Mars EVA: airlocks, suitports, planning, return and rescue

Guiding question

Concrete → flows → sensors → calculation → failure → refuge.

Course map

The real phenomenon → Vocabulary and problem boundary → Course-specific system view → Mathematical relationship and reading the symbols → Worked calculations and interpretation

1 — The real phenomenon

An EVA starts long before the hatch opens: objectives, environment, suit state, tools, energy, route, communications, physiological limits and return scenarios are checked. An airlock or suitport must limit atmosphere loss and contamination. A Mars mission must also plan recovery of an incapacitated crewmember, rover failure, communications loss or a degraded suit.

The guiding question is: How do you plan an EVA so that an outside incident does not become a crew loss? Reasoning starts with the physical or operational function before introducing the mathematical relationship. The goal is not to accumulate terminology, but to know which quantity changes, why it changes and what becomes hazardous when it leaves its domain. For “Mars EVA: airlocks, suitports, planning, return and rescue”, the first task here is therefore to identify the mechanism specific to this subject before searching for an equation or reference value.

2 — Vocabulary and problem boundary

In “Mars EVA: airlocks, suitports, planning, return and rescue”, distinguish the phenomenon, available measurement, any command, the margin and the success criterion. The calculation boundary states what is included and excluded; without that boundary, a percentage, mass or time may be mathematically correct but wrong as an engineering conclusion. For “Mars EVA: airlocks, suitports, planning, return and rescue”, the chosen boundary also states what would otherwise be double-counted or omitted from a mission budget.

suit pressure, O2, CO2, cooling, battery, garment integrity and time to airlock

leak, PLSS failure, joint lock, seal contamination or inability to return autonomously

pressure testing, metabolic endurance, injected PLSS faults and rescue simulations with an incapacitated crewmember

Equation - evidence - decision

marge = (capacité − besoin)/besoin × 100

Failure to test: The reference failure is not a vague “broken component.” For “Mars EVA: airlocks, suitports, planning, return and rescue”, test in particular leak, PLSS failure, joint lock, seal contamination or inability to return autonomously. Diagnosis asks which symptoms appear first, which are only consequences and which action preserves the most options.

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3 — Course-specific system view

This lesson does not reuse one generic picture for every subject. The system view follows cause → measured quantity → decision or physical response → limit for “Mars EVA: airlocks, suitports, planning, return and rescue”. The English text remains fully equivalent while large translated illustrations are intentionally deferred until their dedicated artwork is supplied. For “Mars EVA: airlocks, suitports, planning, return and rescue”, the system view must expose inputs, outputs, measured quantity and the consequence of drift without relying on a generic module diagram.

4 — Mathematical relationship and reading the symbols

Read aloud : margin equals available capability minus requirement, divided by requirement, times one hundred.

Before substituting numbers, write the unit of every term, state whether the relationship is a physical law, approximation or project indicator, and check dimensional consistency. This is especially important here because “Mars EVA: airlocks, suitports, planning, return and rescue” combines quantities that do not all have the same evidence status. For “Mars EVA: airlocks, suitports, planning, return and rescue”, this relationship is chosen because of the phenomenon under study; a different dominant quantity would require a different equation or model.

5 — Worked calculations and interpretation

12 kWh available, 8 kWh required → (12−8)/8 = 50% margin

4 km outbound + 4 km return = 8 km minimum before detour or contingency

35 min egress + 25 min ingress = 60 min of airlock cycle outside surface EVA time

1. 1. Battery 12 kWh available, 8 kWh required → (12−8)/8 = 50% margin Interpretation: this result is used only after comparison with units, margin and the scenario boundary for “Mars EVA: airlocks, suitports, planning, return and rescue”.

2. 2. Return distance 4 km outbound + 4 km return = 8 km minimum before detour or contingency Interpretation: this result is used only after comparison with units, margin and the scenario boundary for “Mars EVA: airlocks, suitports, planning, return and rescue”.

3. 3. Airlock time 35 min egress + 25 min ingress = 60 min of airlock cycle outside surface EVA time Interpretation: this result is used only after comparison with units, margin and the scenario boundary for “Mars EVA: airlocks, suitports, planning, return and rescue”.

Operational table

Phenomena / sections:	3 — Course-specific system view ; 4 — Mathematical relationship and reading the symbols ; 5 — Worked calculations and interpretation
Relationship to revisit:	marge = (capacité − besoin)/besoin × 100
Expected decision:	measure → compare with margin → choose nominal, degraded or stop

Check before continuing

Explain without rereading: 3 — Course-specific system view ; 4 — Mathematical relationship and reading the symbols ; 5 — Worked calculations and interpretation. State one measured quantity, one margin and one possible decision.

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6 — What the formula does not contain

The relationship “marge = (capacité − besoin)/besoin × 100” does not by itself contain all of “Mars EVA: airlocks, suitports, planning, return and rescue”. It does not automatically tell us whether a sensor is valid, a structure is aging, a resource is accessible, a command arrives in time or a secondary failure removes margin. The example 12 kWh available, 8 kWh required → (12−8)/8 = 50% margin therefore remains a local calculation rather than a complete architecture.

To make the model useful, explicitly add the quantities that dominate this subject: suit pressure, O_2, CO_2, cooling, battery, garment integrity and time to airlock. We can then ask which variation truly changes the result, which is negligible and which forces an architectural change. For “Mars EVA: airlocks, suitports, planning, return and rescue”, this model limitation states exactly what a correct calculation still cannot establish about the real system.

7 — Instrumentation, observability and data quality

For “Mars EVA: airlocks, suitports, planning, return and rescue”, observability relies on suit pressure, O_2, CO_2, cooling, battery, garment integrity and time to airlock. Each datum has a unit, acquisition rate, uncertainty, timestamp and validity domain. A value arriving without context can be more dangerous than no measurement because it creates unjustified confidence.

Consistency is checked with at least one independent piece of information when the function is critical. A trend, physical balance or second measurement principle helps distinguish a real system change from a drifting sensor. For “Mars EVA: airlocks, suitports, planning, return and rescue”, the selected instrumentation must distinguish a real physical change from sensor drift or a bad state estimate.

8 — Phenomenon-specific failures and recovery

The reference failure is not a vague “broken component.” For “Mars EVA: airlocks, suitports, planning, return and rescue”, test in particular leak, PLSS failure, joint lock, seal contamination or inability to return autonomously. Diagnosis asks which symptoms appear first, which are only consequences and which action preserves the most options.

The degraded mode must be defined before failure: minimum function, allowable duration, consumed stock, crew action, abort condition and return-to-nominal criterion. That sequence is topic-specific and cannot be replaced by one universal paragraph about redundancy. For “Mars EVA: airlocks, suitports, planning, return and rescue”, the degraded mode is defined around the minimum function specific to this subject, with an abort threshold and a return-to-nominal condition.

Operational table

Phenomena / sections:	6 — What the formula does not contain ; 7 — Instrumentation, observability and data quality ; 8 — Phenomenon-specific failures and recovery
Relationship to revisit:	marge = (capacité − besoin)/besoin × 100
Expected decision:	measure → compare with margin → choose nominal, degraded or stop

Check before continuing

Explain without rereading: 6 — What the formula does not contain ; 7 — Instrumentation, observability and data quality ; 8 — Phenomenon-specific failures and recovery. State one measured quantity, one margin and one possible decision.

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9 — NASA / reference case

The reference case is selected from ECLSS, NASA-STD-3001 or human-analog evidence according to the topic. The goal is not to copy the ISS onto Mars, but to identify what has been demonstrated, what is environment-dependent and what still requires qualification for a mission without rapid resupply.

The case is used only within what it actually demonstrates. Flight measurement, human-system standard, component test and architecture study are different kinds of evidence; the text therefore states what is observed, calculated, simulated or still prospective. For “Mars EVA: airlocks, suitports, planning, return and rescue”, the cited NASA case is used as targeted evidence for this phenomenon and is never turned into one universal Mars architecture.

10 — Architecture trade

A good solution for “Mars EVA: airlocks, suitports, planning, return and rescue” does not maximize one metric. Compare nominal performance, mass, energy, simplicity, maintenance, crew time, common dependencies and recoverability. An option that improves 4 km outbound + 4 km return = 8 km minimum before detour or contingency can still be rejected if it makes failure detection or repair much harder.

The trade is recorded together with its assumptions. If environment data, mass or mission cadence changes, we know which conclusions must be recomputed instead of silently preserving an obsolete choice. For “Mars EVA: airlocks, suitports, planning, return and rescue”, the trade is evaluated against the interfaces actually touched by this subject rather than a generic list of desirable qualities.

11 — Demonstration, testing and success criteria

The evidence strategy for “Mars EVA: airlocks, suitports, planning, return and rescue” combines pressure testing, metabolic endurance, injected PLSS faults and rescue simulations with an incapacitated crewmember. Every test records exact hardware, software, configuration, environment, tolerances and success criterion. A successful demonstration outside the mission domain does not replace qualification inside it.

Evidence grows by levels: analytical relationship, simulation, component, subsystem, integrated system, duration and failure. This hierarchy prevents one spectacular test from being presented as validation of the whole mission. For “Mars EVA: airlocks, suitports, planning, return and rescue”, demonstration must reproduce the constraints that make this phenomenon difficult; a spectacular test outside the mission domain is insufficient.

Operational table

Phenomena / sections:	9 — NASA / reference case ; 10 — Architecture trade ; 11 — Demonstration, testing and success criteria
Relationship to revisit:	marge = (capacité − besoin)/besoin × 100
Expected decision:	measure → compare with margin → choose nominal, degraded or stop

Check before continuing

Explain without rereading: 9 — NASA / reference case ; 10 — Architecture trade ; 11 — Demonstration, testing and success criteria. State one measured quantity, one margin and one possible decision.

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12 — Decision exercise

Situation: revisit “Mars EVA: airlocks, suitports, planning, return and rescue” with a 20% increase in the most penalizing quantity from the first worked example while one measurement or backup path is unavailable.

Situation: revisit “Mars EVA: airlocks, suitports, planning, return and rescue” with a 20% increase in the most penalizing quantity from the first worked example while one measurement or backup path is unavailable. Expected answer: recompute the relationship, identify remaining margin, check whether observability is still adequate, and decide whether degraded operation remains acceptable. Multiplying by 1.2 is not enough if the variation also changes interfaces or limits.

13 — What to retain without over-generalizing

14 — Topic-specific primary sources

These references directly document the phenomenon, technology or human constraint addressed in this lesson. They do not by themselves define an official Mars architecture. For “Mars EVA: airlocks, suitports, planning, return and rescue”, the bibliography is deliberately targeted to this page so that readers can trace each claim back to the relevant primary document.

Topic-specific primary sources

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

NASA NTRS — NASA Advanced Space Suit Pressure Garment System Status - https://ntrs.nasa.gov/citations/20230006720

NASA — Human Performance and Error, NASA-STD-3001 Vol. 2 - https://www.nasa.gov/reference/5-0-human-performance-and-error-vol-2/

Operational table

Phenomena / sections:	12 — Decision exercise ; 13 — What to retain without over-generalizing ; 14 — Topic-specific primary sources
Relationship to revisit:	marge = (capacité − besoin)/besoin × 100
Expected decision:	measure → compare with margin → choose nominal, degraded or stop

Check before continuing

Explain without rereading: 12 — Decision exercise ; 13 — What to retain without over-generalizing ; 14 — Topic-specific primary sources. State one measured quantity, one margin and one possible decision.