

AM-14.02 — Additive manufacturing: why a printed part is not automatically qualified

Guiding question

□ MEASURED · □ CONVENTION · □ CALCULATED · □ LEARNING ASSUMPTION · □ MISSION DATA · △ APPROXIMATION

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

Additive manufacturing builds a part layer by layer from feedstock such as metal powder, wire, polymer or paste. The geometric freedom is remarkable, but a machine completing a job without an error message does not prove strength, fatigue life, leak tightness or service life.

The guiding question is: What evidence separates a merely printed part from a genuinely reliable part? 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 “AM-14.02 — Additive manufacturing: why a printed part is not automatically qualified”, 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 “Additive manufacturing: why a printed part is not automatically qualified”, 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 “AM-14.02 — Additive manufacturing: why a printed part is not automatically qualified”, the chosen boundary also states what would otherwise be double-counted or omitted from a mission budget.

MTTR, access, tools, spare inventory, required skill, downtime and requalification outcome
inaccessible part, incompatible spare, ambiguous procedure or repair accepted without functional test
maintenance mockups, timing studies, replacement tests, inspection and post-repair verification

Equation - evidence - decision

relation propre au cours

Failure to test: The reference failure is not a vague “broken component.” For “Additive manufacturing: why a printed part is not automatically qualified”, test in particular inaccessible part, incompatible spare, ambiguous procedure or repair accepted without functional test. Diagnosis asks which symptoms appear first, which are only consequences and which action preserves the most options.

AM-14.02 — Additive manufacturing: why a printed part is not automatically qualified**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 “Additive manufacturing: why a printed part is not automatically qualified”. The English text remains fully equivalent while large translated illustrations are intentionally deferred until their dedicated artwork is supplied. For “AM-14.02 — Additive manufacturing: why a printed part is not automatically qualified”, 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

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 “Additive manufacturing: why a printed part is not automatically qualified” combines quantities that do not all have the same evidence status. For “AM-14.02 — Additive manufacturing: why a printed part is not automatically qualified”, 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

1. Exemple relation numérique du cours Interpretation: this result is used only after comparison with units, margin and the scenario boundary for “Additive manufacturing: why a printed part is not automatically qualified”.

6 — What the formula does not contain

The relationship “relation propre au cours” does not by itself contain all of “Additive manufacturing: why a printed part is not automatically qualified”. 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 relation numérique du cours therefore remains a local calculation rather than a complete architecture.

To make the model useful, explicitly add the quantities that dominate this subject: MTTR, access, tools, spare inventory, required skill, downtime and requalification outcome. We can then ask which variation truly changes the result, which is negligible and which forces an architectural change. For “AM-14.02 — Additive manufacturing: why a printed part is not automatically qualified”, this model limitation states exactly what a correct calculation still cannot establish about the real system.

Operational table

Phenomena / sections:	3 — Course-specific system view ; 4 — Mathematical relationship and reading the symbols ; 5 — Worked calculations and interpretation
Relationship to revisit:	relation propre au cours
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.

AM-14.02 — Additive manufacturing: why a printed part is not automatically qualified

7 — Instrumentation, observability and data quality

For “Additive manufacturing: why a printed part is not automatically qualified”, observability relies on MTTR, access, tools, spare inventory, required skill, downtime and requalification outcome. 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 “AM-14.02 — Additive manufacturing: why a printed part is not automatically qualified”, 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 “Additive manufacturing: why a printed part is not automatically qualified”, test in particular inaccessible part, incompatible spare, ambiguous procedure or repair accepted without functional test. 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 “AM-14.02 — Additive manufacturing: why a printed part is not automatically qualified”, the degraded mode is defined around the minimum function specific to this subject, with an abort threshold and a return-to-nominal condition.

9 — NASA / reference case

NASA material is used as an evidence dossier: requirements, reliability, maintainability, testing and configuration. The lesson never turns a generic failure rate into a universal truth; it shows how evidence is bounded to defined hardware, environment and duration.

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 “AM-14.02 — Additive manufacturing: why a printed part is not automatically qualified”, the cited NASA case is used as targeted evidence for this phenomenon and is never turned into one universal Mars architecture.

Operational table

Phenomena / sections:	7 — Instrumentation, observability and data quality ; 8 — Phenomenon-specific failures and recovery ; 9 — NASA / reference case
Relationship to revisit:	relation propre au cours
Expected decision:	measure → compare with margin → choose nominal, degraded or stop

Check before continuing

Explain without rereading: 7 — Instrumentation, observability and data quality ; 8 — Phenomenon-specific failures and recovery ; 9 — NASA / reference case. State one measured quantity, one margin and one possible decision.

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10 — Architecture trade

A good solution for “Additive manufacturing: why a printed part is not automatically qualified” does not maximize one metric. Compare nominal performance, mass, energy, simplicity, maintenance, crew time, common dependencies and recoverability. An option that improves relation numérique du cours 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 “AM-14.02 — Additive manufacturing: why a printed part is not automatically qualified”, 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 “Additive manufacturing: why a printed part is not automatically qualified” combines maintenance mockups, timing studies, replacement tests, inspection and post-repair verification. 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 “AM-14.02 — Additive manufacturing: why a printed part is not automatically qualified”, demonstration must reproduce the constraints that make this phenomenon difficult; a spectacular test outside the mission domain is insufficient.

12 — Decision exercise

Situation: revisit “Additive manufacturing: why a printed part is not automatically qualified” with a 20% increase in the most penalizing quantity from the first worked example while one measurement or backup path is unavailable.

Situation: revisit “Additive manufacturing: why a printed part is not automatically qualified” 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.

Operational table

Phenomena / sections:	10 — Architecture trade ; 11 — Demonstration, testing and success criteria ; 12 — Decision exercise
Relationship to revisit:	relation propre au cours
Expected decision:	measure → compare with margin → choose nominal, degraded or stop

Check before continuing

Explain without rereading: 10 — Architecture trade ; 11 — Demonstration, testing and success criteria ; 12 — Decision exercise. State one measured quantity, one margin and one possible decision.

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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 “AM-14.02 — Additive manufacturing: why a printed part is not automatically qualified”, 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 TechPort — In-Space Manufacturing Portfolio - <https://techport.nasa.gov/projects/11874>

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

NASA — Systems Engineering Handbook - <https://www.nasa.gov/reference/systems-engineering-handbook/>

Operational table

Phenomena / sections:	13 — What to retain without over-generalizing ; 14 — Topic-specific primary sources ; Topic-specific primary sources
Relationship to revisit:	relation propre au cours
Expected decision:	measure → compare with margin → choose nominal, degraded or stop

Check before continuing

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