NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

DEEP SPACE FOOD CHALLENGE

MARS TO TABLE

Official Challenge Rules

January 2026

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Revision Tracking Log

Date	Revision #	Section	Description
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Terms and Definitions

Definitions of Challenge Administrators

- **National Aeronautics and Space Administration (NASA):** Is an independent agency of the U.S. Federal Government responsible for the civilian space program, as well as aeronautics and space research.
  - **NASA Centennial Challenges:** Led by NASA, Centennial Challenges are public prize competitions that strive to be audacious and inspirational with a focus on long-range NASA goals while addressing complex mission needs. Challenges also identify new sources of expertise and stimulate current and new markets for government and commercial collaboration. The competitions ensure NASA's needs are met and provide potential for terrestrial applications and opportunities for the betterment of humanity.
- **Methuselah Foundation (Methuselah):** Is a non-profit organization that strives to advance human health and longevity. They develop and partner with programs and organizations to accelerate breakthroughs in these areas. NASA has partnered with Methuselah Foundation for Methuselah to serve as the Allied Organization and help execute the Challenge.
- **Floor23 Digital (Floor23):** Is a Wisconsin-based innovation and engagement company that helps organizations design and manage contests, Challenges, and other collaborative activities. Its signature platform, Innobear, supports everything from participant registration and submission handling to engagement tracking, judging workflows, and data insights.

Definitions of Legal Terms

- **Judging Panel:** A panel of professionals and subject matter experts from government, academia, and industry who will evaluate and score all submissions.
- **Phase:** A stage of the Challenge representing a key step in the development of food production technologies for feeding crews on long duration space exploration missions. This Challenge will have one Phase, with the potential for follow-on activities or opportunities.
- **Proof of Incorporation:** Documentation showing that an entity is incorporated in and maintains a primary place of business in the United States.
- **Proof of Nationality:** Documentation proving the nationality of a Team leader and/or Team members.
- **Registered Team:** A Team that has met the requirements of eligibility as stated in the Official Rules and has been officially notified of their status by the Challenge Administrators.
- **Team:** An individual, group of individuals, or Entity (e.g. university, business, etc.) that have officially registered and are approved to compete in the Challenge (U.S., International).
- **Team Agreement:** A legal contract between a Team and the Methuselah Foundation that describes the legal conditions of participating in the Challenge.
- **Team Leader:** A representative of the Team that is responsible for compliance with the Challenge rules by all members of the Team and serves as the primary point of contact for Challenge-related administrative matters.
- **Team Member:** An individual who participates on a Team in the Challenge.

Definitions of Technical Terms for this Challenge

- **Concept of Operations:** A document describing the detailed operations of a proposed food system from a user's perspective, illustrating a complete production cycle including setup, operations, cleanup, and all activities required to prepare for the succeeding production cycle.
- **Food Products:** Any substance – either raw, semi-processed, or processed – that is intended for crew consumption to maintain health and life while serving as a source of nutrients (carbohydrates, fats, proteins and micro-nutrients). These products can come from a wide variety of plant or animal sources but should be safe, nutritious, and appealing.
- **Food Standards:** The mandatory regulations and guidelines that define requirements for food product quality, safety and stability as well as for the materials that come into contact with food throughout the production, processing and preparation cycle.
- **Food Technologies:** The application of scientific and engineering principles to the production, processing, preparation, and preservation of food to ensure safety, nutrition, and quality. For space applications sustainability, reliability, maintainability, and the use of crew time should be primary considerations.
- **Full Food System (also referred to as Space Food System):** Consists of all the components, technologies and processes involved in providing safe and nutritious food for astronauts on missions beyond Earth. This includes the consideration of such aspects as type and source of inputs, production technologies, product harvesting and processing, meal preparation, galley design, storage, waste handling, nutritional optimization, and menu planning. It is important to note that space food systems do not exist in isolation but are closely integrated with other vehicle and habitat systems in how they affect both resource utilization and environmental parameters. As an example production of foods often requires growing and harvesting of the raw ingredient, separating edible ingredients from non-usable/edible components, and subsequent processing of the ingredient (e.g. grinding, baking, fermenting). The Full Food System includes all of this, considering the food streams and the waste streams.
- **Habitat:** Refers to all indoor, environmentally controlled areas. The habitat can contain noncontiguous areas such as greenhouses and outbuildings, and teams are free to divide the habitat into operational zones.
- **In-Situ:** Refers to the use of locally sourced or produced items.
- **Mission Points:** Refers to distinct times over the course of a surface mission that represent the various cycles of the food system. For the purposes of this Challenge, the core mission points that Teams must detail include system startup, nominal operations, contingency maintenance, and system shutdown.
- **Provisions from Earth:** Items that are shipped as logistics along with the crew or are either pre-positioned prior to crew arrival or sent on a follow-on resupply mission.
- **Reliability:** The quality of being dependable, trustworthy, or of performing consistently well. Reliability requires working as expected in normal, well known circumstances. (Jones, 2021)
- **Resilience:** The ability to recover from or adjust easily to an unanticipated accident or change. (Jones, 2021)
- **Robustness:** The capability of performing without failure under a wide range of possible conditions. Robustness implies strength and toughness under potential off-nominal conditions. (Jones, 2021)
- **Sol:** The name for a single day on Mars which is slightly longer than an earth day at 24 hours and 39 minutes.

Challenge Overview

The complexities of our food systems are easily overlooked in the modern era. For much of the world, a single meal represents a complex system of agricultural inputs, processing, preservation, packaging, refrigeration, and distribution. The infrastructure that feeds our society has been built over generations, evolving with technology and the needs of our communities. However, one day soon, humans will travel to places that are beyond the reach of that food system. How will we feed teams of explorers on years-long expeditions, millions of miles from Earth?

For space exploration, the current food system is mainly made up of prepackaged foods that are prepared on the ground and shipped to the International Space Station (ISS). When humans return to the lunar surface, the early missions will continue to use prepackaged foods; however, preparing to extend the duration of lunar missions and sustaining the astronauts on surface missions on Mars will require transitioning to an Earth-independent and complete food system. Thus, examining the possibilities for future food systems will need to consider options for the design and integration of different components, while also identifying steps for testing that can lead to future applications in a Mars habitat.

From 2021 to 2024, NASA successfully executed its first Deep Space Food Challenge (DSFC), which focused on identifying individual technologies with potential to contribute to the overall food production system. The Challenge demonstrated what's possible and also identified an opportunity to look more broadly at how different concepts and technologies could work together and be integrated to make up the complete food system.

Building on the foundation of the DSFC's success, NASA saw an opportunity to continue exploring innovative solutions for space food systems and developed Mars to Table as the next competition to launch under the newly minted Deep Space Food Challenge series. Mars to Table seeks to lay the groundwork for future Challenges that will maintain the rigorous momentum needed to invent complex, reliable systems that will feed tomorrow's space explorers.

Solutions from Mars to Table could influence the future state of an integrated food system that:

- Provides all daily nutritional needs;
- Offers a variety of palatable and safe food choices that incorporates pre-packaged, bulk, and in-situ food sources;
- Utilizes acceptable, safe, and quick preparation methods; and
- Addresses the full spectrum of the functionality of the food system from production, processing and maintenance to preparation, waste-management and storage.

In short, future crew members will require nutritious foods that they will enjoy eating within the many environmental constraints and using the available technology for life far from Earth. The process to create, grow, and/or prepare food must not be excessively time-consuming or unpleasant for the crew to perform. Although there are many food systems on Earth that may offer benefits to space travelers, it's important to recognize that these systems may not be able to meet the demands of the deep-space environment.

Challenge Objectives

This is a design Challenge that seeks to incentivize the development of a complete space food system for a planetary surface that integrates a variety of food sources and associated technologies, and that meets 100% of the crew's variable nutritional needs within the constraints of a Martian habitat.

This Challenge seeks to incentivize Teams to develop a combination of technologies, systems and approaches that meet the full nutritional requirements of future crews to make up a comprehensive food system. The Challenge is designed as one single Phase where Teams will spend up to seven months creating a nutritious and complete meal plan for a crew on Mars, along with a detailed, data-supported concept of operations for the integrated food system that supports and provides for that meal plan. Teams will visualize this concept through a design layout and walkthrough video, and will present all deliverables, including a recorded presentation, for a judging panel to review.

This Challenge will identify approaches to the full food system that can:

- Provide for a 15-person surface expedition crew, including one dedicated food systems engineer and one nutrition/meal prep specialist;
- Support sustained operations for a multi-year surface mission (excluding Earth-Mars transit phases);
- Utilize Earth-provisioned foods and/or bulk ingredients for no more than half of the overall system, with the goal to approach pre-packaged/bulk ingredients as enhancements versus necessities; and

- Substantially augment or fully integrate with the Environmental Control and Life Support System (ECLSS) for closed-loop or near closed-loop resource utilization.

Terrestrial Potential

Innovations in food systems and technologies have the potential to transform how we address food security and resilience across diverse and challenging environments here on Earth. In rural and remote areas, modular hydroponic or aeroponic systems can enable local, year-round crop cultivation without reliance on arable land or supply chains. For military and warfighters, compact, nutrient-dense meal solutions – such as 3D-printed rations or self-heating, shelf-stable foods – can improve endurance and reduce logistical burdens. Affordable, rapidly deployable food systems can be critical in disaster relief scenarios, offering immediate and sustainable nutrition in crisis zones. These technologies also hold promise for extreme environments like polar research stations or deep sea exploration, where traditional agriculture is unfeasible. By harnessing these innovations, we can build adaptable and resilient food systems to meet human needs in any condition.

This Challenge seeks to bridge this gap via innovative food systems that promote a sustainable food production future for space while simultaneously offering benefits for people back on Earth who deal with unique food challenges of their own.

Timeline

Below is an overview of the expected timeline for the Challenge.

Table 1. Competition Calendar

Event	Date
Challenge Opens for Registration/Application Submission	January 12, 2026
Solution Summary Due	May 22, 2026
Registration Closes	July 31, 2026
Final Submission Deadline	August 14, 2026
Top Teams Notified of Judging Panel Q&A Participation	August 26, 2026
Judging Panel Q&A Sessions	August 31, 2026 to September 4, 2026
Winners' Announcement and Awards	September 2026 (Exact Date TBA)

Note: Teams registering after the May 22, 2026 Progress Update deadline must submit their Solution Summary at the time of registration to be considered eligible.

Registration and Submissions

Registration will open when the Challenge opens and will remain open until July 31, 2026 at 6 p.m. Eastern Time (ET).

NASA has contracted with Floor23 Digital to help administer the Challenge. In order to register, all Teams must:

- Navigate to the Challenge website, deepspacefood.org, and click "Register" to visit the Floor23 landing page.
- Complete the Registration Form to create a Team, designating a Team name and Team leader.

- Download the Team Agreement template.
- Upload a completed and signed Team Agreement.
- Provide Proof of Citizenship for the Team Leader and each Team Member.
- If the Team is competing as an Entity, provide Proof of Incorporation showing that the entity is incorporated in and maintains a primary place of business in the United States.
- Provide a Preliminary Concept Abstract and Team Description: Teams must complete the online Registration Form by entering a Preliminary Concept Abstract and a Team Description into the designated text fields. The abstract must provide a high-level overview of the proposed food system, identifying primary production technologies and the general approach to meeting Challenge objectives, while the Team Description should briefly outline the Team's background, affiliations, and expertise.

Once a Team has completed all of these items, they will receive a communication explaining whether: 1) their registration has been verified; 2) their registration has not been verified because additional information is required; or 3) their registration has not been verified because they are not eligible. As soon as a Team has been deemed eligible and approved to participate in the Challenge, they will receive all submission templates and other necessary documentation to begin working on their submission. As such, Teams are strongly encouraged to begin the registration process as soon as possible so they have ample time to receive these materials and complete their submission before the Final Submission Deadline of August 21, 2026 at 6 p.m. ET.

Eligibility

The Challenge is open to U.S. and International Teams that meet the eligibility requirements found in the Legal Requirements section of this document. All interested Teams will register for the Challenge by the deadline and meet the eligibility requirements in order to participate in the Challenge and win a prize (U.S. Teams only). The registration links will be provided through the official Challenge website**:** deepspacefood.org.

Teams will be officially registered to compete after the Team Agreement is co-signed by the Methuselah Foundation and the Team Leader. Until registration is confirmed, a Team is not considered registered.

Multiple Submissions

Each Team may only submit one (1) solution for this Challenge. Multiple submissions by the same Team are not allowed.

Artificial Intelligence/Large Language Models

All submissions must represent original work developed by the members of each Team. Teams are permitted to utilize Generative AI, Large Language Models (LLMs), and other AI-assisted tools as force multipliers to assist in the development of their submissions. This includes the use of AI for brainstorming, data analysis, drafting text, generating code, or creating visual assets.

However, this Challenge operates on a "Human-in-the-Loop" mandate:

- **Verification:** All AI-generated outputs must be rigorously reviewed, verified, and validated by human Team Members. Teams are responsible for ensuring all scientific data, nutritional calculations, and engineering specifications are accurate and grounded in reality.
- **Accountability:** The Team bears full, sole responsibility for the content of their submission. Inaccuracies, "hallucinations," or plagiarism resulting from the use of AI tools will be treated as errors made by the Team itself and may result in penalization or disqualification.

- **Originality:** While AI may be used to assist in articulation or visualization, the core innovation, system architecture, and strategic approach must originate from the Team.
- **Disclosure:** Teams using AI tools must include a brief statement in their Solution Summary acknowledging the tools used and the scope of their application (e.g., "Generative AI was used to assist in drafting the narrative and visualizing the habitat layout").

NASA and the Methuselah Foundation reserve the right to request clarification regarding AI use and to disqualify submissions that are found in violation of this policy. Teams are responsible for understanding the copyright and ownership limitations regarding the output of the specific AI tools they utilize. NASA and Methuselah Foundation are not responsible for IP disputes arising from a Team's use of non-copyrightable AI-generated content.

Judging and Winning

U.S. Teams will be judged and scored for the chance to win a monetary prize from NASA, while International Teams will be judged and scored for the chance to earn recognition from NASA.

The Challenge Judging Panel will be made up of subject matter experts both internal and external to NASA. The Judging Panel makes recommendations to NASA stakeholders, who will choose the final winners of the Challenge.

Determining Challenge Finalists and Winners

Following the submission deadline, the Judging Panel will review all eligible submissions and discuss, evaluate, and rank each entry using the criteria outlined in Appendix C, Table 4. Top-performing Teams will be invited to participate in a live, virtual Q&A session with the Judging Panel. These Q&A sessions will be coordinated and scheduled in adherence to the competition calendar in Table 1.

The winners of the Challenge will be determined by both the total score achieved through their deliverables, as well as a qualitative rank by the Judging Panel following the Q&A sessions. Challenge winners will be selected at NASA's discretion through the evaluation process described in this document and awarded as described below.

Prize Purse for U.S. Teams

The Challenge will offer an aggregate prize purse of up to $750,000 for U.S. Teams. U.S. Teams must meet the eligibility requirements in order to receive a prize from NASA. These criteria are defined in the Legal Requirements section of this document.

After the Judging Panel makes recommendations, up to one (1) U.S. Team will be named as the overall winner of the Challenge and be awarded up to $300,000. Up to two (2) additional U.S. Teams will be named as second and third place winners and awarded up to $200,000 and $100,000, respectively. Up to three (3) $50,000 categorical awards may be awarded for recognizing U.S. Teams who make exemplary advancements or innovations in a given focus area, including but not limited to: Crew Experience, Transformational Innovation, Terrestrial Potential, etc.

Recognition for International Teams

International Teams must meet the eligibility requirements in order to participate in the Challenge. International Teams are not eligible to be awarded prize money.

After the Judging Panel deliberates in August 2026, up to three (3) International Teams may be named the International Winner and International Runners-Up of the Challenge.

Mission Scenario

Your crew of 15 are landing on the surface of Mars, where your mission is to relieve the existing astronaut crew of their duties and continue surface operations for 500 Martian sols (513.75 Earth days).

The structural framework for your Mars surface habitat has reached design maturity and is now prepared for integration with a comprehensive food production and management system. While the goals of your surface mission are scientific in nature, maintaining the crew's physical and mental health through a diverse, nutrient-complete diet will be critical to mission success. Providing that diet in the harsh Martian environment will require a complex, integrated food system with meticulous planning, careful resource utilization, and robust flexibility under unexpected changes. Fortunately, you came equipped with a comprehensive scheme to keep the crew fed.

Your comprehensive food production and management system covers topics as broad as projected monthly water use down to the specific ingredients required for each item on the crew's menu. Food items from Earth account for less than half of your food system input (based on calories), while the majority of food items will be produced, grown, processed, prepared, and stored at the Martian base.

Considerations for a Full Food System

Section 7 of STD-3001: NASA Spaceflight Human-System Standard; Volume 2: Human Factors, Habitability, and Environmental Health makes considerations for core elements and attributes that should contribute to an overall space food system. The full document can be found in Appendix A of this rules document. These elements and attributes are detailed in brief below:

- Safely and reliably meet the nutritional needs of astronauts
- Be compatible with habitat infrastructure, resources and capabilities
- Include all production technologies that provide food outputs
- Ensure that all production and preparation processes can be both controlled and monitored in ways consistent with minimizing crew time requirements
- Include hardware, appliances, and tools to collect and/or harvest and process food outputs
- Account for the disposal or repurposing of system waste streams.
- Provide the ability to produce, harvest, process, and prepare all food outputs into food or meals and determine the safety of all processes and outputs.
- Provide a basis for the nutritional composition of the food outputs and suggest ways to measure and adjust nutrition to meet individual crew needs.
- Include all hardware, appliances and tools required for meal preparation
- Provide a communal area for meal consumption
- Provide the capability to clean and sanitize all system hardware with products, materials and processes consistent with crew and habitat safety.
- Have designated protocols and solutions to store unused outputs (excess production/leftovers)

Deliverables

Teams will create a detailed **Concept of Operations** for an integrated food system that rationalizes a **14-Sol Meal Plan**. Additionally, Teams will outfit a Mars habitat with their proposed system models through an illustrative **Design Layout**. In addition to the documents required, Teams will present via a **recorded video pitch** where they will walk through the Concept of Operations and Design Layout and relate their innovations back to their proposed Meal Plan.

This Challenge will utilize BioSim, an advanced life-support simulation platform originally developed in partnership with NASA Johnson Space Center. BioSim has been extended into a high-resolution testing and benchmarking platform for this Challenge, and provides an end-to-end view of how bioregenerative life support systems perform under stress, allowing researchers to explore and compare mission scenarios including plant growth environments, air revitalization, waste management, and crew health.

Participants will build a **Python model** of their solution and upload it through a custom interface provided by the Challenge Administrators. Once uploaded, the software will run standardized benchmarks across numerous mission configurations. This process will evaluate how the proposed solution performs in silico under real-world constraints and off-nominal conditions, such as, intermittent power failures and outages, water restrictions or supply interruptions, and variances in crew size and metabolic loads, as well as interoperability of various technologies.

The full details of each submission requirement are described in the following section, and official submission templates will be provided via the Challenge website deepspacefood.org for all registered Teams.

Submission Requirements

All Teams will provide the required information described below via online submission portal. All reports, applications, documents, and videos must be submitted in English. No submissions will be accepted outside of the stated deadlines.

1. Solution Summary:

- **Title (not to exceed 10 words):** This title may be displayed on the Challenge website post-submission.
- **Solution Summary**: This document must not exceed five (5) pages (plus one (1) page for references) and must be formatted as letter size (8.5" x 11") with margins no smaller than 0.5". Document text must be single-spaced with Arial font, size 11. The document must be submitted as a PDF. The summary must include an abstract (not to exceed 250 words), a breakdown of the Team and affiliations (one (1) page), a description of the proposed technology, and any relevant figures necessary to explain the concept. In the Solution Summary, Teams should address:
    - What the proposed solution is
    - How the solution is novel, sustainable, and innovative
    - How the solution progresses food systems toward Earth-independence
    - How the solution can improve food security on Earth
- **Intellectual Property:** Teams must explain who owns the intellectual property of the proposed solution. If the solution is built on existing or off-the-shelf technology, Teams should detail the permissions (if applicable) they have to use that technology. If a Team is part of an organization, the submission should indicate which Team Members own the intellectual property.

2. 14-Sol Meal Plan: Registered Teams will generate a submission using the template provided upon being deemed eligible to complete. This template covers the following:

- A plan detailing an astronaut's meals over a two-week period (14 sols). Teams can either follow a traditional breakfast/lunch/dinner mealtime cadence, or they may suggest innovative approaches to astronaut mealtimes that deviate from this standard while remaining nutritionally beneficial, varied, and nourishing.
- Opportunities for up to two (2) supplemental food items (e.g. snacks, contingency meals, etc.) per sol.
- Nutritional information and serving sizes (in ounces/kilograms) for all food products (e.g., meals, snacks, etc.).
- Detailed information on the source of each ingredient used in the meal plan (see "Ingredients" in the "Assessment Criteria" section of this document for more information).

3. Concept of Operations: This element will be formatted in a slide deck and must include several key elements that ensure the space food system is functional, sustainable, scalable, and suitable for its intended environment. These elements include:

- **Operational Protocols**: Explain how the system functions across four mission points in the food system cycle (startup, nominal operations, contingency maintenance, and shutdown), including the transitions between them and the interactions among key subsystems.
- **Production Methodology**: Specify each type of food production technology being incorporated – such as soil-based agriculture, hydroponics, aquaponics, vertical farming, fermentation-based systems, cellular agriculture, etc. – along with the rationale for its selection based on goals and constraints.
- **Input Requirements**: Clearly define the necessary resources such as water, volume, energy, raw materials (seeds, nutrients, growing media), and labor. This also includes environmental controls like lighting, temperature, and humidity management if needed.
- **Safety, Reliability, and Resilience**: Define stopgaps, failsafes, and procedures that keep infrastructure, inputs, and food outputs secure and dependable. Suggest features that increase reuse of resources, promote self-sufficiency, and maintain food production during unplanned disruptions.
- **Human Factors and Usability**: Consider ease of use, training requirements, ergonomics, and safety for all operators, especially those who may have limited agricultural or food production expertise.
- **Monitoring and Control Systems**: Include sensors, automation technologies, and data platforms to monitor crop health, environmental conditions, and system performance for optimal output and predictive maintenance.
- **Resource Management**: Include systems for water recycling and filtration, nutrient delivery, air revitalization (if applicable) and waste reduction or composting.
- **Scalability and Evolvability**: Ensure the system can be scaled up or down and adapted to different conditions by using modular components or standardized designs.

Teams must include an Appendix with their Concept of Operations slide deck to:

- Clarify information presented in the slide deck,
- Demonstrate the feasibility of their approach using representative values, reporting the expected sizes of the input and output streams including water and power use,
- Connect the supporting information to key points made in the verbal presentation,
- Address potential expected issues raised by judges, and
- Discuss maturity of the key technologies utilized in the mission, along with a brief discussion on what technology gaps would need to be filled to accomplish the proposed deployment.

This Appendix is only to be used as a reference document for justifying/proving claims made in a Team's Concept of Operations slide deck and is not to be used as "extra space" for introducing concepts and/or ideas.

A suggested Concept of Operations template will be provided on the Challenge website, deepspacefood.org, for registered Teams.

4. Design Layout: This design is a visual-style breakdown of the required elements of the food system, organized as if one were reading an overall system diagram or schematic layout. While there are no specific software tools recommended for this deliverable, suggested formats may include CAD, illustration, or animation. See Appendix D: Judging Rubric for more details.

Layout of a food system within a habitat will be critical for optimal system performance. Within a habitat, some areas may serve multiple operational functions, while others may be dedicated to individual key tasks. A Team's blueprint will demonstrate the arrangement of all food system components, highlighting dimensions, operational zones, configuration of resource management infrastructure, rationale for location/placement relative to other habitation areas, etc. The operational architecture of the system will dictate which components are represented in the blueprint and how those components are organized. Teams may consider the following items in developing their system layout. This list is not exhaustive, and not all components will necessarily be included in all system architectures.

Table 2. Blueprint Design Considerations

Component	Suggested Considerations
Overall Habitat Size	Estimated values and/or schematics will be provided as part of the submission template package, which is delivered upon a Team's approval to participate in the Challenge. Teams must determine and justify the volume of space needed for the components of their proposed solutions.
Resource Management	Water source and filtration/recycling unit; power supply and storage (e.g. solar panels, batteries); nutrient tanks/growing media storage; seed and starter culture storage; air filtration/environmental control
Control and Operations	Command interfaces, data monitoring center, computing resources
Production	Growing units (e.g. vertical racks, hydroponic beds, bioreactors); lighting systems (e.g. light collectors, LED grow lights or natural light integration); climate control components (HVAC, humidifiers, heaters); automation components (robotic arms, seed planters, harvesters)
Food Processing	Infrastructure for post-harvest preparation, cleaning, food packaging, storage
Human Interface	User controls, cooking areas, meal assembly, dining

5. Submission Walkthrough Video: This video should tell the story of a Team's full submission and how it works, including a presentation of the Concept of Operations and visualization/walkthrough of the Design Layout, while tying everything back to the 14-Sol Meal Plan. The presentation should also include a detailed visual rendering that demonstrates the system's functionality, efficiency, and user interaction from start to finish.

The video should not exceed 10 minutes in length and use clear narration, consistent graphics, and logical sequencing. It should also include captions or on-screen subtitles for accessibility, and be submitted as a YouTube, Vimeo, or similar cloud-based file-sharing link.

6. Simulation Model Code: Teams must submit a functional Python-based model of their proposed solution components. This code must be compatible with the BioSim library (github.com/scottbell/biosim) to allow for in silico testing and benchmarking of the system's performance under various mission scenarios.

Assessment Criteria

Each Team's submission will be assessed by a panel of Judges and evaluated using defined operational constraints and performance criteria, which can be found in this document's Appendix. In general, all components of the food system are required to:

- Meet the performance criteria described in Table 3 (Outlined in Appendix B)
- Stay within the operational constraints described in Table 4 (Outlined in Appendix C)

For baseline requirements and assumptions related to crew health, human factors, habitability, and environmental health, see the STD-3001: NASA Spaceflight Human System Standard Volumes 1 and 2 in Appendix A. A table defining the point values associated with each performance criterion and operational constraint can be found in Appendix C. Below outlines further nutritional considerations necessary for inclusion in a Team's submission:

Ingredients: Every ingredient within a proposed menu must include information on where and how it is sourced (produced using a food system technology, pre-packaged from Earth, bulk shipment from Earth, grown using a certain agricultural system, etc.), how it is cooked/prepared, whether excess is capable of being stored/preserved, and if there is waste, how it is managed.

Nutrition: Requirements vary depending on an astronaut's biological needs. Nutritional variation should be considered in a Team's meal plan, as the astronaut crew, illustrated in the Mission Scenario, is diverse in age and gender. Certain activity levels also require different nutritional requirements.

- According to STD-3001: NASA Spaceflight Human-System Standard, a space food system must "provide a food system with a diet including the nutrient composition that is indicated in the Dietary Reference Intake (DRI) values as recommended by the National Institutes of Health … The system shall provide each crewmember with an average of 12,698 kJ (3,035 kcal) per day. For crewmembers performing EVA operations, the food system shall provide an additional 837 kJ (200 kcal) per EVA hour above nominal metabolic intake."
- More information related to crew health and nutritional requirements is found in Appendix A of this document.

Nutrient Degradation: Over time, nutrients will degrade as food items age toward decomposition. This is a major reason why one food source (i.e. pre-packaged, or growing food) cannot satisfy all of a crew's needs.

- Long-duration storage (post harvest/post cooking) solutions such as refrigeration, freezing, dehydration, freeze-drying, dry storage, are potential options for maximizing nutrient viability and palatability/acceptability. Teams may offer options that incorporate these solutions, should they also meet the other requirements of the submission (space allocations, crew labor, etc.). Teams should note that maximizing freshness and availability of food sources is highly valued by crews and mission support.

Opportunities for Future Phases

Challenge administrators are exploring potential follow-on opportunities for continued development of Challenge outcomes through subsequent phases and/or Challenges. Finalists may be invited to participate in these efforts if they are made available. The initiation of any follow-on Challenges is contingent upon the outcomes of the current Challenge.

Legal Requirements

In General

Teams are responsible for understanding and complying with these Legal Requirements.

Challenge Eligibility Requirements

NASA welcomes applications from individuals, groups of individuals, and/or organizations or entities that meet the Eligibility Requirements provided below.

In order to participate in the Challenge, each individual, whether acting alone or as part of a Team must identify their nationality.

No Team Member shall be a citizen of a country on the NASA Export Control Program list of Designated Countries List Column II: Countries determined by the Department of State to support terrorism. The current list of designated countries can be found at oiir.hq.nasa.gov/nasaecp. Please check the link for the latest updates. This includes individuals with dual citizenship unless they are a U.S. citizen or a lawful permanent U.S. resident (green card holder).

By participating as a Team Member, you affirm that you are not affiliated with the People's Republic of China (China), including Hong Kong and Macau, or a China-owned entity, and you will not participate, collaborate, or coordinate bilaterally with China or any China-owned entity in relation to your participation in the Challenge. "China or China-owned entity" means any department, agency, or instrumentality of the government of the People's Republic of China and any governmental subdivision thereof, including Hong Kong and Macau, any company owned by the People's Republic of China, or any company, university, or similar institution incorporated under the laws of the People's Republic of China or governmental subdivision thereof, including Hong Kong and Macau.

Subject to the conditions set forth herein, foreign nationals can participate as a member of a Team in the Challenge. However, foreign nationals are not eligible for a cash prize and must acknowledge acceptance of this by signing and submitting a Foreign Participant Acknowledgement Form in the Team Agreement.

Eligibility to Compete and Win Prizes from NASA

In order to be eligible to win a prize from NASA:

- Individuals must be U.S. citizens OR permanent residents of the United States, AND over the age of 18.
- Organizations must be an entity incorporated in AND maintaining a primary place of business in the United States.
- Teams must be composed of otherwise eligible individuals or organizations AND led by an otherwise eligible individual or organization.
- Team Leader must be a U.S. citizen or permanent resident.

A Team may include foreign nationals and be eligible to win prize money as long as the foreign national signs and delivers a disclosure wherein they disclose his/her citizenship and acknowledge that he/she is not eligible to win a prize from NASA, AND the foreign national is:

- An employee of an otherwise eligible U.S. entity participating in the Challenge,
- An owner of such entity, so long as foreign citizens own less than 50% of the interests in the entity,
- A contractor under written contract to such entity, OR
- A full-time student who, during the time of the Challenge, (1) is enrolled in an accredited institution of higher learning, (2) has a valid student visa and (3) is otherwise in compliance with all local, state, and U.S. Government laws and regulations regarding the sale and export of technology.

Team Members must furnish proof of eligibility (including proof of citizenship or permanent resident status, for individuals, and proof of incorporation and primary place of business, for entities) which proof must be satisfactory to NASA in its sole discretion. A Team's failure to comply with any aspect of the eligibility requirements will result in the Team being disqualified from winning a Prize from NASA.

U.S. government employees may enter the Challenge, or be members of prize-eligible Teams, so long as they are not acting within the scope of their Federal employment, and they rely on no facilities, personnel, hardware, access, knowledge, information previously developed, or other resources that are available to them as a result of their employment except for those resources available to all other Teams on an equal basis.

U.S. government employees participating as individuals, or who submit applications on behalf of an otherwise eligible organization, will be responsible for ensuring that their participation in the Challenge is permitted by the rules and regulations relevant to their position and that they have obtained any authorization that may be required by virtue of their government position. Failure to do so may result in the disqualification of them individually or of the entity which they represent or in which they are involved.

Teams will be ineligible to win the prize from NASA if any Team Member is a U.S. Government entity or employee acting within the scope of their employment. This includes any U.S. Government organization or organization principally or substantially funded by the U.S. Government, including Federally Funded Research and Development Centers, Government-owned, contractor operated (GOCO) facilities, and University Affiliated Research Centers. Any such entity or individual will obtain prior written approval from their cognizant ethics officer that such participation does not violate federal personnel laws or applicable agency policy. A copy of this approval to participate in the Challenge will promptly be provided to the Methuselah Foundation.

Participants may not use Federal funds from a grant award, cooperative agreement, or other transaction award to develop their Challenge submissions or to fund efforts in support of their Challenge submissions.

Current employees and consultants of the Methuselah Foundation may only participate as Team Members on a Team when that Team is not competing for the prize from NASA. Participation of such parties as Team Members on a Team will make a Team ineligible for any prize award from NASA.

Team Roles and Responsibilities

Each Team will designate a Team Leader. The Team Leader will be responsible for compliance with the rules, including prize eligibility rules, by all members of their Team. Prize funding will be released only to the Team Leader.

Intellectual Property Rights

Notwithstanding the contents of these rules, NASA and the Methuselah Foundation claim no intellectual property (IP) rights from Teams. All trade secrets, copyrights, patent rights, and software rights will remain with each respective Team.

To the extent the Team owns IP resulting from its participation in the Challenge, the Team agrees to negotiate in good faith with NASA for a grant of a nonexclusive, nontransferable, irrevocable license to practice or have practiced for or on behalf of the United States, the intellectual property throughout the world, at reasonable compensation, if NASA chooses to pursue such a license.

Insurance and Indemnification

Each Team Member agrees to assume any and all risks and waives claims against the Methuselah Foundation and the U.S. Government and its related entities, except in the case of willful misconduct, for any injury, death, damage, or loss of property, revenue, or profits, whether direct, indirect, or consequential, arising from each Team Member's participation in the Challenge, whether such injury, death, damage, or loss arises through negligence or otherwise. For the purposes of this section, the term "related entity" means a contractor or subcontractor at any tier, and a supplier, user, customer, cooperating party, grantee, investigator, or detailee.

Team agrees to obtain any and all insurance policies and coverage required by its local, state, or Federal governments to conduct any and all activities related to or required by participation of Team and the Team Members in the Challenge.

Use of Names, Trademarks, and Insights

Team may not use the name, trademark or insignias of NASA, its contractors, or collaborators on its printed materials related to the participation of Team in the Challenge without prior written consent from NASA's Prizes, Challenges, and Crowdsourcing Program. Team agrees that unauthorized use of such names, trademarks, and insignias shall result in elimination from participation in the Challenge if Team continues unauthorized use after being notified to cease and desist by NASA, its contractors, or collaborators, as applicable.

Delay, Cancellation or Termination

The Team acknowledges that circumstances may arise that require the Challenge to be delayed indefinitely or canceled. Such delay or cancellation, and/or the termination of the Challenge, will be within the full discretion of NASA and the Methuselah Foundation, and the Team accepts any risk of damage or loss due to delay, cancellation, and/or termination.

Appendix

Appendix A: Reference Materials

NASA's Current Systems and Standards

- STD-3001: NASA Spaceflight Human-System Standard; Volume 1: Crew Health: standards.nasa.gov/sites/default/files/standards/NASA/C//nasa-std-3001-vol-1-rev-c-signature.pdf
- STD-3001: NASA Spaceflight Human-System Standard; Volume 2: Human Factors, Habitability, and Environmental Health: standards.nasa.gov/system/files/tmp/NASA-STD-3001%20Vol%202%20Rev%20E_1.pdf
- Life Support Baseline Values and Assumptions Document (BVAD): ntrs.nasa.gov/citations/20210024855
- Human Integration Design Handbook: nasa.gov/organizations/ochmo/human-integration-design-handbook

2023 Moon to Mars Architecture Definition Document

- https://www.nasa.gov/wp-content/uploads/2024/01/rev-a-acr23-esdmd-001-m2madd.pdf?emrc=67072cd5ca62f

Evolution of Foods for ISS

- nasa.gov/feature/space-station-20th-food-on-iss

NASA Surface Habitats and Habitation Systems

- https://ntrs.nasa.gov/api/citations/20200002973/downloads/20200002973.pdf
- ntrs.nasa.gov/api/citations/20240015571/downloads/ESDMD-001%20-%20ADD%20Rev%20B1%20Final.pdf
- https://ntrs.nasa.gov/api/citations/20200001427/downloads/20200001427.pdf
- nasa.gov/reference/jsc-surface-habitats
- nasa.gov/reference/marshall-habitation-systems

Environmental Control and Life Support Systems (ECLSS)

- nasa.gov/reference/environmental-control-and-life-support-systems-eclss

NASA Human Research Roadmap

- Evidence Report: Risk of Performance Decrement and Crew Illness Due to an Inadequate Food System

NASA Earth Sciences Division (ESD): Addressing Global Challenges

- nasa.gov/content/esd-food-security

Informational Articles, Books, and Papers

- "Human Adaptation to Spaceflight: The Role of Food and Nutrition – 2nd Edition," Smith, S., Zwart, S., Douglas, G., Heer, M., Government Publishing Office, 2021
- "Space Food for Thought: Challenges and Considerations for Food and Nutrition on Exploration Missions," Douglas, G.L, and Zwart, S.R., and Smith, S.M., The Journal of Nutrition [online journal], Vol. 150, Issue 9
- "Going Beyond Reliability to Robustness and Resilience in Space Life Support Systems," H. W. Jones, Vols. ICES-2021-140, 2021
- "Feeding the Final Frontier: Lessons and Actions Derived from the Deep Space Food Challenge," Bullard, S., Shelton, A., Tucker, R., Meyers, A., Fritsche, R., Blomqvist, T., Gobel, D., and Herblet, A., Presented at the International Astronautical Congress (IAC 2025), Sydney, Australia.
- "Sensory Evaluation Techniques, Fourth Edition" Meilgaard, Morten C., B. Thomas Carr, and Gail Vance Civille. CRC press, 2006

BioSim

- github.com/scottbell/biosim

Appendix B: Operational Constraints

Teams may use the below assumptions in regards to environmental and resource constraints:

Table 3. Operational Constraints

Item	Description
Volume	● Teams may propose the volume needed for food production, preparation, and consumption within a Martian surface habitat. ● Teams may suggest additions to the core habitat that are used for food-exclusive activities (e.g. greenhouses, bioreactors, waste treatment modules, etc.) ● Teams must describe the required sizes, power needs, inputs/outputs, and how they will use that volume.
Mass	● Not constrained; mass components must be defined and accompanied with a source.
Water	● Not constrained; water components must be defined and accompanied with a source.
Power	● Not constrained; power needs must be estimated and provided. ● Teams should also consider including fail-safe operations in the event of power loss, e.g. identify elements that require battery or some other form of backup. ● Teams are not responsible for designing the power source/production system; however, they may propose the type (e.g. solar, nuclear, etc.)
Variety	● Multiple food sources are required to discourage a one-solution-fits-all approach. ● Consideration for different varieties of crops: plants, fungi, animals, other organisms and food outputs. ● Pre-packaged meals or food items, including bulk ingredients, spices, and pre-made meals, can provide no more than half of the total meal plan (by calories).
Internal (Habitat) Environment	Teams should assume their system will be operable under the following conditions: ● Gravity: 3.71 m/s^2 ● Atmosphere: 8.2 psi (56.5 kPa) with 34% oxygen ● Temperature: 65° F (18° C) to 80° F (27° C)
Crew Time	● All components of continuously maintaining the food system must be executable within a typical workday/workweek for the food systems engineer and nutrition/meal prep specialist. Teams should assume a 45-hour workweek over five Martian sols, or nine hours per sol. Maintaining the food system should not require overtime. ● Teams should assume they are feeding a crew of 15, including one food systems engineer and one nutrition/meal prep specialist.

Appendix C: Performance Criteria and Scoring System

Teams should use the below criteria as benchmarks for estimating how well their system may perform:

Table 4. Performance Criteria and Scoring System

Criteria	Description	Max. Score
Overall (20% of total score)		
Form, Fit, and Function	How well does the Team demonstrate a clear understanding of the mission constraints and system capabilities around volume, mass, water, power, variety, internal habitat environment, and crew time?	200
Adherence to STD-3001	How well does the proposed solution align with the guidelines laid out in section 7 of the STD-3001: NASA Spaceflight Human-System Standard; Volume 2: Human Factors, Habitability, and Environmental Health document?	
Operational Protocols (30% of total score)		
Operational Safety	How well does the Team incorporate system redundancy and operational contingencies to maintain continuous nominal operations, food security, and safe food delivery?	300
Food Safety	How well does the proposed solution consider food safety across all levels of system operations including (but not limited to) production, processing, cooking, consumption, and storage?	
Crew Responsibilities	How clearly are the responsibilities and time allocations for the specialized crewmembers described at the four mission points? Does the proposed solution reflect an accurate assessment of labor expectations and effort needed to operate and maintain the system?	
Concept of Operations	Does the Concept of Operations clearly explain how the system functions across four mission points in the food system cycle as described in the Mission Scenario, including the transitions between them and the interactions among key subsystems? Are the operations technically and operationally feasible for the Mission Scenario?	
Processing and Preparation	How feasible are the proposed procedures, timelines, resources, and suite of hardware required for processing and preparing food?	
Design, Feasibility, and Mission Fit (20% of total score)		
Production Methods and Feasibility	Does the Team identify and rationalize realistic and efficient food production methods? Are the methods technically appropriate, sustainable, and feasible for the Mission Scenario?	200
Inputs and Environmental Control	Does the Team clearly define the necessary resources such as water, energy, and raw materials (e.g. seeds, nutrients, growing media, etc.), as well as environmental controls like lighting, temperature, and humidity management? Are the requirements realistic and manageable relative to the Mission Scenario?	
Monitoring and Control Systems	How well does the proposed solution describe the credible use of sensing and automation technologies and other platforms to monitor crop health, environmental conditions, and system performance for optimal output and predictive maintenance? Does the incorporation maximize efficiency, safety, sustainability, longevity, and output?	
Circular Resource Systems	How well does the proposed solution recycle limited resources? Are they well-integrated and feasible or augment a Mars surface habitat, and do they support long-term sustainability?	

Human Factors and Usability	How well does the Team consider human factors, ergonomics, and ease of use in the system and habitat design?	
Scalability and Modularity	To what degree can the proposed system be scaled or adapted for future missions, expanded crew sizes, or different conditions? Is there modularity or standardization of designs built into the design?	
Meal Plan and Nutrition (15% of total score)		
14-Sol Meal Plan	How well does the proposed solution span a full 14 sols and provide sufficient meals for a 15-member crew? Does the meal plan provide a thoughtful cadence that ensures nutritional continuity, mental wellness, and realistic daily structure?	150
Menu Flexibility	How well are supplemental food items (e.g. snacks, contingency meals, etc.) included and realistically designed to address shelf stability, ease of preparation, and nutritional value?	
Meal Cadence and Psychology	How often and under what circumstances do crewmembers dine? How well does the proposed solution leverage food and community to mitigate the psychological impacts of long duration missions?	
Nutritional Balance	How well does the proposed solution include a diverse mix of ingredients to support health, preference, and system redundancy? Does the meal plan provide balanced and complete nutrition aligned with mission duration and crew needs?	
Ingredient Sourcing	How well does the proposed solution account for the source of each ingredient, and what considerations are made for availability, cadence of use, and shelf life?	
Variety	How much variety is offered in the proposed meal plan?	
Communications and Presentation (15% of total score)		
Submission Formatting	How well does the proposed solution adhere to the document formatting guidelines specified in the rules and submission templates?	150
Appendix	To what level of detail does the Team's Concept of Operations Appendix clarify information presented in the slide deck, demonstrate the feasibility of their approach, reiterate key points made in the verbal presentation, and address potential issues raised by judges? Does it add value by reinforcing or clarifying ideas from the Concept of Operations without introducing new ones?	
Blueprint Components and Layout	How well is the proposed solution illustrated in the Team's Blueprint Design/Layout? What considerations are made for the key components of the blueprint: resource management, control and operations, production, food processing, and human interface?	
Video Presentation	How well does the video provide a cohesive, complete walkthrough of the Team's proposed solution, explaining how the system functions from start to finish and complements the Meal Plan?	
	Total Points Possible:	**1,000**