasis on minimal complexity, yet maximum capability to adapt to any client servicing need. Though automation is not required, the architecture of the C3-Servicing design track should minimize any human interaction needed to make the OAC functionable.

7.1 Motivation

Satellites are expensive. The cost to replace a GEO satellite can easily reach $500M or more. Most satellites become obsolete because their sensors or components age out or fail, or their available propellent is expended. Typically, a satellite has potential residual use after its baseline mission, so extending the applications is warranted. Servicing is the means to reutilize, extend, or change that mission at a fraction of the cost of a new one, and at a fraction of the time to design, build, and put that new one on orbit.

7.2 Definitions

- A **modular** spacecraft is one that has design features that are plug and play and can be assembled with modern day advanced manufacturing techniques. This is in order to allow for ease in modifications to baseline configurations, as required for multiple missions. A spacecraft of this type could have the following features:
  - Designed for ready integration with other spacecraft via use of standard interfaces
  - Sized to easily be packaged within standard launch vehicle parameters
  - Optimized to maximize the use of off-the-shelf components or subsystems
- A **maintainable** spacecraft has one or more of the following characteristics:
  - Able to accept multi-missions so it can be reused many times for different clients
  - Designed for upgradable sensors and components dependent on the mission requirements
  - Designed to be refueled by servicer satellites, or can refuel client satellites
  - Robotic or other feature types to enable the replacement of parts prone to wear or failure (such as batteries or solar panels), or the upgrade of subsystems like flight computers for edge processing
  - Chemical or electric propulsion capability (or a hybrid system) to move to the client satellite in a particular orbit or a combination of orbits
- **Autonomous servicing** is a capability suite that does not rely on human-in-the-loop to complete its operation, but rather has sufficient software to identify, diagnose, and execute a servicing function.
- **Client satellite** is one that needs a servicing function while in orbit. Note that it could be one that is already in orbit, or one that is yet to launch where the servicing requirement is built into the design and therefore will rely on the capability at some point during its mission lifetime. (The latter represents a use case of growing interest.)
- **Critical servicing functions** include but are not limited to: 1) refueling via propellent transfer or swap of propulsion tanks; 2) physical interactions to “nudge” or release caught

deployables such as antennas and solar arrays; 3) space situational awareness inspections via fly-by and proximity observations; 4) docking; 5) carrier vehicle for debris removal concepts requiring a controllable maneuvering base; 6) augmentation of clients via replacement of instruments/components; 7) mylar removal and replacement; 8) surgical robotics for high precision; 9) repositioning of a client to a different orbit; and 10) serving as a depot for parts readily available.

- **Cutting-edge technologies** are those that either represent the state of the art or those that are under development for adoption in the next few years. Students are encouraged to push the limits on what could be considered cutting edge.
- **On-orbit Attachable Components (OAC)** can be attached by the MRV onto satellites already in orbit. Teams may choose the host satellite onto which OACs would be installed. Teams should identify how OACs would attach. There are no hard constraints on the OACs, but if teams incorporate elements that are very large or have high power requirements, teams should be able to provide justification and address how they mitigate potential challenges.

7.3 Requirements for Conceptual Design

- The team will research and analyze past failure modes for satellites in orbit to learn what features are needed for their OAC designs. Using that information as a basis, the purpose of their OAC(s) will be defined.
- The resulting on-orbit attachable components will include well-considered, purposefully selected hardware and software, equipment, and sensors to accurately perform the attachment and other operations required in proximity of the client satellite.
- Requirements and functions of each subsystem should be clearly defined, and the size, weight, and power (SWaP) estimates should be based on realistic assessment of current or future system configurations that are under development.
  - Teams need to create realistic budgets for SWaP and propulsion.
- The spacecraft will be designed to fit inside the shroud of the selected launch vehicle.
- The MRV spacecraft and OACs could be designed to fit inside the shroud of the teams' selected launch vehicle. An allowed alternative is to assume the OACs are carried on a different launch to the MRV or a persistent platform for the MRV to access when needed.
- Select and validate a mission area of interest, which will include the chosen orbit, class of client satellite, candidate features to be serviced, what type of devices or tools will be required for the servicing, docking or grappling operations, and other mission parameters needed to execute the mission.
- Cutting-edge technologies may include capabilities not yet demonstrated on orbit, but which would be feasible with a few years of development.
- If the candidate design is a persistent platform, add the features required of the clients to rendezvous and dock with the platform and provide the unique docking requirements.
- Identify the chosen robotic features and assess needed fidelity of the system, which may include a surgical robotic capability.
- The candidate features to be serviced should include the critical servicing functions shown above and should be chosen based on a systems engineering perspective of

tradeoffs or via trade study. For example, for refueling, is it better to transfer propellent through a port, or just replace an on-orbit attachable propellent tank? Is it easier to repair a damaged solar array, or attach a new roll-out solar array (ROSA) over the existing one? What attachment mechanisms are optimal for a low-risk approach to connecting an OAC to the client?

- Key design elements:
  - The concept design should consider the entire mission lifecycle, from launch through mission success and data retrieval.
  - Consideration should be given to known loads and environmental factors, including operating in vacuum and in microgravity, temperature variations in orbit, surviving micrometeorite impacts, radiation, electrostatic discharge, outgassing, thruster plume deposition, atomic oxygen effects, and designing to survive launch loads.
  - Consider manufacturability, adaptability, and accessibility for servicing.
  - Is the OAC a standalone item, or does it require power of comms from the servicer?

7.4 Recommended Majors

This track is very involved, and it is important that some team members have some experience and knowledge of satellite design and architectures. It is recommended to have a larger team of seven or more students to effectively pursue this challenge. For single-major teams, this project works best with teams of aerospace engineering majors; however, interdisciplinary teams of combined engineering majors would also work very well, they feature a core group of aerospace engineering majors. Other STEM majors outside of engineering are free to participate within the challenge; however, they must consider how to gain or leverage others with engineering expertise to fully satisfy the requirements of this challenge. Students with interest in business development may be useful for evaluating the business case.

7.5 Exemplar Projects

Below are ideas to help inspire your team as you select a project. Teams may directly follow the example or adapt as they see fit.

Inspection as a service. Install a suite of inspection tools that could be used to evaluate the host satellite and other satellites in similar orbital planes.

High-pressure gas transfer. Teams will propose methods to perform high-pressure gas or supercritical fluid transfer. The vehicle design will flow from that concept, and remaining capacity should enable the servicer to travel from a depot to satellites in planar orbits.

Enable installation of multi-layer insulation (MLI). Use the MRV to repair, replace or supplement the MLI on a satellite.

Install solar panels. Identify or design an end effector that would enable the installation of solar panels on a satellite sent to orbit with minimal installed solar capability and already designed for orbital assembly. Determine how the solar panels would be installed.

Space situational awareness (SSA). Provide one hemisphere of visibility for the target satellite, which is able to detect a reflective sphere of 5 cm radius out to 5 km in sunlight. The OAC is limited to a mass of 50 kg; should include on-board image processing to detect brightness, relative direction, and angle rate; and will have low data-rate comms through an appropriate network. The OAC must be attachable by MRV.

8. Track 4 Challenge: Orbital Construction (C3-Construction)

Design orbital or lunar surface infrastructure element(s) and outline the mission describing its construction using autonomous robotic technologies. Teams should focus on the development of the (reversible) joining methods and modular utility outfitting (including power and data cabling, fluid and gas transfer routing, or comparable utility systems) to enable functional, reconfigurable infrastructure. Teams may leverage building blocks from previous work in modular construction systems or propose an original construction architecture designed from the ground up. Teams should specify which types of robotic agents they will use and where they will source their materials from.

8.1 Motivation

Robotic assembly and construction are critical capabilities for developing sustainable and scalable infrastructure that enables a persistent presence in space. Challenges related to developing cost-effective and economical systems, demonstration of reliability in extreme environments, and mass limitations of launch vehicles have limited our ability to easily scale construction activities in space. Recent advances in autonomous robotic systems, materials, and integrated system designs have enabled development of robotic assembly systems that can (1) scale physically and economically, (2) be adaptable and be reconfigured for multiple mission scenarios and needs, and (3) have performance characteristics that meet aerospace needs. NASA wants the next generation of explorers to think about how these types of missions and systems are designed and executed to enable a scalable and economical future for space exploration.

8.2 Definitions

- **Orbital Infrastructure** is any system or asset in orbit that provides capabilities or services for users. Examples include:
  - Spacecraft refueler
  - Persistent payload host platform
  - Mars transport vehicle
  - Spaceport
- **Lunar infrastructure** is any system or asset on the lunar surface that provides capabilities or services for users. Examples include:
  - Tower for power or communications

  - Shelters
  - Berms and landing pads
  - Rover repair vehicle
- **Mission** is defined as the development, execution, and operation of an activity to achieve a goal.
- **Robotic construction** is the process of building an asset that is performed by robotic agents. This can include excavation, material logistics, manufacturing, assembly and more.
- **Building blocks** are modular structural units that are connected together to create a larger structure. Some examples of building blocks are listed below:
  - ARMADAS voxel: a cuboctahedron shaped building block that has four reversible connections on each of the faces
  - Tri truss: a truss building block that can be used to build curved structures
  - Tall lunar tower: a truss assembly system for building towers
  - Sandbags: a building block consisting of a bag filled with regolith (or other material) that can be stacked to create a structure
- **Robotic agents** are electro-mechanical systems that are used to automate the construction process. Some examples of robotic technologies are listed below:
  - Fixed robot arm: a robot arm that can manipulate materials and perform tasks using end effectors
  - Transport robot: a robotic agent that carries building blocks from a depot to the build front
  - Joining robot: a robotic agent that joins or fastens building blocks together
  - Crane robot: a robotic agent that can lift heavy payloads vertically and provide offloading capabilities
  - Inspection robot: a robotic agent that monitors the health of the structure
  - Outfitting robot: a robotic agent that can install outfitting modules onto the base structure
- **Autonomous** means it should operate on its own and resolve problems with minimal levels of input. Teams should describe and justify their expected level of autonomy.
- **Outfitting** means adding a specific capability to the base substructure to support a desired application. Some examples of outfitting are listed below:
  - Utility outfitting:
    - Power and data cabling: Electronics can be installed on the substructure to provide power and data transmission.
    - Pipe and ducting: Fluid and air transfer systems can be installed to provide needed capability.
  - Functional outfitting:
    - Rail system: Rail modules are installed on the substructure to provide an integrated transportation system.
    - Paneling: Panel modules are installed on the substructure to provide a covered shelter.
    - Surface interfaces: Footer modules can be installed on the bottom of the substructure to interface with the surface.

- **Material source** means where the construction material is manufactured and coming from. This can be from materials sourced from the earth, from supply depots in orbit, on the moon, or from in-situ resource utilization materials gathered from local sources.

8.3 Requirements for Conceptual Design

- Systems engineering
    - Goals, needs, and objectives should be clearly described.
    - High-level requirements should be included.
    - CONOPS should be included and describe the sequencing of construction, including transport of raw materials.
    - Risks and mitigations should be identified and described.
- Concept design and analysis
    - Include CAD model of the robotically assembled functional structure.
    - Description of the manufacturing sequence and which tools would be used in construction. If additional tools are needed to enable construction, describe those.
    - Describe the purpose of the structure and why it is better to assemble in space instead of fitting it within a single payload fairing and deploying directly.
    - Analysis to assess relevant metrics such as mass efficiency, performance, and survivability.
    - Analysis for structure and process to perform in the expected environment.
    - Describe the joining method you would employ and why you would choose it.
    - Describe how to outfit the non-structural elements into the system (functional modules, power and data routing, fluid transport, etc.).
    - Describe the sequencing of the build process in at least six steps in lieu of animating the entire process.
    - Describe how your team would use in-space resources; if your requirements exceed those described above, define what is needed to complete your mission.
    - Describe how the materials to enable the mission are sourced — both long distance and local logistics.
    - If other steps are required to create a functioning system, describe those steps.

8.4 Recommended Majors

Due to this track creating large structures and developing a plan to assemble them, it is important that teams consider members with structural design experience. For single-major teams, this project works best with teams of aerospace engineers, civil/structural engineers, mechanical engineers, and architects. Interdisciplinary teams combining engineering and architecture majors would also work very well. Other STEM majors outside of engineering are free to participate within the challenge; however, they must consider how to gain or leverage others with engineering expertise to fully satisfy the requirements of this challenge.

8.5 Exemplar Projects

Below are ideas to help inspire your team as you select a project. Teams may directly follow the example or adapt as they see fit.

Adaptable truss structure for an orbital logistics depot. Assume there is a large structure shaped like the payload fairing of a Starship-class launch vehicle, open to space on the cylindrical end. Design a manufacturing facility that contains the following key elements: (1) on the inside diameter of the structure there are stores of materials and manufacturing stations; (2) along the central axis of the structure, extending from the nose past the end of the vehicle, is a truss structure; (3) along the truss structure, there are rails for objects to move along the length; (4) there are docking ports along the length of the truss and at its terminus. Your team will design the factory and illustrate its deployment and operation.

Building block assembly system. Design an autonomous robotic assembly system that constructs structures using different building blocks.

Railroad track development. Create a process where robots can autonomously lay down tracks to different lunar sites. Specify the type of track. Modify or design a robot that can perform the assembly.

9. Track 5 Challenge: In-Space for Earth (C3-Return)

Design a manufacturing payload hosted by Dispatch’s Free Flyer 1 reentry vehicle to produce materials in space with properties that are impossible to achieve on Earth.

9.1 Motivation

The microgravity and vacuum environment of low Earth orbit (LEO) enables manufacturing processes that are physically impossible on the ground. In microgravity, fluid dynamics change fundamentally: crystals grow larger and with greater uniformity, protein structures fold without gravitational sedimentation, and semiconductor materials crystalize without convective currents that introduce defects. These are not incremental improvements — they represent distinct material properties that can produce better drugs, faster electronics, and novel materials with no terrestrial equivalent.

Until recently, manufacturing in orbit required access to the International Space Station (ISS), which is expensive, heavily subscribed, and tied to schedules that are outside a researcher’s control. Commercial reentry vehicles change this. Dispatch’s reentry vehicle is purpose-built to close the loop on the in-space manufacturing cycle: launch a payload, process it in orbit, and return the product to Earth on a commercial timeline. This track challenges students to design the payload that fills that capsule.

9.2 Definitions

- **Dispatch Free Flyer 1** is the reentry vehicle for this track. It is a commercial capsule designed to carry payloads from LEO back to Earth with controlled recovery. Key specifications:
    - Maximum payload mass: 30 kg
    - Payload envelope: 50 cm x 30 cm x 60 cm
    - Available power: up to 100 W continuous
    - On-orbit thermal environment:
        - -20 °C to +30 °C with payload off
        - +50 °C ± 10 °C with 100 W payload on
        - +4 °C ± 2 °C with 10 W payload on
    - Reentry thermal environment: payload interface plate will not exceed 40 °C during reentry; thermal peak duration is approximately 15 minutes
    - Full interface details: http://dispatch.space/payload-user-guide
- **In-space processing** is any operation performed in the orbital environment that leverages microgravity, vacuum, radiation, or thermal cycling to alter or produce a material, biological sample, or product. Examples include:
    - Protein or small-molecule crystal growth for pharmaceutical applications
    - Semiconductor crystal growth (GaN, SiC, ZBLAN fiber)
    - Metal alloy solidification or foam metal production
    - Biological cell culture or organoid growth
    - Thin film deposition in vacuum
- **Return product** is the material, sample, or manufactured good that is recovered after reentry and has value for use on Earth. The return product is the primary output of the mission.

9.3 Requirements for Conceptual Design

- The payload must be designed to fit within the Dispatch Free Flyer 1 envelope (50 cm x 30 cm x 60 cm), within both the 30 kg mass limit and 100 W continuous power budget.
- The payload must demonstrate a process that produces a return product with properties that are meaningfully different from what can be achieved on Earth, with that difference clearly quantified or cited from prior research.
- The payload should be designed to operate semi-autonomously during the in-space processing phase with limited remote commands.
- Key design elements:
    - **Process design**: Describe the specific in-space process in detail. What happens step by step? What controls the process (i.e., time, temperature, fluid dynamics)? What instrumentation monitors it? What triggers the end of the processing phase?
    - **Return product**: Clearly define what is being returned. Quantify the target properties or characterize what measurements will be taken post-recovery to validate the mission. Identify what facility or organization would analyze the returned sample.

- **CAD**: The design must be captured in CAD with essential views to explain the payload configuration, internal layout, and concept of operations.
- **Bill of goods**: A rough bill of materials required to build and integrate the payload should be included in the C3 Final Showcase presentation.
- **Commercial context**: Describe the downstream value of the return product. Who would use it? What is the potential commercial or scientific application? This is not a business plan requirement, but teams should connect their design to a real application. The most valuable products are those that cannot be produced on Earth and have a clear terrestrial use.

9.4 Recommended Majors

This track draws from chemical engineering, materials science, biomedical engineering, and aerospace engineering. The in-space processing component (e.g., crystal growth, semiconductor manufacturing, biological samples) requires domain expertise that is less common in traditional aerospace capstone tracks. Teams with a chemical or materials-science core are well suited, particularly if they include members with aerospace systems knowledge to address the launch and reentry environment. Interdisciplinary teams combining chemical, materials, biomedical, and aerospace engineers are ideal. Other STEM majors are welcome, but the team should ensure it can address both the process design and the spacecraft integration requirements.

9.5 Exemplar Projects

Wafers for semiconductors. Develop a system that creates wafers for semiconductors. This includes developing a module that keeps the wafers safe during transportation back to Earth.

Crystal growth of pharmaceuticals. Develop a process that allows for the growth of crystals needed to create a specific pharmaceutical. Teams should also develop a module that allows for the return of the pharmaceutical crystals back to Earth.

Growing biological tissue. Teams must identify a specific type of biological tissue to grow in microgravity. This includes designing the structure so the tissue can return safely to Earth.

Fiber-optic cable manufacturing. Develop a process that utilizes microgravity to grow the ultra-pure fluoride glass needed for fiber optics. Teams must determine the amount of fluoride glass that can be manufactured and returned to earth to be used for fiber-optic cables.

10. Track 6 Challenge: Architecture of Autonomous Space Clusters (C3-Cluster)

Develop an architecture and key elements that would enable a cluster of vehicles that would autonomously perform important functions in orbit or on the lunar surface (U.S. persons only).

10.1 Motivation

Space has become increasingly populated since satellites were first launched. Some satellites provide key functions for day-to-day life, such as GPS-enabled navigation and weather monitoring. As time goes on, these satellites face degradation and increased risk of collision that could result in complete loss of a satellite, requiring either its repair or the development of new space-based technologies. A satellite swarm is a unique solution to support these satellites or develop revolutionary technologies for operating in space. These capabilities include, but are not limited to, lunar satellite and station servicing, lunar and asteroid resource mining, and improved positioning, navigation, and timing (PNT) capabilities on orbit and on the lunar surface.

This track focuses on pushing the state of the art forward. A great project will account for the current state of the art in the space domain, incorporating a suite of intelligent systems and capabilities (such as machine vision, on-board computing, autonomous decision making) while identifying technologies that could surpass current capabilities and be resilient in the face of partial systems failures. Teams will identify the different types of vehicles required, their capabilities, and realistic estimates of their sizes. While this mission is not constrained by pre-set mass or volume budgets, teams should be realistic and aim to achieve their stated mission with the fewest resources necessary.

Potential missions could include: scavenging satellites, space situational awareness, excavating lunar regolith from lava tubes, or other missions that would benefit from a large number of small, autonomous systems working in concert.

10.2 Definitions

- **Machine vision** is the capability of a spacecraft to perceive and interpret its visual environment using cameras, sensors, and image processing algorithms. Satellite swarms may use machine vision to accomplish the following:
  - Identifying, detecting, and tracking targets
  - Assessing damage, degradation, or status of target object
  - Navigating relative to other swarm members or celestial bodies
- **On-board computing** is the computational hardware and processing power embedded within each satellite of the swarm, allowing them to execute complex algorithms locally rather than relying solely on ground-based control. This includes:
  - Processing sensor data in real time
  - Running navigation and guidance algorithms
  - Executing coordination protocols between swarm members
  - Managing spacecraft subsystems and health monitoring
  - Enabling rapid decision-making without communication delays to Earth
- **Autonomous decision-making** is the ability of individual satellites or the swarm collectively to make operational decisions without human intervention or ground control input. This encompasses:
  - Path planning and collision avoidance maneuvers
  - Task allocation among swarm members

- Responding to emergencies or system failures
- Adapting mission plans based on changing conditions
- Coordinating formation flying and cooperative behaviors
- Determining when and how to service target satellites

- **PNT** is the ability of a satellite to determine where it is located in three-dimensional space relative to a target object or celestial body (positioning), plan and execute trajectories from current position to desired locations (navigation), and time synchronize across the swarm for coordinated operations (timing). This is essential for maintaining orbital swarm formations, executing proximity operations, and operating in GPS-denied environments.

10.3 Requirements for Conceptual Design

- Identify mission(s) satellite swarm is providing. Break mission(s) down into capabilities and functions that satellites will need to perform.
- Determine orbital architecture of satellite swarm. Final deliverable should include a model to show selected orbital architecture.
- Identify new or existing technologies needed to accomplish necessary satellite functions. New technologies should be adequately conceptualized and explained to fully describe the intended purpose and integration within the satellite design.
- Develop an algorithm for the satellite swarm to autonomously perform its functions. The final deliverable may include an animation of the swarm performing its mission.
- Design each unique satellite used in the swarm. If all satellites are identical, then one satellite design is required. If all satellites use the same bus with various payloads, the bus and each unique payload should be designed. If each satellite is unique, each satellite design should be included. The design should focus on capability and requirements, with SWaP estimates for essential components. Detailed satellite design is not expected.
- Provide a cost summary that includes costs for all satellites, required technological development, and launch(es). If the mission requires new technologies, include a timeline to develop and advance these technologies to technology readiness level (TRL) 9. Lunar rovers, asteroid mining, or other swarm missions would have equivalent requirements.

10.4 Recommended Majors

This track requires knowledge of orbital mechanics, robotics, AI, and autonomy algorithms. Teams with aerospace engineering, mechatronics, and computer science and engineering backgrounds are well suited for this track. Additional recommended majors will depend on the selected mission (i.e., asteroid mining would benefit from majors with mining and materials science expertise).

10.5 Exemplar Missions

Scavenging satellites. Develop a satellite swarm architecture capable of autonomously identifying dead satellites and scavenging parts for reuse.

Lunar PNT. Develop a satellite swarm architecture capable of providing PNT services for satellites in lunar orbit and for lunar habitats.

Orbital debris mapping. Develop a satellite swarm architecture capable of autonomously identifying and categorizing orbital debris throughout Earth's orbital regimes.

11. Deliverables and Evaluation Criteria

11.1 Deliverables

The main deliverable for C3 is the final presentation in April 2027. The technical paper and (optional*) prototype are due in the same time frame. Other deliverables are less critical but are intended to help teams keep on pace, communicate the progress of their projects, and facilitate engagement across teams and mentors.

1. **C3 Final Showcase briefing**: Judging will be based upon a 24-minute briefing the **week of April 12, 2027,** that comprises over 90% of the score. The brief is ***not a design review***. Rather, you are crafting a story about proposed concept, supported by visuals and analysis. Consider that your team is trying to convince the audience that it is worthwhile to invest in your team to advance its goals.
2. **Technical paper**: At 10-20 pages, the paper accompanies the final briefing and will account for 5% of the final score. The paper and briefing will be due **April 8, 2027**, the Thursday before the Final Showcase begins.
3. **Mission statement**: 50-150 words + 3 questions requiring domain-specific expertise teams would like to have answered. These questions will be shared with mentors across C3 for discussion with teams. Due by **October 16, 2026**.
4. **Midpoint Showcase brief**: 5-minute brief the **week of December 7, 2026**; after this event, each team will receive feedback from one or more COSMIC members on their progress. After delivering briefs and viewing other entries, each team will compose three questions for other teams and submit them to C3 organizers.
5. * A prototype is only required for the C3-Lunar track, counting for 20% of the score for C3-Lunar track rankings but not factoring into overall C3 rankings. For all other tracks, Best Functional Prototype is an optional category for recognition. For all entries, a video (5 minutes or less) of the prototype **must be submitted by April 15, 2027**, for scoring. C3-Lunar teams demonstrating prototypes at NASA MSFC in April are encouraged but not required to use footage of their demos in their final video submissions.

Teams of 8 or more students can tackle any challenge but are not eligible for prizes in Track 1.

11.2 Evaluation Criteria for Presentations

The following elements requested below match the judging rubrics provided later in this document, with more detail provided here for Category 1 and Category 3.1.

1. **The presentation must describe in sufficient detail the design to understand the following about the conceptual design**:
    1. **Technical impact of demonstrated capability**. If the mission is successfully executed, how much impact would those capabilities have for future space missions? Consider the following questions:
        i. Would it enable new or improved types of spacecraft or lunar operations?
        ii. Could it be used to improve existing spacecraft or lunar operations?
        iii. Are other technology developments required for this capability to be useful?
    2. **Feasibility of proposed mission**. How likely is it that this mission (if funded) could be designed and built within five years? Evaluation of these items should be considered when scoring this category: the bill of materials, current CAD drawings, plans to develop technology as needed, approach for manufacturing, and testing.
    3. **Innovativeness of the payload design**. Is the design original in a pertinent way? Considerations for this category:
        i. Has this been demonstrated in space before?
        ii. Has it ever been proposed?
        iii. Has it been executed in a similar fashion?
        iv. Is it uniquely suited for its proposed function?
    4. **Fulfillment of demand**. Do teams connect their proposed concept to the high priorities of the target customer community appropriate for their track?
        i. C3-Manufacturing: connect the work to the high-value missions identified by COSMIC.
        ii. C3-Lunar: connect the work to prepare or support a surface fission reactor.
        iii. C3-Servicing: connect the work to the high-value missions identified by COSMIC.
        iv. C3-Construction: connect the work to the high-value missions identified either by COSMIC or those identified in the NASA Moon-to-Mars architecture or Moon Base initiative.
        v. C3-Return: connect the work to themes or products identified in NASA's "In Space Production: Applications Within Reach."
        vi. C3-Cluster: connect the work to the high-value missions identified either by COSMIC or those identified in the NASA Moon-to-Mars architecture or Moon Base initiative.

2. **Provide an overview of the system and the program**:
    1. Animate one or more key operating sequences.
    2. Create a storyboard for the complete operation.
    3. The recommended path to proceed to a Preliminary Design Review (PDR).
    4. Document achievement of key milestones.

3. **Describe the engineering concepts utilized in the design in sufficient detail**:
    1. Analysis demonstrating that the proposal conforms to design and performance requirements.

i. **Elements to consider for Tracks 1, 2, 3, and 5**:
    1. Will it fit within the assigned volume, staying within mass and power requirements?
    2. Will the proposed bus support the operations; if not, has the team identified potential solutions?
    3. Does the design consider the launch/descent environment?
    4. Does the design demonstrate a useful capability by combining or sequencing multiple technologies?
    5. Is the appropriate type of analysis performed?

ii. **Elements to consider for Track 4**:
    1. What volume, mass, and power are required for your proposal?
    2. Does the concept create a useful capability?
    3. Is the appropriate type of analysis performed?
    4. Identify the systems you would need (i.e., number of spacecraft, expected total mass and volume, number of launches required).
    5. Is there an ideal orbit or distance from earth that will allow for optimal performance/construction?

iii. **Elements to consider for Track 6**:
    1. What volume, mass, and power are required for your proposal?
    2. Does the concept create a useful capability?
    3. Is the appropriate type of analysis performed?
    4. Identify the systems you would need (i.e., number of spacecraft, expected total mass and volume, number of launches required).
    5. Specify where the cluster will operate (i.e., which orbital planes or lunar zones).
    6. How would the constructed part be used?

2. Identification and mitigation of risks associated with the design.
3. Generate a high-level overview of data handling and ground communications.
4. Summary of trade studies that help illustrate the design development.

4. List key lessons learned during the project:
1. Three innovative ideas that were shared, even if not pursued.
2. Three technologies most important to develop for this demo or other ISAM activities.
3. Three biggest challenges encountered, even if avoided.

5. The work should be well defined and clearly described:
1. Make a professional, concise, coherent presentation at the C3 Final Showcase.
2. Write a 10-20-page technical paper that would be appropriate for an engineering conference, journal, engineering magazine, etc. (The deadline for submitting an extended abstract to the AIAA SciTech Forum is typically late May. While optional, it accounts for 5% of the score and builds good experience.)
3. By October 24, 2026, describe your planned concept in 50-150 words and list three references (not taken from this packet) relevant to your work.

4. Give a 5-minute "pitch" to give a clear and concise idea about the status of the work during the Midpoint Showcase.

11.3 Guidance for Evaluating Prototypes

Prototypes are optional for all tracks except C3-Lunar, where they are required and contribute 20% of the track's final score. Prototypes do not factor into overall C3 rankings and will not be considered in judging winners, except as a tool to illustrate and evaluate conceptual designs on: The team with the best functional prototype will be recognized.

1. **Inclusion of Novel Subsystems**. Does the prototype isolate and validate high-risk, custom-engineered elements over standard flight-heritage parts?
2. **Functionality**. Does the prototype function? If there is a mechanism, does that work? If there is an operational step in the demo mission, is that included?
3. **Readiness**. Does the prototype help prove out the design concept? How much of the design is prototyped? Does the prototype fit within the constraints of the commercial host platform?
4. **Utility**. Can the prototype be used in the next stages of design or be used for developmental testing?

11.4 Guidance for Evaluating Paper

COSMIC will launch a new consortium publication, the *COSMIC Journal*, and the C3 team with the Best Paper distinction in 2026-2027 will be invited to publish their work. Criteria for evaluating the Best Paper are different than the criteria for evaluating the presentations. In general, the paper as written should be suitable for publication at a technical conference. This is distinct in many ways from the Final Report that may be required for a Capstone class.

The intent of the C3 paper is not to demonstrate how much effort your team expended, nor is it to document all the alternatives considered. Instead, the paper should inform the reader about your innovation; demonstrate that you understand the state of the art and considered alternatives; highlight how this innovation fits into the growing ISAM ecosystem; and to perform sufficient engineering work to show that your concept is viable. While the C3 paper accounts for a small portion of the overall presentation score, the evaluations performed by *COSMIC Journal* editors will not be used to determine the winning teams. To evaluate and choose the Best Paper for publication, editors will review the submissions with these criteria.

1. **Technical Quality**. How strong is the engineering analysis? Has the team performed sufficient work to demonstrate that their concept is technically viable? (30%)
2. **Originality**. Is the proposed concept novel? Does it combine or propose technologies in ways not previously considered? (20%)
3. **Impact**. Would execution of the concept advance ISAM by enabling new capabilities useful for a range of applications? (20%)
4. **Writing**. Is the paper well-written, concise, and well-organized? Is it easy to understand the important elements in an initial reading? (15%)

5. **Literature review**. Does the paper put the proposed concept into proper context? Does it identify similar projects and illustrate how the work is a step forward? (15%)

11.5 Prizes and Other Opportunities

The editors of the *COSMIC Journal* will offer to publish the work awarded Best Paper, and each track is expected to provide non-monetary awards and other opportunities. Prizes for 2026-2027 tracks (subject to change) include but are not limited to those listed below.

Track 1 (C3-Manufacturing)
Teams may have the opportunity to test a prototype with the terrestrial simulator at Arkisys in California. The winning team will be invited to present its mission to Arkisys virtually or on-site.

Track 2 (C3-Lunar)
Teams will have the opportunity to test their prototypes on the lunar proving grounds at NASA Marshall Space Flight Center (MSFC) in April 2027. All C3-Lunar prototypes can be considered for demonstration at the Mars Arctic Research Station in summer 2027. The winning team will be invited to present their work to NASA engineers leading the effort to establish a Moon Base.

Track 3 (C3-Servicing)
The winning team will be invited to present its project to senior executives at Northrop Grumman headquarters in April 2027. The current expectation is that travel will be funded.

Track 4 (C3-Construction)
The winning team will be invited to present its proposal to leading NASA experts on in-space assembly in April 2027.

Track 5 (C3-Return)
The winning team will receive company merchandise from Dispatch and potentially an opportunity to present its work to Dispatch virtually or on-site in April 2027.

Track 6 (C3-Cluster)
The winning team will be invited to present its project to senior personnel at The Aerospace Corporation in April 2027.

12. Timeline

12.1 Key dates for universities and other educational institutions

- August 10, 2026: C3 information packet released, and registration opened
- September 11, 2026: Preferred registration deadline (will close after 100 teams register)
- September 14, 2026: Mentors matched with teams
- October 12, 2026: Late registration deadline (will close after 100 teams register)

12.2 Key registration and deliverable dates for students

- September 14, 2026: Live on-boarding session for teams and mentors (to be recorded)
- October 12, 2026: Deadline to register teams for the COSMIC Capstone Challenge (registration will close after 100 teams register)
- October 16, 2026: Provide a mission statement and associated questions
- December 7-11, 2026: **Midpoint Showcase** and announcement of prizes
- April 12-16, 2027: **Presentation and judging at C3 Final Showcase** (winners announced the following week)

12.3 Key milestones and recommended completion dates for student teams

Recommended dates are based upon two university semesters from September 7, 2026 through April 30, 2027, and may be adjusted for other timeframes. Guidance is available at https://cosmicspace.org/c3/ for teams attempting to complete this effort in a single semester.

- September 15, 2026: Identify who on the team will serve as program manager
- October 12, 2026: Select operations to form the foundation of the target capability
- November 14, 2026: Present Systems Requirements Review (SRR) to peers, mentor, and advisor
- January 12, 2027: Complete trade studies
- March 2, 2027: Present Conceptual Design Review to peers, mentor, and advisor
- April 5, 2027: Develop a plan to reach Preliminary Design Review (PDR)
- April-May 2027: Complete post-competition survey when provided
- May 2027: Submit paper to technical conferences (such as AIAA SciTech Abstracts)

12.4 Key dates for organizers, mentors, judges, and sponsors

- April 13, 2026: Mentor registration opens
- June-July 2026: Socializing C3 at COSMIC meetings and through university networks
- August 5, 2026: Preferred mentor registration deadline
- Week of September 8, 2026: Live on-boarding session for teams and mentors
- September 29, 2026: Late mentor registration deadline
- September 30, 2026: Judge registration opens
- November 1, 2026: Deadline for sponsors to offer prizes
- Week of December 7, 2026: **Midpoint Showcase** and announcement of categories and any prizes
- February 2027: Send Out Schedule Survey
- (to begin planning C3 Final Showcase agenda)
  March 2027: Judge registration closes; establish agenda for presentations and judging assignments
- March-April 2027: Judge orientation and on-boarding
- April 12, 2027: Presentation and judging at **C3 Final Showcase** (winners announced the following week)

- April 17, 2027: Send out post-competition survey to judges, mentors, and advisors
- Late April 2027: Meet with judges, mentors, and advisors to gather feedback

12.5 Recurring events

- COSMIC will host weekly office hours for questions and guidance beginning week of August 31, 2026.
- Every 4 weeks, each track champion will host office hours for their track.
- Teams will meet with industry mentors and university advisors on a biweekly basis.
- COSMIC will host occasional ISAM seminars during the C3 timeline.

13. Expectations

13.1 Expectations for students

- Contact mentors to set up weekly or biweekly meetings and act professionally in those interactions.
- Recognize that your mentor is a resource, not an obligation (teams that meet regularly do better).
- Read through this entire C3 Information Packet at the start of the project (focus on your track).
- Review reference documents.
- Reach out to mentors, academic advisors, and C3 committee as appropriate with questions.
- Complete all required classwork, even if it is not required for C3.
- Address and document key milestones from Timeline page.
- Eligibility: all participants must be enrolled at a U.S.-based college.
- Complete post-competition survey if requested.

13.2 Expectations for professors and other academic advisors/ leads

- Sign up for C3 on website by August 13, 2026 (preferred) and no later than October 9, 2026.
- Regularly direct and encourage students to contact their mentors.
- Reach out to C3 committee with questions about the program.
- Help students form teams as: part of a class, for a student club, or as independent study
- For design classes, grades are based upon the school's own criteria; professors may choose to use the judging criteria provided to inform their grades but should not use judges' scores.
- Complete post-competition survey when provided

13.3 Expectations for mentors

- Meet 4-10 hours monthly with students (at least bi-weekly).

- Serve as the ISAM expert for the students and direct them to appropriate resources.
- Contact C3 committee if there are team issues or with other questions.
- Treat the students as junior engineers; encourage them to be innovative.
- Do not share export-controlled or proprietary information with teams.
- Support, encourage, and advise students.
- Are not responsible for evaluating individual students or the team.
- Complete post-competition survey when provided.

13.4 Expectations for judges

- Attend judge's onboarding brief, which includes overview of ISAM and C3 objectives.
- Spend one or more days listening to presentations and scoring entries.
- Do not act as a judge for any team you have advised, with allowed exceptions for providing feedback regarding the Midpoint Showcase or for answering basic questions during office hours and other times you would be available to multiple teams.
- Review the C3 Information Packet and score sheets before the C3 Final Showcase.

13.5 Expectations for C3 committee

- Provide clear guidelines to all stakeholders.
- Be available on a daily basis for email and a weekly basis for verbal communications.
- Maintain a compelling program throughout the academic year and incorporate feedback from stakeholders.

14. Reference Documents

14.1 General References

About ISAM & related technologies

- COSMIC one-stop shop
- COSMIC ISAM 101
- NASA ISAM overview
- COSMIC released products
    - ISAM Resources & References database
    - COSMIC Lexicon
    - ISAM Technology Taxonomy

Technology assessment and development roadmaps (recommended reading)

- "In-Space Servicing, Assembly and Manufacturing Strategy," National Science & Technology Council. April 2022. https://cosmicspace.org/wp-content/uploads/2025/01/04-2022-ISAM-National-Strategy-Final.pdf
- "In-space Servicing, Assembly, and Manufacturing (ISAM) State of Play," John Mulvaney, Dr. Dale Arney, Jose Morel (NASA Langley Research Center), Christopher Stockdale (Analytical Mechanics Associates, Inc.), Christopher Whitlock (University of Kansas), Vishruth Balaji (Texas A&M). October 1, 2025. https://ntrs.nasa.gov/citations/20250008988
- "In-Space Servicing, Assembly, and Manufacturing for the New Space Economy," Alec Cavaciuti, Joseph Heying, Joshua Davis. July 2022. https://csps.aerospace.org/sites/default/files/2022-07/Cavaciuti-Davis-Heying_ISAM_20220715.pdf
- "Toward a Fully Capable In-Space Manufacturing Ecosystem," Matthew B. Obenchain, Alex Trujillo, Jacob Rome, Joseph H. Heying, Arianna Villegas, Vinay K. Goyal and Deneen Taylor. AIAA SciTech 2025 Forum. January 2025. https://doi.org/10.2514/6.2025-1781
- "Design for Servicing - Design Considerations for a Serviceable Space Vehicle," Craft H., ATR-2026-00300

Exemplar ISAM missions

- NASA OSAM-1
- DARPA Orbital Express
- Northrop Grumman Mission Extension Vehicle
- Astroscale Refueler
- Swift Boost Mission
- Mission Robotic Vehicle

Economic Analysis

- "In-Space Servicing, Assembly, and Manufacturing: Benefits, Challenges, and Policy Options," General Accounting Office, GAO-25-107555, July 2025. https://www.gao.gov/products/gao-25-107555
- "Feasibility study for a commercial space station in low earth orbit," Benas, et. al., Acta Astronautica, April 2025. https://doi.org/10.1016/j.actaastro.2024.09.058
- On-orbit servicing as a future accelerator for small satellites, Levchenko, et. al., npj Space Exploration, April 2026. https://doi.org/10.1038/s44453-025-00024-7
- "Orbital Manufacturing Design Impacts: Small Satellite Refueler Study," Heying, et. al., AIAA SciTech Forum 2026. https://doi.org/10.2514/6.2026-1050
- The Economic Case for an Orbital Satellite Factory, Trujillo, et. al., AIAA ASCEND 2023. https://doi.org/10.2514/6.2023-4676

About the COSMIC Capstone Challenge

- Guidance for tackling C3 in a single semester. https://cosmicspace.org/wp-content/uploads/2026/07/Suggested-C3-Scheduling-Tips_UPD-1.pdf
- "Overview of the ISAM Design Challenge and Competition," Jacob Rome and Vinay Goyal. AIAA 2024-0628. AIAA SciTech 2024 Forum. January 2024. https://doi.org/10.2514/6.2024-0628
- "Orbital Manufacturing Initiative," Rome (SSDM). April 2024. https://cosmicspace.org/wp-content/uploads/2024/07/Orbital_Manufacturing_Initiative_April_2024.pdf
- COSMIC Capstone Challenge LinkedIn Group. https://www.linkedin.com/groups/14485139/
- "COSMIC Capstone Challenge," Joey Heying and Jacob Rome, AIAA SciTech 2025 Forum, January 2025. https://doi.org/10.2514/6.2025-0803
- "Driving ISAM Workforce Development with the COSMIC Capstone Challenge," Rome, Heying and Goyal, AIAA SciTech 2026 Forum, January 2025. https://doi.org/10.2514/6.2026-1048

Example projects

- University of California San Diego: Autonomous Rail Transportation Network for Spacecraft Servicing and Inspection, Lovekin, E., Kattee, A., D'Souza, R., Khan, E., AIAA SciTech 2025 Forum. January 2025.
- Kennesaw St.: "Conceptual Development Design Challenge of On-Orbit Autonomous Manufacturing Payloads," Goyal, Vijay, AIAA SciTech 2025 Forum.
- California State University Northridge, "Concept Development for Autonomous In-Space Additive Manufacturing, Inspection Using Thermography, and Robotic Manipulation,"

William A. Sulprizio, Rogelio Reynoso, Erek Flores, Noah Liu and Joshua Santiago. AIAA SciTech 2025 Forum.

- University of Florida: "Autonomous Dual Interchangeable Robotic Arms for In-Space Servicing, Assembly, and Manufacturing," Tindall, J., et. al., Small Sat, August 2025
- United States Air Force Academy: "Space Printer for Autonomous Manufacture of Mega-Structures (SPAMM)," Timperley, S., Costantino, G., AIAA SciTech 2026 Forum
- Virginia Tech: "Project Daedalus: A Spacecraft Concept for In-Orbit Manufacturing, Assembly, and Inspection of Aluminum Structures," Vinod, T., et. al., AIAA SciTech 2026 Forum
- Kennesaw St. University: "Conceptual Design for In-Orbit Polymer Recycler," Goyal, V., Buitrago, D., et. al., AIAA SciTech 2026 Forum,
- Kennesaw St. University: "Conceptual Design for Assembly and Storage Platform for In-Orbit Relay Equipment," Goyal, V., Abair, D., et. al., AIAA SciTech 2026 Forum

Design review templates

The first reference listed is **required reading**. The others are provided for students as guidelines for conducting reviews and planning the work. They are meant to be descriptive not prescriptive.

- "Introduction to Conceptual Design," Lee (**Required**)
- "NASA System Requirements Review Template," Benedict
- "NASA System Concept Review Template," Benedict
- "EML2322L – Design Report Template," University of Florida
- Fundamentals of Systems Engineering (short 23-slide presentation from NASA)
- Systems Engineering Fundamentals
- The Beginner's Guide to Systems Engineering

Program Management

- NASA Research and Technology Program and Project Management Requirements (Revalidated w/change 5) NPR 7120.8A
- NASA Systems Engineering Processes and Requirements Updated w/Change 2. NPR 7123.1D
- Project Planning for Beginners: https://www.youtube.com/watch?v=ZWmXi3TW1yA
- Project Management Fundamentals from Coursera

Other Design Competitions

Links are provided to other competitions to spark ideas amongst students as they pursue their design projects. While most of the competitions focus on building prototypes, many have solid university-appropriate guidelines on how to progress through the design process.

- AIAA Design/ Build/ Fly

- Formula SAE
- 3D Printed Aircraft Competition
- American Solar Challenge
- Revolutionary Aerospace Systems Concept Academic Linkage (RASC-AL)
- Intelligent Ground Vehicle Competition
- NASA Student Launch Initiative

14.2 References for C3-Manufacturing

Partial selection of technologies that would benefit on-orbit demonstration

- "No More Lost in Space: Low-SWAP ID and Tracking Aids," Barbara M. Braun, The Aerospace Corporation (OTR 2021-00372)
- "Methods of Non-Destructive Evaluation of Composites," NASA (LAR-TOPS-120)
- "ISS Interface Mechanisms and Their Heritage," John Cook, Valery Aksamentov, Thomas Hoffman, and Wes Bruner, The Boeing Company (NASA 20110010964)
- "Applications of Permanent Magnet in Outer Space," Stanford Magnets
- "Technology Roadmap for the Development of an Orbital Smallsat Factory," Matthew Obenchain et al., The Aerospace Corporation/United States Space Force Space Systems Command/NASA Langley Research Center (NASA 20230015444)

Host Vehicle

This vehicle was chosen to provide all teams with a common starting point. Other companies offer similar host capabilities, either as a satellite bus or a persistent platform.

- CAD for the Bosuns Locker, courtesy Arkisys
- Interface Control Drawing for the Bosuns Locker, courtesy Arkisys

14.3 References for C3-Lunar

Partial selection of technologies that would benefit lunar surface infrastructure demonstration

- "Moon-to-Mars Architecture," NASA
- "Moonbase," NASA
- "Ten NASA Science, Tech Instruments Flying to the Moon on Firefly Lander," NASA
- "NASA Enables Construction Technology for Moon and Mars Exploration," NASA
- "Lunar Landing Pads," NASA (KSC-TOPS-89)
- "Design Analysis for Lunar Safe Haven Concepts," Iok Wong et al., NASA Langley Research Center/NASA Marshall Space Flight Center (NASA 20210024725)

Fission Surface Power

- "Lunar Surface Power Systems," John Scott, NASA Space Technology Mission Directorate (NASA 20230005406)
- "Demonstration Proves Nuclear Fission System Can Provide Space Exploration Power," NASA
- "NASA's Fission Surface Power Project Energizes Lunar Exploration," NASA
- "Fission System to Power Exploration on the Moon's Surface and Beyond," NASA
- "Fission Surface Power—A Conceptual 350-kW (thermal) Microreactor Designed for Lunar Power Around SpaceX Falcon Heavy Mass Constraints," Daniel Watson et al., Nuclear Technology Journal (doi.org/10.1080/00295450.2024.2423144)
- "A Summary of NASA Architecture Studies Utilizing Fission Surface Power Technology," https://arc.aiaa.org/doi/10.2514/6.2010-6599
- "Fission Surface Power System Initial Concept Definition," NASA/TM—2010-216772
- "Reference Reactor Module for the Affordable Fission Surface Power System," Poston, D., Kapernick, R., et. al., AIP Conference Proceedings, 2008

Host Vehicle

This vehicle was chosen to provide all teams with a common starting point. Other companies offer similar host capabilities, either as a satellite bus or a persistent platform.

- Griffin Lunar Lander, Astrobotic

14.4 References for C3-Servicing

Partial selection of technologies that would benefit lunar surface infrastructure demonstration

- "A New Design Approach: Modular Spacecraft," Matthew Kohut, NASA
- "Autonomous Robot Swarms for Lunar Orbit Servicing and Space Asset Assembly," NASA Space Technology Mission Directorate
- "Technologies for Refueling Spacecraft On-Orbit," David Chato, NASA Glenn Research Center, (NASA 20000121212)
- "Space Situational Awareness," Space Safety Institute, The Aerospace Corporation
- "Robotic Servicing Arm," NASA NEXIS

Host Vehicle

This vehicle was chosen to provide all teams with a common starting point. Other companies offer similar host capabilities, either as a satellite bus or a persistent platform.

- SpaceLogistics, Northrop Grumman
- The MRV, Northrop Grumman
- Mission Robotic Vehicle Fact Sheet, Northrop Grumman

14.5 References for C3-Assembly

Partial selection of technologies that would benefit in-space assembly demonstration

- "SpaceFrame: Modular Spacecraft Building Blocks for Plug and Play Spacecraft," Miller et al., AeroAstro Inc./Air Force Research Laboratory
- "Robotic Technologies for In-Space Assembly Operations," Roa et al., German Aerospace Center (DLR)
- "Robotic Assembly and Outfitting for NASA Space Missions," NASA
- "NASA Enables Construction Technology for Moon and Mars Exploration," Loura Hall, NASA

Reference systems

These systems were chosen to provide all teams with a common starting point. Other companies offer similar capabilities.

- "ARMADAS," Sanders et al., NASA Ames Research Center
- "TriTruss: New and Novel Structural Concept Enabling Modular Space Telescopes and Space Platforms," Doggett et al., NASA Langley Research Center/National Institute of Aerospace
- "Tall Lunar Tower," Matthew Mahlin, NASA Langley Research Center
- "Lunar Sandbags," Du et al., Space Exploration Initiative, Massachusetts Institute of Technology

14.6 References for C3-Return

Early reference work

- Analysis of Selected Opportunities for Manufacturing in Space, B. Wahl, 1969. One of the earliest ISAM papers.

Host Vehicle

- Dispatch Space Payload Guide, https://dispatch.space/payload-user-guide

Exemplar Projects

- Bulk semiconductor crystal growth (III-V / II-VI, e.g. InSb, CdZnTe). Microgravity cuts convection and defect density. Precedent: InGaSb growth on the ISS, npj Microgravity, 2015. https://www.nature.com/articles/npjmgrav201511
- Protein / antibody crystallization for drug delivery. Crystalline suspensions enable concentrated, lower-volume subcutaneous dosing. Precedent: Merck pembrolizumab (Keytruda), npj Microgravity, 2019. https://www.nature.com/articles/s41526-019-0090-3

- Stem cell expansion for regenerative medicine. Microgravity boosts proliferation and reduces spontaneous differentiation; culture and expand cells, then return them. Far more tractable and autonomous than printing whole tissues. Precedent: Cedars-Sinai iPSC work, Cell Stem Cell, 2025. https://www.cell.com/cell-stem-cell/fulltext/S1934-5909(25)00332-7
- ZBLAN optical fiber. Suppressed crystallization yields far lower signal loss than terrestrial fiber. Precedent: Space-based ZBLAN fabrication, Space: Science & Technology, 2025. https://spj.science.org/doi/10.34133/space.0572

Motivation and precedent

- "In-Space Manufacturing: Technologies, Challenges, and Future Horizons," S. A. Jose et al. Journal of Manufacturing and Materials Processing, 9(3):84. 2025. Open-access review surveying additive manufacturing, materials processing, and biomanufacturing; a good menu for picking a technology to design around. https://doi.org/10.3390/jmmp9030084
- "In-Space Servicing, Assembly, and Manufacturing National Strategy," National Science & Technology Council. April 2022. https://csps.aerospace.org/sites/default/files/2022-05/Natl%20Space%20Servicing%20Strategy%20Apr22.pdf
- "Protein Crystal Growth in Microgravity," L. J. DeLucas et al. Science, 246(4930): 651-654. November 1989. https://pubmed.ncbi.nlm.nih.gov/2510297/
- "The Potential of Microgravity: How Companies Across Sectors Can Venture into Space," McKinsey & Company. 2024. https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/the-potential-of-microgravity-how-companies-across-sectors-can-venture-into-space
- "Return of the Ritonavir: A Study on the Stability of Pharmaceuticals Processed in Orbit and Returned to Earth," Improved Pharma / Varda Space Industries. ChemRxiv preprint. March 2024. The only pharmaceutical made in orbit and recovered through reentry - the direct precedent for this track. https://chemrxiv.org/engage/chemrxiv/article-details/65faecbee9ebbb4db91b4ac1

14.7 References for C3-Cluster

- "Starling," NASA
- "BlackJack," DARPA
- "Pelican Delivers the Details; Rapid, responsive, resilient," Planet Labs
- "LUNANET: CRAFTING THE NAVIGATION AND CONNECTIVITY FRAMEWORK FOR LUNAR EXPLORATION'S NEXT ERA," The Aerospace Corporation
- "Northrop Grumman's Mission Robotic Vehicle Launches, Ushering in a New Era of In-Space Servicing," Northrop Grumman
- "Spacecraft Formation Flying," Alfriend et al.
- "A Survey on Aerial Swarm Robotics," Chung et al.

15. Vision For the Future of the COSMIC Capstone Challenge

The genesis of C3 was the ISAM Design Challenge starting in Fall 2022, a senior design project developed by The Aerospace Corporation to harness the creativity of college students while introducing them to the emerging ISAM field. It has since evolved into the formalized, defined structure of C3, which has been crafted with input from industry mentors, government customers, capstone professors, competition organizers, competition judges, and student participants. C3's current focus is to expand the program successfully and maintain the high level of mentor-team engagement. With the expansion to six tracks, each with its own champion, C3 is being developed to sustain and grow in the future.

C3 has been developed to encourage participation within the construct of a **2-semester senior engineering design class**, often referred to as a Capstone project. However, **it is not restricted to that category**. Student clubs and groups of students, either undergraduate or graduate, pursuing independent or directed study, can participate. The best outcome of C3 is an excited core of students who want to continue projects past the conceptual design phase to detailed design work or even prototyping.

There is a strategic component to casting C3 as a judged competition with mentoring. To be precise, the judges and mentors will often be drawn from elements of the government and industry that are interested in pursuing these projects. **The successful version of this program would connect student teams with funding sources to continue their work towards eventual missions,** executed either by successor university teams or by contractors capable of executing them. This element could play well with student clubs, which typically have year-to-year carryover — continuity that could be leveraged in future iterations of C3 that bring promising Conceptual Designs to the Preliminary Design phase.

For the 2026-2027 academic year, C3 remains focused on the engineering part of the problem. In future iterations, the **scope may be widened to encourage non-engineering students with an interest in ISAM to participate**. This could be done through the problem statement, through the judging rubric, or via additional categories. For example, up to 10 points could be awarded for developing a business plan to identify how the project would go from Conceptual Design through launch by identifying funding sources, launch opportunities, and long-term project management. The team that creates the best 1-page marketing pitch for potential sponsors could receive a separate award, and there could be a similar approach for artwork.

C3 remains a work in progress. The development of the program in the future will be guided by mentors, judges, students, professors, supporters, and COSMIC members. The community will inform future C3 Information Packets. It is the intent of COSMIC to appeal to a broad swath of students as we work to advance ISAM while exposing students to the possibilities of ISAM.

16. Administrative Items

- COSMIC has no rights to any intellectual property generated during this project, with limited permission to share the final products as described in the next bullet.
- By participating in C3, entrants hereby grant to the C3 organizers a world-wide, royalty-free, non-exclusive, sublicensable right to copy, publish, and distribute the outbriefs from the competition, and create derivative works therefrom, for any purpose, including, without limitation, sharing the same with the COSMIC membership and (past, current, and future) participants in a COSMIC Capstone Challenge, and for authoring summaries, articles, briefings, and marketing materials, including for public dissemination.
- There is no guarantee of monetary prizes being awarded. If there are any prizes awarded by C3 sponsors, the prize is the sole responsibility of the sponsors.
- All C3 judges and mentors must be authorized participants from a COSMIC member organization; COSMIC is no cost to join, and open to any U.S. organization.
- Any authorized participants from a COSMIC member organization may serve as mentors or a judge. Mentors may serve that role for multiple teams. C3 organizers may fulfill judge and/or mentor roles. Mentors, advisors, and organizers may not act as judges for teams they have advised.
- If C3 is used as a Capstone, scoring criteria used in this solicitation is not required for use in grading students. It is up to the discretion of the professor to select class grading material. Likewise, mentor feedback should not have direct impact on student grades.
- There is a strict no-harassment policy.
- All participants (entrants, judges, and mentors) must abide by International Traffic in Arms Regulations (ITAR) rules. Mentors must not provide any information to any team that is ITAR-controlled, and student entries must not include any ITAR-restricted materials.
- Entrants must be enrolled at a U.S.-based educational institution. Participants in the C3-Clusters track must be U.S. persons. For all other tracks, there are no citizenship or nationality restrictions for any student members of participating teams or their advisors.
- COSMIC membership is not required for teams or their associated educational institutions to participate.

17. COSMIC Capstone Challenge 2026-27 Score Sheet

Judges may score each subcategory, or may score the entire category as a whole, depending upon their preference.

Track Number: ______________________________

*Team Name: ______________________________

Team Organization: ______________________________

Team Members: ______________________________

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*Judge's Name: ______________________________

Total Score: ______________________________

Date: ______________________________

* Required fields
(Note that categories 5.3, 5.4 and 6 will be scored by the organizers.)

Category 1: Conceptual Design (See Section 11.2 for Details)			
Subcategory	**Description**	**Score Range**	**Score (½ OK)**
1.1 Technical Impact of Demonstrated Capability	If the mission is successfully executed, how much impact would those capabilities have for future space missions?	0-8	
1.2 Feasibility of Proposed Mission	How likely is it that this mission (if funded) could be designed & built within 5 years?	0-8	
1.3 Innovation	Is the design original in a pertinent way?	0-7	
1.4 Advancing High-Value Missions	Do teams connect their proposed concept to the high priorities of the targeted customer community appropriate for their track?	0-5	
Category Total	**Conceptual Design: How does the team show that their mission would be viable, useful, and novel?**	**0-28**	

Category 2: Systems and Program Overview			
Subcategory	**Description**	**Score Range**	**Score (½ OK)**
2.1 Animate key operating sequence	Utilizing CAD designs, a prototype, or other tools, develop an animation or video to show step by step processes required to execute concept design.	0-7	
2.2 Storyboard of complete operation	At each phase of a mission (from launch until deorbit), illustrate and describe the varying configurations and operations the concept will progress through over the mission's duration.	0-7	
2.3 Path to PDR	Has team identified next steps for design process & outlined a sequenced to advance to Preliminary Design Review?	0-4	
2.4 Program Management Milestones	Did the team provide evidence that they hit the key milestones: Selecting a program manager, selecting operations, presenting SRR, completing trade studies, presenting CoDR, develop path to PDR?	0-4	
Category Total	**Systems and Program Overview: How well did the team manage the project and communicate their ideas?**	**0-22**	

Category 3: Project Engineering			
Subcategory	**Description**	**Score Range**	**Score (½ OK)**
3.1 Required Elements	How well did the team follow the challenge prompt and did they do engineering analysis to justify their design decisions? See Section 11.2 for details.	0-15	
3.2 Identify & mitigate risks	Has the team identified likely points of failure and identified potential solutions?	0-4	
3.3 Data handling & comms	Develop a high-level overview/flowchart of data management and ground communications needs	0-3	
3.4 Trade Studies	Has the team highlighted trade studies to illustrate the design development & selection process?	0-4	
Category Total	**Project Engineering: Did the team complete key engineering steps in support of their mission concept?**	**0-26**	

Category 4: Lessons Learned			
Subcategory	**Description**	**Score Range**	**Score (½ OK)**
4.1 Innovative concepts	What are the three most innovative ideas you had? Even if they weren't pursued.	0-3	
4.2 Tech. gap assessment	Identify three technologies as most important to develop for this effort.	0-3	
4.3 Biggest challenges	The three biggest challenges with the design process, even if you avoided them.	0-3	
Category Total	**Lessons Learned: Did the team learn and convey important lessons during their project?**	**0-9**	

Category 5: Deliverables			
Subcategory	**Description**	**Score Range**	**Score (½ OK)**
5.1 Presentation	Clarity, professionalism, and persuasiveness of the presentation, including visual aids and verbal communication. Consider these 5 key elements: Chart construction, verbal explanations, cohesiveness, proper use of white space, handling of questions.	0-8	
5.2 Paper	A paper ten-to-twenty pages long which would be suitable for inclusion in a technical conference. Consider elements such as length, organization, technical content, writing, and bibliography.	0-4	
5.3 Mission Statement	Describe your planned concept in 50-150 words & pose 3 questions requiring domain-specific expertise relevant to your mission.	0-1	
5.4 "Pitch" Presentation	During the Midpoint Showcase, teams will give 5-minute pitches that clearly & concisely describe their idea & their status. Then pose 3 questions for other teams about their projects.	0-2	
Category Total	**Deliverables: Was the material well-organized and presented clearly? Did the paper meet the basic requirements?**	0-15	

Category 6: Prototype (Optional/Required for Track 2)			
Subcategory	**Description**	**Score Range**	**Score (½ OK)**
6.1 Inclusion of Novel Subsystems	Does the prototype isolate and validate high-risk, custom-engineered elements over standard flight-heritage parts?	0-7	
6.2 Functionality	Does the prototype function? If there is a mechanism, does that work? If there is an operational step in the demo mission, is that included?	0-6	
6.3 Readiness	Does the prototype help prove out the design concept? How much of the design is prototyped? Does the prototype fit within the constraints of the commercial host platform?	0-6	
6.4 Utility	Can the prototype be used in the next stages of design or be used for developmental testing?	0-6	
Category Total	**Prototype**	**0-25**	

Summary			
Category	**Description**	**Score Range**	**Score (½ OK)**
1.	Conceptual Design	0-28	
2.	Systems and Program Overview	0-22	
3.	Project Engineering	0-26	
4.	Lessons Learned	0-9	
5.	Deliverables	0-15	
Grand Total	**COSMIC Capstone Challenge**	**0-100**	
Opt. Prototype	If the team opted to create a functional prototype, provide a score based upon its function and performance	0-25	

Team Name: ______________________________

Judge's Name: ______________________________

Technical Paper Evaluation			
Metric	Description	Score Range	Score
1. Technical Quality	How strong is the engineering analysis? Has the team performed sufficient work to demonstrate that their concept is technically viable?	0-30	
2. Originality	Is the proposed concept novel? Does it combine or propose technologies in ways not previously considered?	0-20	
3. Impact	Would execution of the concept advance ISAM by enabling new capabilities useful for a range of applications?	0-20	
4. Writing	Is the paper well written, concise, and well organized? Is it easy to understand the important elements on an initial reading?	0-15	
5. Literature Review	Does the paper put the proposed concept into proper context? Do they identify similar projects and illustrate how their work is a step forward?	0-15	
Total	Technical Paper Evaluation	0-100	