Precursor cargo mission: deliver and activate a base before the crew

Guiding question

Concrete → interfaces → measurement → calculation → failure → recovery.

Course map

Mission brief → System map → Data and assumptions → Governing relationship → Starting calculations

1 — Mission brief

Decide what must work without humans before the first crew departs.
This capstone mission requires several modules at once. An answer is complete only when it closes physical budgets, describes sensors and actions, retains margin, handles a credible failure and explains what the crew must do. For this mission, the criterion is applied explicitly to « Precursor cargo mission: deliver and activate a base before the crew ».

2 — System map

Start by drawing mass, energy, information and authority flows. An arrow without a unit or owner is incomplete. The map is then used to identify common dependencies and interfaces that can propagate failure. For this mission, the criterion is applied explicitly to « Precursor cargo mission: deliver and activate a base before the crew ».
A precursor cargo mission is judged by its ability to turn a successful landing into infrastructure that is genuinely usable before the crew departs Earth. The system map separates assets that must deploy autonomously, tasks that can tolerate delayed teleoperation and functions requiring physical redundancy. Power, communications, thermal control, robotics, storage and navigation aids are not independent parallel tasks; some must be available before later commissioning steps can safely begin.

Equation - evidence - decision

A = temps_disponible / temps_total

Failure to test: Check air, water, thermal control, radiation, food, medicine and workload where relevant to this mission. The goal is to avoid a false “all good” technical calculation that forgets sleep time, suit donning or the need for a second crewmember during a critical operation. For this mission, the criterion is applied explicitly to « Precursor cargo mission: deliver and activate a base before the crew ».

Precursor cargo mission: deliver and activate a base before the crew

3 — Data and assumptions

The supplied numbers are training-scenario data. Copy them with units, add missing assumptions and separately mark values that come from NASA sources. Any value that changes the verdict requires sensitivity analysis. For this mission, the criterion is applied explicitly to « Precursor cargo mission: deliver and activate a base before the crew ».

The scenario must define a commissioning order. A robust strategy first establishes telemetry and safe power, then checks thermal and mechanical state before irreversible deployments. The student classifies each operation as reversible, recoverable by a backup robot, or critical with no simple rollback. This classification determines where verification pauses belong and which data must be received on Earth before the sequence continues.

4 — Governing relationship

The equation is only an entry point. It must be connected to a budget, an available measurement and a decision threshold. If units do not reduce correctly, stop before using a calculator. For this mission, the criterion is applied explicitly to « Precursor cargo mission: deliver and activate a base before the crew ».

5 — Starting calculations

Disponibilité 840 h disponibles ÷ 1 000 h campaign = 0,84 Interpret the result inside the global budget before making a decision.

Stock eau 1 800 L ÷ 60 L/j = 30 days Interpret the result inside the global budget before making a decision.

Énergie chantier 22 kW × 9 h = 198 kWh Interpret the result inside the global budget before making a decision.

6 — Mass, power and time budget

Build three separate tables. The mass budget distinguishes structure, consumables, spares and margin. The energy budget separates instantaneous power from accumulated energy. The time budget includes operations, maintenance, rest and communications delay. Positive margin in one table does not automatically compensate for a deficit in another. For this mission, the criterion is applied explicitly to « Precursor cargo mission: deliver and activate a base before the crew ».

Operational table

Phenomena / sections:	3 — Data and assumptions ; 4 — Governing relationship ; 5 — Starting calculations
Relationship to revisit:	A = temps_disponible / temps_total
Expected decision:	measure → compare with margin → choose nominal, degraded or stop

Check before continuing

Explain without rereading: 3 — Data and assumptions ; 4 — Governing relationship ; 5 — Starting calculations. State one measured quantity, one margin and one possible decision.

Precursor cargo mission: deliver and activate a base before the crew

The autonomous campaign budget is more than 840 available hours out of 1,000. The student identifies which work hours are genuinely substitutable between robots, which operations share the same arm or tool, and which bottleneck sets overall cadence. Eighty-four percent availability can be acceptable for schedule-tolerant work yet unacceptable when the failed capability blocks the only electrical or fluid connection required by the rest of the base.

7 — Navigation, communications and state knowledge

State which variables must be known locally, which can be reconstructed later by Earth, and what accuracy each decision requires. Radio delay means safing and initial diagnosis must be possible without waiting for Earth. For this mission, the criterion is applied explicitly to « Precursor cargo mission: deliver and activate a base before the crew ».

Delayed communications require graded autonomy. The system must stop a hazardous motion, protect a battery or enter safe mode without waiting for Earth. A complex reconfiguration may still remain under human authority after data review. The student builds a decision matrix that states what the robot may decide, what it may recommend, and what it must never execute without authorization.

8 — Survival and human factors

Check air, water, thermal control, radiation, food, medicine and workload where relevant to this mission. The goal is to avoid a false “all good” technical calculation that forgets sleep time, suit donning or the need for a second crewmember during a critical operation. For this mission, the criterion is applied explicitly to « Precursor cargo mission: deliver and activate a base before the crew ».

Before crew launch is authorized, the precursor base must provide evidence of readiness: power production across repeated cycles, thermal stability, redundant communications, measured inventories and demonstrated contingency operations. A photograph of deployed hardware is not sufficient. The dossier needs operating duration, trends, tested alarms and evidence that the system can return to a safe configuration after an injected fault.

9 — Mission-specific injected incident

Operational table

Phenomena / sections:	7 — Navigation, communications and state knowledge ; 8 — Survival and human factors ; 9 — Mission-specific injected incident
Relationship to revisit:	A = temps_disponible / temps_total
Expected decision:	measure → compare with margin → choose nominal, degraded or stop

Check before continuing

Explain without rereading: 7 — Navigation, communications and state knowledge ; 8 — Survival and human factors ; 9 — Mission-specific injected incident. State one measured quantity, one margin and one possible decision.

Precursor cargo mission: deliver and activate a base before the crew

After 400 h of autonomous operations, a robotic arm loses one degree of freedom and halves installation rate; tasks required before crew arrival must be replanned. For this mission, the criterion is applied explicitly to « Precursor cargo mission: deliver and activate a base before the crew ».

For AM-16.02, the answer must show which quantities in “Precursor cargo mission: deliver and activate a base before the crew” are recomputed, which assumptions cease to be valid and which action remains reversible before consuming an irreversible reserve.

Losing one degree of freedom on the robotic arm requires replanning rather than continuing at the same paper schedule. The student separates tasks that remain possible, tasks requiring a second robot and tasks that become impossible, then recomputes the base-readiness date. The decision is whether crew launch remains acceptable, must be delayed, or requires an earlier cargo opportunity to deliver corrective hardware.

10 — Decision and justification

End with an explicit decision: continue, delay, reconfigure, abandon an activity or enter refuge mode. Cite the three quantities controlling that decision and the remaining margin. A conclusion without a numerical or operational criterion is an opinion, not an engineering decision. For this mission, the criterion is applied explicitly to « Precursor cargo mission: deliver and activate a base before the crew ».

The final deliverable contains an explicit definition of 'base ready'. It should not be a general impression. It can combine a minimum set of operational functions, a demonstration duration, energy reserve, verified water inventory and a successful recovery exercise. The objective is to turn a list of delivered hardware into measurable operational capability.

11 — Required deliverables

Operational table

Phenomena / sections:	; 10 — Decision and justification ; 11 — Required deliverables
Relationship to revisit:	A = temps_disponible / temps_total
Expected decision:	measure → compare with margin → choose nominal, degraded or stop

Check before continuing

Explain without rereading: ; 10 — Decision and justification ; 11 — Required deliverables. State one measured quantity, one margin and one possible decision.

Precursor cargo mission: deliver and activate a base before the crew

12 — Assessment rubric

40%: calculation and unit consistency; 20%: interface treatment; 15%: margins and degraded mode; 15%: human factors and procedure; 10%: source quality and separation of data, assumptions and scenarios. For this mission, the criterion is applied explicitly to « Precursor cargo mission: deliver and activate a base before the crew ».

13 — Reference sources

Topic-specific primary sources

NASA TechPort — NASA Platform for Autonomous Systems - https://techport.nasa.gov/projects/94884

NASA NTRS — Current NASA Plans for Mars In-Situ Resource Utilization - https://ntrs.nasa.gov/citations/20180002086

NASA — Systems Engineering Handbook - https://www.nasa.gov/reference/systems-engineering-handbook/

NASA-STD-8729.1A — Reliability and Maintainability Standard - https://standards.nasa.gov/standard/NASA/NASA-STD-87291

Operational table

Phenomena / sections:	12 — Assessment rubric ; 13 — Reference sources ; Topic-specific primary sources
Relationship to revisit:	A = temps_disponible / temps_total
Expected decision:	measure → compare with margin → choose nominal, degraded or stop

Check before continuing

Explain without rereading: 12 — Assessment rubric ; 13 — Reference sources ; Topic-specific primary sources. State one measured quantity, one margin and one possible decision.