

Medical emergency under radio delay: decide before Earth replies

Guiding question

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

Course map

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

1 — Mission brief

Organize local diagnosis, treatment, delayed consultation and crew workload.

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 « Medical emergency under radio delay: decide before Earth replies ».

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 « Medical emergency under radio delay: decide before Earth replies ».

A medical emergency under radio delay begins with a local authority framework. The crew must know which actions are authorized without Earth consultation, what data must be recorded, and when remote expertise remains useful. The scenario's 48-minute full exchange including analysis means some evolving decisions cannot wait for a reply. The objective is to design that autonomy, not to replace clinical expertise with improvisation.

Equation - evidence - decision

$$t_{\text{boucle}} = 2 \times \text{délai_aller} + \text{temps_traitement}$$

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 « Medical emergency under radio delay: decide before Earth replies ».

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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 « Medical emergency under radio delay: decide before Earth replies ».

Data are prioritized by their ability to change a decision: symptoms, vital signs, time evolution, relevant history and response to an intervention. Forty-eight measurements over eight hours are not forty-eight useful pieces of information if they are redundant or poorly timestamped. The student builds a trend sheet that supports both local decisions and later analysis by the Earth medical team.

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 « Medical emergency under radio delay: decide before Earth replies ».

5 — Starting calculations

Boucle minimale $2 \times 18 \text{ min} + 12 \text{ min} = 48 \text{ min}$ Interpret the result inside the global budget before making a decision.

Surveillance $6 \text{ mesures/h} \times 8 \text{ h} = 48 \text{ mesures}$ Interpret the result inside the global budget before making a decision.

Charge équipe $3 \text{ personnes} \times 2,5 \text{ h} = 7,5 \text{ person-hours}$ 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 « Medical emergency under radio delay: decide before Earth replies ».

Operational table

Phenomena / sections:	3 — Data and assumptions ; 4 — Governing relationship ; 5 — Starting calculations
Relationship to revisit:	$t_{\text{boucle}} = 2 \times \text{délai_aller} + \text{temps_traitement}$
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 resource budget includes medication, oxygen, energy, instruments and crew time. The scenario's 7.5 person-hours must be compared with other critical base duties. If three people are occupied, who watches systems, communications and possible EVA needs? The plan therefore reallocates roles and defines a threshold at which non-vital operations are suspended.

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 « Medical emergency under radio delay: decide before Earth replies ».

Communications are prepared as complete packets. Instead of sending one question and waiting, the crew transmits measurements, timeline, actions already taken, hypotheses and upcoming decisions. It explicitly states the time after which a response can no longer change local action. This turns communication delay into an information-design constraint rather than passive waiting.

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 « Medical emergency under radio delay: decide before Earth replies ».

Human factors require double protection: the patient and the decision maker. Stress, fatigue and confirmation bias can cause every new measurement to be interpreted in favor of the initial diagnosis. The exercise therefore requires periodic reassessment and assigns one crewmember to search for evidence inconsistent with the leading hypothesis. Closed-loop communication also reduces medication or execution errors.

Operational table

Phenomena / sections:	7 — Navigation, communications and state knowledge ; 8 — Survival and human factors
Relationship to revisit:	$t_{boucle} = 2 \times \text{délai_aller} + \text{temps_traitement}$
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

The clinical symptom evolves faster than an Earth communication round trip; the crew must decide locally, record observations and prepare delayed consultation instead of waiting for impossible real-time authorization. For this mission, the criterion is applied explicitly to « Medical emergency under radio delay: decide before Earth replies ».

For AM-16.11, the answer must show which quantities in “Medical emergency under radio delay: decide before Earth replies” are recomputed, which assumptions cease to be valid and which action remains reversible before consuming an irreversible reserve.

When the condition evolves faster than the radio cycle, the student defines a local decision point with observable criteria. Immediate action, close monitoring and a contingency procedure are compared without inventing medical treatment not provided by the scenario. The justification explains why waiting becomes riskier than acting, or the reverse. Earth remains important for follow-up, confirmation and strategy after stabilization.

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 « Medical emergency under radio delay: decide before Earth replies ».

The final deliverable is a timestamped timeline separating observations, hypotheses, decisions, actions and Earth messages. This separation allows later review of whether the team acted using information actually available at that moment. The debrief then identifies training, telemedicine, equipment or procedure changes that would reduce uncertainty during a similar future event.

Operational table

Phenomena / sections:	9 — Mission-specific injected incident ; ; 10 — Decision and justification
Relationship to revisit:	$t_{boucle} = 2 \times \text{délai_aller} + \text{temps_traitement}$
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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11 — Required deliverables

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 « Medical emergency under radio delay: decide before Earth replies ».

13 — Reference sources

Topic-specific primary sources

NASA — Health and Medical Care, NASA-STD-3001 - <https://www.nasa.gov/reference/3-0-health-and-medical-care/>

NASA NTRS — Assessment of the State of Communication Delay Research - <https://ntrs.nasa.gov/citations/20250003885>

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

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

Operational table

Phenomena / sections:	11 — Required deliverables ; 12 — Assessment rubric ; 13 — Reference sources
Relationship to revisit:	$t_{boucle} = 2 \times \text{délai_aller} + \text{temps_traitement}$
Expected decision:	measure → compare with margin → choose nominal, degraded or stop

Check before continuing

Explain without rereading: 11 — Required deliverables ; 12 — Assessment rubric ; 13 — Reference sources. State one measured quantity, one margin and one possible decision.