

Leak plus fire: manage two emergencies that conflict

Guiding question

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

Course map

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

1 — Mission brief

Isolate a volume, control smoke and protect the refuge without creating a second disaster.

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 « Leak plus fire: manage two emergencies that conflict ».

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 « Leak plus fire: manage two emergencies that conflict ».

A leak and a fire demand actions that can conflict. Ventilation can help control contaminants but can feed combustion; isolation protects the rest of the base but may trap smoke, heat or a crewmember. The system map shows pressurized volumes, valves, fans, detectors, evacuation routes and refuge. The student therefore reasons about action sequence rather than executing two independent procedures at once.

Equation - evidence - decision

$$\dot{m} = \Delta m / \Delta t$$

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 « Leak plus fire: manage two emergencies that conflict ».

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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 « Leak plus fire: manage two emergencies that conflict ».

Measurements must distinguish leak, combustion and sensor fault: pressure, loss rate, smoke, temperature, atmosphere composition and electrical state. The student defines combinations that justify compartment isolation and those that require confirmation. One alarm should not automatically drive the base into a configuration that creates a more serious hazard.

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 « Leak plus fire: manage two emergencies that conflict ».

5 — Starting calculations

Perte gaz $6\text{ kg} \div 20\text{ min} = 0,30\text{ kg/min}$ Interpret the result inside the global budget before making a decision.

Autonomie refuge $48\text{ h} - 7\text{ h} = 41\text{ h}$ restantes Interpret the result inside the global budget before making a decision.

Filtration $3\text{ filtres} \times 4\text{ h} = 12\text{ h-filtre}$ 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 « Leak plus fire: manage two emergencies that conflict ».

Operational table

Phenomena / sections:	3 — Data and assumptions ; 4 — Governing relationship ; 5 — Starting calculations
Relationship to revisit:	$\dot{m} = \Delta m / \Delta t$
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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A mass-loss rate provides a time horizon, but that horizon depends on volume, pressure and isolation capability. Forty-one hours remaining in another resource budget matter only if essential functions are still powered. The exercise therefore closes atmosphere, energy and filtration together and verifies refuge capability after isolation.

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 « Leak plus fire: manage two emergencies that conflict ».

Situation awareness must survive reconfiguration. If a compartment is isolated, sensors and a camera may still be required to determine whether the fire is out or leakage continues. The student states how data cross the isolated boundary and which instrumentation has independent power. Otherwise the crew can gain pressure integrity while losing all knowledge of the event.

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 « Leak plus fire: manage two emergencies that conflict ».

Incident command separates decision from execution. One person maintains the global picture, another performs technical actions and a third prepares refuge or medical support. Closed-loop communication is especially important when alarms arrive together. The scenario also requires an evacuation criterion: the point at which local recovery is abandoned in favor of refuge.

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:	$m_{dot} = \Delta m / \Delta t$
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.

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The affected compartment is losing pressure while a smoke detector confirms a fire; isolating too early may trap smoke while ventilation may worsen gas loss, so action ordering becomes central. For this mission, the criterion is applied explicitly to « Leak plus fire: manage two emergencies that conflict ».

For AM-16.09, the answer must show which quantities in “Leak plus fire: manage two emergencies that conflict” are recomputed, which assumptions cease to be valid and which action remains reversible before consuming an irreversible reserve.

The response sequence is justified: confirm the event, remove hazardous energy sources when possible, protect the crew, isolate at the correct time, control the atmosphere, and prepare recovery. The student explains how the order changes when a crewmember is inside the affected volume or when leakage prevents sufficient pressure from being maintained. A decision tree is preferable to one universal linear checklist.

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 « Leak plus fire: manage two emergencies that conflict ».

Return to nominal requires more than a cleared alarm. The leak must be located, hot spots excluded, atmosphere purged or filtered, damage inspected and the isolated function tested before reconnection. The final report distinguishes safing, temporary repair and complete requalification so operational pressure does not turn a provisional fix into an uncontrolled permanent configuration.

11 — Required deliverables

Operational table

Phenomena / sections:	; 10 — Decision and justification ; 11 — Required deliverables
Relationship to revisit:	$m_{dot} = \Delta m / \Delta t$
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.

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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 « Leak plus fire: manage two emergencies that conflict ».

13 — Reference sources

Topic-specific primary sources

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

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

Operational table

Phenomena / sections: 12 — Assessment rubric ; 13 — Reference sources ; Topic-specific primary sources

Relationship to revisit: $\dot{m} = \Delta m / \Delta t$

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.