Dust storm and degraded power: survive one week

Guiding question

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

Course map

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

1 — Mission brief

Reduce loads, preserve life-support loops and plan cleaning without assuming one universal light-loss value. 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 « Dust storm and degraded power: survive one week ».

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 « Dust storm and degraded power: survive one week ».
A week of degraded power is a stock-and-priority problem. The map links solar generation, batteries, vital loads, heating, communications, water processing and deferrable activities. Continuous loads are separated from loads that can be shifted in time. The objective is not merely minimum survival; it is avoiding load shedding that creates a delayed failure such as over-cold hardware or untreated water inventory.

Equation - evidence - decision

$E_{jour} = P_{moy} \times 24\ h$

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 « Dust storm and degraded power: survive one week ».

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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 « Dust storm and degraded power: survive one week ».

The scenario uses several solar-generation assumptions rather than one average value. A storm can vary from sol to sol, and initial battery state strongly changes margin. The student calculates at least a degraded nominal case and a more severe case, then defines state-of-charge thresholds that progressively trigger science reduction, industrial shutdown and survival mode.

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 « Dust storm and degraded power: survive one week ».

5 — Starting calculations

Charge critique 7,5 kW × 24 h = 180 kWh/j Interpret the result inside the global budget before making a decision.

Stock batterie 900 kWh ÷ 180 kWh/j = 5 theoretical days Interpret the result inside the global budget before making a decision.

Délestage 22 kW - 8 kW = 14 kW shed 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 « Dust storm and degraded power: survive one week ».

Operational table

Phenomena / sections:	3 — Data and assumptions ; 4 — Governing relationship ; 5 — Starting calculations
Relationship to revisit:	E_jour = P_moy × 24 h
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.

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The theoretical five-day result from 900 kWh divided by 180 kWh/day is a scale estimate, not guaranteed endurance. It assumes all stored energy is usable and load stays constant. The budget reserves an unplanned fraction, accounts for losses and identifies minimum instantaneous power. A battery can contain energy while still being unable to support a critical peak.

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 « Dust storm and degraded power: survive one week ».

Forecasting is an operational data stream. Irradiance, state of charge, battery temperature, deposited dust and actual consumption are tracked as trends. Earth can improve models, but the crew must be able to shed loads locally. The lesson requires a simple rule: which measurement triggers which action, after what delay, and under what condition the previous service level may be restored.

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 « Dust storm and degraded power: survive one week ».

Human factors also matter in load shedding. Reducing lighting, heat or communications can affect sleep, workload and coordination. The survival plan therefore preserves minimum functions for crew performance and avoids an energy saving that rapidly degrades decision quality. Maintenance that prevents a larger failure can remain higher priority than immediate savings.

Operational table

Phenomena / sections:	7 — Navigation, communications and state knowledge ; 8 — Survival and human factors
Relationship to revisit:	$E_{jour} = P_{moy} \times 24$ h
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. State one measured quantity, one margin and one possible decision.

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9 — Mission-specific injected incident

Actual solar generation remains below the nominal scenario for several sols; the crew must sequence load shedding, preserve heating and ECLSS, then define an exit threshold from economy mode. For this mission, the criterion is applied explicitly to « Dust storm and degraded power: survive one week ».

For AM-16.08, the answer must show which quantities in “Dust storm and degraded power: survive one week” are recomputed, which assumptions cease to be valid and which action remains reversible before consuming an irreversible reserve.

If generation stays low for several sols, the team does not restart every load at the first improvement. It first rebuilds reserve, confirms stable production and returns equipment in groups. The student defines a restart order and a minimum margin before ISRU or industrial loads resume. This avoids repeated start-stop cycles that stress hardware and immediately drain batteries.

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 « Dust storm and degraded power: survive one week ».

The final deliverable includes a seven-sol state-of-charge curve and a load-shedding timeline. Each power step is tied to named loads. The student also explains how a genuinely independent second energy source would change the scenario: redundancy is not just extra kilowatts; it changes common-cause failure exposure.

11 — Required deliverables

Operational table

Phenomena / sections:	9 — Mission-specific injected incident ; ; 10 — Decision and justification
Relationship to revisit:	$E_{jour} = P_{moy} \times 24$ h
Expected decision:	measure → compare with margin → choose nominal, degraded or stop

Check before continuing

Explain without rereading: 9 — Mission-specific injected incident ; ; 10 — Decision and justification. State one measured quantity, one margin and one possible decision.

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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 « Dust storm and degraded power: survive one week ».

13 — Reference sources

Topic-specific primary sources

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

NASA NTRS — Advanced Exploration Systems Life Support Systems Project Overview - https://ntrs.nasa.gov/citations/20210015025

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

NASA — NASA Spaceflight Human-System Standard Volume 2 - https://www.nasa.gov/reference/nasa-std-3001v2/

Operational table

Phenomena / sections:	12 — Assessment rubric ; 13 — Reference sources ; Topic-specific primary sources
Relationship to revisit:	E_jour = P_moy × 24 h
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.