Long-range EVA: rover failure and crewmember rescue

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 whether the team can return to the airlock with sufficient energy, oxygen and time.
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 « Long-range EVA: rover failure and crewmember rescue ».

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 « Long-range EVA: rover failure and crewmember rescue ».
An EVA 9 km from the airlock must be designed as a rescue operation before departure. The map includes the primary rover, secondary return option, suit endurance, communications, routes and locations where the crew can safely pause. The objective is not maximum range; it is preserving a credible path back to a pressurized atmosphere after a single failure.

Equation - evidence - decision

t_retour = distance / vitesse

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 « Long-range EVA: rover failure and crewmember rescue ».

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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 « Long-range EVA: rover failure and crewmember rescue ».

Scenario data must become time and energy margins. A theoretical three-hour walk does not mean a real three-hour return: terrain, fatigue, navigation, assisting a crewmember and PLSS consumption can all lengthen the trip. The student builds nominal and degraded cases and reserves margin that is not spent on additional science at departure.

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 « Long-range EVA: rover failure and crewmember rescue ».

5 — Starting calculations

Retour 9 km ÷ 3 km/h = 3 h Interpret the result inside the global budget before making a decision.

Batterie 14 kWh - 3 h × 3,2 kW = 4,4 kWh remaining Interpret the result inside the global budget before making a decision.

Marge temps 4 h 20 - 3 h = 1 h 20 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 « Long-range EVA: rover failure and crewmember rescue ».

Operational table

Phenomena / sections:	3 — Data and assumptions ; 4 — Governing relationship ; 5 — Starting calculations
Relationship to revisit:	t_retour = distance / vitesse
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.

Long-range EVA: rover failure and crewmember rescue

The rover budget separates remaining energy from required power. The scenario's 4.4 kWh after three hours may be inadequate if slope, heating or battery degradation raises instantaneous demand. The student therefore defines a turn-back point based on energy, suit time and health state rather than a fixed distance on a map.

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 « Long-range EVA: rover failure and crewmember rescue ».

Medical and technical state must be shared without overwhelming the crew. PLSS pressure, oxygen reserve, heart rate, symptoms, location and rover energy are prioritized. Earth can analyze data, but radio delay means the local team needs immediate-return criteria. The lesson distinguishes information useful for diagnosis from information that actually changes the next-minute decision.

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 « Long-range EVA: rover failure and crewmember rescue ».

Rescue planning must protect the second crewmember. A fatigued person may require assistance, slow movement and increase consumption for both suits. Roles are assigned: examination, communications, equipment preparation and global situation awareness. A plan that concentrates every critical task on one individual creates a new single point of failure.

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:	t_retour = distance / vitesse
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.

Long-range EVA: rover failure and crewmember rescue

The rover fails 9 km from the airlock while one crewmember shows abnormal fatigue; the return decision must include actual speed, PLSS endurance, battery, daylight and towing capability. For this mission, the criterion is applied explicitly to « Long-range EVA: rover failure and crewmember rescue ».

For AM-16.07, the answer must show which quantities in “Long-range EVA: rover failure and crewmember rescue” are recomputed, which assumptions cease to be valid and which action remains reversible before consuming an irreversible reserve.

After rover failure, the student compares walking, local repair, waiting for robotic rescue or combining those options. The decision uses actual remaining suit time, symptom trend, local conditions, distance and the probability of repair without consuming unsafe margin. A repair-abandon threshold is defined because spending too long on an uncertain vehicle can eliminate the remaining walking option.

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 « Long-range EVA: rover failure and crewmember rescue ».

The final debrief reconstructs the timeline minute by minute from failure detection to airlock return. Every strategy change is tied to new information. The student then identifies decisions that could have been made before the EVA—route choice, cached supplies, follower rover, turn-back threshold—so that the next event depends less on heroic improvisation.

11 — Required deliverables

Operational table

Phenomena / sections:	; 10 — Decision and justification ; 11 — Required deliverables
Relationship to revisit:	t_retour = distance / vitesse
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.

Long-range EVA: rover failure and crewmember rescue

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 « Long-range EVA: rover failure and crewmember rescue ».

13 — Reference sources

Topic-specific primary sources

NASA NTRS — Crew Health and Performance EVA Evidence Report - https://ntrs.nasa.gov/citations/20220004017

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

NASA NTRS — Human Exploration of Mars: Preliminary Lists of Crew Tasks - https://ntrs.nasa.gov/citations/20190001401

NASA NTRS — Space Flight Resource Management for ISS Operations - https://ntrs.nasa.gov/citations/20110010923

Operational table

Phenomena / sections:	12 — Assessment rubric ; 13 — Reference sources ; Topic-specific primary sources
Relationship to revisit:	t_retour = distance / vitesse
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.