Verification, validation, qualification and configuration: proving what flies

Guiding question

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

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

Verification asks whether the product meets its requirements; validation asks whether it meets the need in its use context. Qualification demonstrates that an article or design withstands defined environments. Configuration management ties each piece of evidence to the actual version of hardware, software and procedure.
The guiding question is: How do we prevent a “tested” system from being different from the one sent to Mars? 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 “Verification, validation, qualification and configuration: proving what flies”, 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 “Verification, validation, qualification and configuration: proving what flies”, 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 “Verification, validation, qualification and configuration: proving what flies”, 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

Couverture = exigences vérifiées / exigences applicables

Failure to test: The reference failure is not a vague “broken component.” For “Verification, validation, qualification and configuration: proving what flies”, 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.

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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 “Verification, validation, qualification and configuration: proving what flies”. The English text remains fully equivalent while large translated illustrations are intentionally deferred until their dedicated artwork is supplied. For “Verification, validation, qualification and configuration: proving what flies”, 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 : verification coverage is verified requirements divided by applicable requirements.

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 “Verification, validation, qualification and configuration: proving what flies” combines quantities that do not all have the same evidence status. For “Verification, validation, qualification and configuration: proving what flies”, 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

186 ÷ 200 = 93%

12 anomalies; 9 closed → 75% closed, independent of criticality

version 3.2 tested; version 3.3 modified → evidence must be reassessed

1. 1. Coverage 186 ÷ 200 = 93% Interpretation: this result is used only after comparison with units, margin and the scenario boundary for “Verification, validation, qualification and configuration: proving what flies”.

2. 2. Defects 12 anomalies; 9 closed → 75% closed, independent of criticality Interpretation: this result is used only after comparison with units, margin and the scenario boundary for “Verification, validation, qualification and configuration: proving what flies”.

3. 3. Configuration version 3.2 tested; version 3.3 modified → evidence must be reassessed Interpretation: this result is used only after comparison with units, margin and the scenario boundary for “Verification, validation, qualification and configuration: proving what flies”.

Operational table

Phenomena / sections:	3 — Course-specific system view ; 4 — Mathematical relationship and reading the symbols ; 5 — Worked calculations and interpretation
Relationship to revisit:	Couverture = exigences vérifiées / exigences applicables
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 “Couverture = exigences vérifiées / exigences applicables” does not by itself contain all of “Verification, validation, qualification and configuration: proving what flies”. 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 186 ÷ 200 = 93% 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 “Verification, validation, qualification and configuration: proving what flies”, this model limitation states exactly what a correct calculation still cannot establish about the real system.

7 — Instrumentation, observability and data quality

For “Verification, validation, qualification and configuration: proving what flies”, 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 “Verification, validation, qualification and configuration: proving what flies”, 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 “Verification, validation, qualification and configuration: proving what flies”, 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 “Verification, validation, qualification and configuration: proving what flies”, 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:	Couverture = exigences vérifiées / exigences applicables
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.

Verification, validation, qualification and configuration: proving what flies

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 “Verification, validation, qualification and configuration: proving what flies”, 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 “Verification, validation, qualification and configuration: proving what flies” does not maximize one metric. Compare nominal performance, mass, energy, simplicity, maintenance, crew time, common dependencies and recoverability. An option that improves 12 anomalies; 9 closed → 75% closed, independent of criticality 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 “Verification, validation, qualification and configuration: proving what flies”, 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 “Verification, validation, qualification and configuration: proving what flies” 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 “Verification, validation, qualification and configuration: proving what flies”, 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:	Couverture = exigences vérifiées / exigences applicables
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.

Verification, validation, qualification and configuration: proving what flies

12 — Decision exercise

Situation: revisit “Verification, validation, qualification and configuration: proving what flies” with a 20% increase in the most penalizing quantity from the first worked example while one measurement or backup path is unavailable.

Situation: revisit “Verification, validation, qualification and configuration: proving what flies” 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 “Verification, validation, qualification and configuration: proving what flies”, 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 — Systems Engineering Handbook - https://www.nasa.gov/reference/systems-engineering-handbook/

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

NASA Safety and Mission Assurance — Reliability and Maintainability - https://sma.nasa.gov/sma-disciplines/reliability-and-maintability

Operational table

Phenomena / sections:	12 — Decision exercise ; 13 — What to retain without over-generalizing ; 14 — Topic-specific primary sources
Relationship to revisit:	Couverture = exigences vérifiées / exigences applicables
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.