COSMOCONSTRUCT

COMMAND THE UNKNOWN

An Adventurous Cooperative Space Mission Design Game

CREATE YOUR MISSION. COMMAND THE UNKNOWN.

PROJECT PROPOSAL & TECHNICAL CONCEPT PAPER

Prepared by MID STRANGERS

Platform: Browser-based interactive game / simulation
Players: 1–4 (individual or collaborative team play)
Flagship scenario: Earth-to-Mars science mission
Status: Proposed concept; prototype and data integration are future implementation work

Project Summary

Challenge	Space Mission Design Game — NASA Space Apps Challenge 2026
Project	COSMOCONSTRUCT
Experience	Design, configure, simulate, manage and evaluate a complete space mission
Players	1–4; single-player or cooperative team
Core loop	Objective → Requirements → Spacecraft & Payload → Launch & Orbit → Simulate → Evaluate
Key constraints	Budget, mass, power, data, communications, time and mission lifetime
Flagship mission	Mars science orbiter / exploration mission

Abstract

COSMOCONSTRUCT is a proposed browser-based interactive game that lets one to four participants design, manage, simulate, and evaluate a complete space mission. Players begin by defining a scientific objective and mission requirements. They then select a destination and mission profile, configure a spacecraft bus, choose scientific instruments, select a launch vehicle and orbit, and balance competing constraints including budget, mass, power, data volume, communications capacity, and mission lifetime. A simulation phase reveals the consequences of these choices through mission events, subsystem performance, and operational challenges. Players may revise their design and run the mission again, comparing outcomes and learning why different engineering choices produce different trade-offs. The flagship scenario is an Earth-to-Mars science mission, while the framework is designed to support additional mission scenarios. The game aims to make integrated mission design accessible through clear visual feedback, guided explanations, resource dashboards, and cooperative decision-making. Scientific facts and any real datasets or media will be sourced from the official Resources tab for the selected challenge and cited in the final implementation.

Keywords

Space mission design; mission simulation; spacecraft configuration; resource management; Mars exploration; STEM game; collaborative engineering; trade-offs.

1. Introduction

A space mission is an integrated system. Scientific goals must be matched with spacecraft capability, instruments, launch options, orbit, communications, power, mass, budget, and mission lifetime. Improving one part of a design can create a constraint elsewhere. For example, adding a high-performance instrument may increase scientific value while also increasing mass, power demand, cost, and data generation.

COSMOCONSTRUCT turns these connected decisions into an interactive learning experience. Players are not limited to repairing a prebuilt spacecraft: they make the mission design choices first, observe the consequences during simulation, and evaluate whether the mission achieved its objectives.

2. Challenge Understanding and Problem Statement

The Space Mission Design Game challenge asks for an interactive experience in which participants can design and manage a complete space mission, experiment with engineering decisions, manage limited

resources, and evaluate mission performance. The challenge specifically supports individual play or collaboration in teams of up to four participants.

Many introductory learning experiences explain spacecraft components or orbital concepts separately. Learners may not see how a decision about an instrument, orbit, launch vehicle, or communications system affects the entire mission. COSMOCONSTRUCT addresses this gap by connecting mission objectives, spacecraft design, resource constraints, simulation, and post-mission evaluation in one game loop.

3. Proposed Solution

COSMOCONSTRUCT is a browser-based mission design game for one to four players. Players define a mission objective, translate it into basic requirements, configure a spacecraft and payload, choose a launch vehicle and orbit, and review a live resource budget. A validation stage identifies incompatible choices before launch. The team then runs a simplified mission simulation, responds to selected operational events, and receives a mission score and explanation of the outcome.

The flagship scenario is a Mars science mission. The game architecture can later support other destinations and mission types, such as lunar exploration or Earth observation, without changing the core design workflow.

4. Aim and Objectives

Aim: To make the end-to-end process of space mission design understandable and engaging through an interactive game that demonstrates engineering trade-offs.

Objectives:
- Let players define a scientific mission objective and convert it into measurable requirements.
- Enable selection of spacecraft subsystems, scientific instruments, launch vehicle, and orbit.
- Model the effects of design choices on mass, power, budget, data, communications, and mission lifetime.
- Check basic compatibility between spacecraft mass, launch capability, orbit, and mission needs.
- Simulate mission progress and selected operational anomalies.
- Evaluate scientific return, mission feasibility, resource efficiency, and mission success.
- Support individual play and cooperative teams of up to four participants.
- Explain the consequences of decisions in accessible language.

5. Target Users and Multiplayer Design

The game is intended for students, beginners, and space enthusiasts. It supports one player or a team of up to four, in accordance with the challenge description.

Suggested roles for a four-person team:
1. Mission Planner — defines mission objectives, requirements, timeline, and success criteria.
2. Spacecraft Engineer — selects the spacecraft bus, structure, power, propulsion, and attitude-control options.
3. Science and Payload Lead — chooses instruments and balances scientific value against mass, power, cost, and data generation.
4. Operations and Resources Lead — manages launch/orbit compatibility, communications, data return, budget, and mission operations.

For solo play, the player can switch between all roles. For two- or three-player teams, responsibilities can be combined. Team members discuss trade-offs and submit joint decisions; the final mission result reflects the shared design rather than separate individual scores.

6. Game Workflow and Mission Stages

Stage 1 — Mission Brief: Players receive a scenario, available budget, destination, mission objective, and constraints.

Stage 2 — Define Objectives and Requirements: Players select or refine a science goal, identify target observations, and set success criteria such as coverage, resolution class, data return, or mission duration. Values are simplified for gameplay and clearly labelled.

Stage 3 — Select Mission Profile: Choose a mission type such as orbiter, lander, flyby, or rover-support mission where available. The first prototype focuses on a Mars science orbiter to keep the scope manageable.

Stage 4 — Spacecraft Configuration: Select a spacecraft bus and components such as structure, power generation, batteries, propulsion, attitude control, onboard computer, thermal control, and communications.

Stage 5 — Scientific Instrument Selection: Choose from instruments with different scientific value, mass, power draw, cost, and data generation. More instruments may increase science score but can exceed available resources.

Stage 6 — Launch Vehicle and Orbit: Select a launch vehicle with a payload capacity, cost, and supported mission capability. Select an orbit or trajectory option with simplified explanations of coverage, communications, observation opportunities, and mission demands. The game checks basic compatibility.

Stage 7 — Resource Review and Readiness Check: Review budget, total mass, power margin, data volume, communications capacity, and planned mission lifetime. Warnings explain which constraints are exceeded and suggest possible design changes without automatically solving the mission.

Stage 8 — Mission Simulation: Advance through mission phases. The simulation updates resource indicators and may introduce a limited number of events, such as a power shortfall, communications outage, instrument anomaly, or trajectory correction requirement.

Stage 9 — Mission Evaluation and Replay: Show whether the objective was achieved, science return, resource efficiency, mission reliability, budget performance, and unresolved risks. Players can change one or more design decisions and run the simulation again to compare outcomes.

7. Resource and Trade-off Model

The central mechanic is a transparent resource dashboard. Every selectable item has a defined effect on relevant resources.

Mass: Sum of spacecraft bus, instruments, propellant, and other selected modules. It must remain within the selected launch capability for the chosen mission profile.

Power: Compare available generation and storage with spacecraft bus load and instrument demand. A design with insufficient power may need fewer instruments, a different power system, or a revised operating plan.

Budget: Track development, launch, and simplified operations costs using game units. Higher-performance options may cost more.

Data: Estimate the volume generated by selected instruments over the planned observation period. Players must ensure the mission can store and transmit the expected data.

Communications: Model a simplified data-return capacity based on antenna, transmitter, contact opportunities, and mission profile. High data generation can exceed communications capacity.

Time and mission lifetime: Compare planned mission duration with system capability, resource reserves, and scenario constraints.

The game should not imply that these simplified calculations are flight-quality engineering. The first version will use transparent educational formulas and labelled illustrative values.

8. Spacecraft, Payload, Launch and Orbit Design

Spacecraft bus options may differ in mass, cost, available power, reliability, and supported subsystem capacity. Components can include structure, solar arrays or other power sources, batteries, propulsion, attitude control, onboard computing, thermal control, and communications.

Scientific instruments should have at least five attributes: scientific value, mass, power consumption, cost, and data generation. This makes the trade-off visible: selecting more or more capable instruments can improve science return while making the spacecraft heavier, more power-hungry, more expensive, and more demanding to communicate with.

Launch vehicles should be represented by simplified payload capacity, cost, and mission compatibility. Orbit options should include a short plain-language explanation of how the orbit affects coverage, observation opportunities, communication, and mission requirements. The game should prevent or warn about clearly incompatible combinations, such as a payload mass above the selected launch capacity.

9. Simulation Events and Fault Management

Operational events add uncertainty after the design phase. Example events include reduced power generation, a communications interruption, an instrument malfunction, unexpected data volume, or a trajectory correction requirement. The event system should connect to the original design: a mission with more power margin or communications capacity may handle some events better.

Events are not the entire game; they are one part of the complete mission lifecycle. The main learning objective remains the relationship between mission objectives, engineering choices, resource limits, and mission performance. Events and their consequences are simplified educational scenarios, not real emergency procedures.

10. Scoring and Mission Evaluation

A proposed 100-point scoring model:

- Scientific objective achievement — 30 points.
- Mission feasibility and subsystem compatibility — 20 points.
- Resource efficiency (budget, mass, power) — 20 points.
- Data and communications performance — 15 points.
- Mission lifetime and operational resilience — 10 points.
- Team collaboration and decision quality — 5 points.

The score should be accompanied by an explanation, not presented as an unexplained ranking. The report can show which constraints were met, which were exceeded, the scientific objective achieved, the data returned, major events, and suggested design improvements. Different designs may succeed with different trade-offs; the game should avoid implying that there is only one perfect answer.

11. Proposed Technical Architecture

Frontend: HTML, CSS, and JavaScript for a responsive browser-based interface. A 2D canvas or lightweight visualization can show the spacecraft, destination, orbit, and mission timeline.

Mission model: A state manager stores the objective, requirements, spacecraft components, instruments, launch vehicle, orbit, resource totals, mission events, and evaluation results.

Rules and simulation engine: Transparent functions calculate simplified mass, power, budget, data, communications, and mission-duration checks. A mission event engine updates the state during simulation.

Multiplayer: The first prototype can use a shared-screen team mode or turn-taking on one device, enabling up to four participants to collaborate without requiring a complex online backend. Online rooms and synchronized role-specific views are future enhancements.

Content and data: NASA resources and any permitted datasets or media are kept distinct from invented game values. Each source is attributed in the interface and final project documentation.

12. Accessibility and Educational Design

The game should be approachable for beginners. Use short tutorials, plain-language definitions, units beside numerical values, visual indicators with text labels, and optional explanations for technical terms. Difficulty can be scaled by changing the number of available components, the number of constraints, and the complexity of events. A sandbox mode may allow experimentation without a strict budget, while challenge mode requires players to meet scenario-specific limits.

13. Evaluation Plan

The prototype will be tested with individual players and teams of up to four. Proposed measures include:

- Percentage of playtests that complete the mission design and simulation flow.
- Number of invalid configurations detected before launch.
- Whether players can explain at least two design trade-offs after playing.
- Mission objective achievement and resource efficiency.
- Whether team members participate in shared decisions.
- Pre- and post-game questions about mass, power, payload, orbit, communications, and data.

These are planned evaluation measures, not completed test results.

14. Scope, Feasibility and Limitations

To keep the project achievable, the first prototype will focus on one complete scenario: a Mars science orbiter. It will include objective selection, a limited set of spacecraft components and instruments, a small number of launch and orbit options, a resource dashboard, a compatibility check, a simplified simulation, and a mission report.

The first version will not attempt high-fidelity orbital mechanics, detailed propulsion modelling, real mission optimization, or a fully realistic spacecraft digital twin. It will not be used for real mission planning. Multiplayer will initially be shared-screen or turn-based for up to four players; online networking can be added later.

15. Future Scope

Future development may add more mission scenarios and destinations, additional instrument catalogs, improved orbit and transfer visualizations, richer communications modelling, online team rooms for up to four players, mission sharing and comparison, leaderboards, instructor mode, and expanded NASA data integrations. A sandbox mode and adaptive tutorials can support both beginners and more advanced participants.

16. Tools and Learning Resources

COSMOCONSTRUCT will include more than 20 interactive tools and learning resources to help players understand spacecraft components, mission systems, and the engineering choices involved in designing a space mission. These tools will provide clear explanations and practical, game-based guidance as players configure, simulate, and evaluate their missions.

17. Conclusion

COSMOCONSTRUCT directly addresses the Space Mission Design Game challenge by placing the full mission lifecycle at the centre of play. Participants define an objective, design the spacecraft and payload, choose launch and orbit options, balance interconnected resources, simulate mission operations, and evaluate the result. Its defining feature is the visible cause-and-effect relationship between engineering decisions and mission outcomes. By supporting individual play and collaboration for up to four participants, the project aims to make complex mission-design trade-offs approachable, interactive, and memorable.

Appendix A — Proposed First-Prototype Feature Set

- Mission objective selection with one flagship Mars science-orbiter scenario.
- Mission requirements and success criteria panel.
- Selectable spacecraft bus and a small catalog of subsystem components.
- Scientific instrument catalog with science value, mass, power, cost, and data generation.
- Two or three launch vehicle options and a small set of orbit/trajectory choices.
- Live resource dashboard for budget, mass, power, data, communications, and mission lifetime.
- Compatibility checks and clear warnings before launch.
- Simple mission timeline with two or three operational events.
- Mission scorecard and explanation of trade-offs, plus replay/compare capability.
- Single-player and shared-screen team play for up to four participants.

Appendix B — NASA Source and Submission Checklist

Use the challenge page's Resources tab as the authoritative starting point for data and references. Before submission, select and actually use at least the resources required by the event rules; cite the exact dataset/page, organization, URL, access date where required, and describe how it informed the game. Do not state that a NASA dataset has been integrated unless it has been implemented and verified.

- NASA Space Apps Challenge — https://www.spaceappschallenge.org/
- NASA Mars Exploration — https://mars.nasa.gov/
- NASA Eyes on the Solar System — https://eyes.nasa.gov/
- NASA Technical Reports Server — https://ntrs.nasa.gov/

Before final submission, add all team member names, the exact challenge title, the project URL or demo if available, the precise NASA resources used, screenshots or a short demo, and any required acknowledgements. Confirm all challenge-specific rules in the event portal.