



ASTRA

AEROSPACE STANDARD

PROCEDURE

Measurement Traceability, Uncertainty and Decision Rules

AF-AST-PR-010

FIRST EDITION

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Aviation / Space / Defense / Future systems

Publication identity and use

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Publication and operation	Prepared publication. Actual technical approval, consultation, institutional adoption, operational effectivity and individual scope activation require separate authentic records.

Purpose and application

Measurands, references, corrections, uncertainty and decision rules used in every relevant family. Measurement confidence, detection performance and administrative completion percentages are not interchangeable.

Source requirements and added implementation detail

The controlling ASTRA source is identified above by content fingerprint. Numbered source clauses and annexes retain their own authority. The retained operating material is restructured and expanded with implementation methods, additional profile controls, worked synthetic examples, decision diagrams and record contracts. Added implementation detail is not presented as an earlier institutional approval or as a change to the supplied core standard. Any additional binding criterion requires the applicable technical adoption process.

The displayed publication date identifies the edition; it is not a fabricated authoring, test, approval or operational date. Actual records retain genuine event times and controlled versions. No named outside organisation or standard is incorporated as a normative reference. AF internal instruments and separate legal or contractual duties remain applicable within their actual scope.

Acceptance boundary

A positive grant requires every applicable mandatory condition to PASS, every N/A to have independent justification, every in-scope nonconformity to be verified closed, and competent independent authority. HOLD, unknown state, missing evidence, a favourable average, a signature image or a completed form cannot substitute for those conditions.

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1 Scope, trigger and responsibility

Measurands, references, corrections, uncertainty and decision rules used in every relevant family. Measurement confidence, detection performance and administrative completion percentages are not interchangeable.

Trigger: A measurement, calibration, calculated technical result or quantitative conformity decision is planned or reviewed.

Accountable process owner: Technical Methods Lead. Actual named appointments and deputies are recorded separately. The process owner coordinates execution; technical review, independent conformity decisions and operational permissions retain their separate mandates.

Input	Output / destination
Actual request or triggering event, scope and current technical basis	A traceable process record linked to its case/object and the required form modules.
Competence, conflict, authority and access evidence	Approved assignment and lawful access before affected work begins.
Original observations, technical results, limitations and prior history	Reasoned accept/hold/escalation decision; preserved adverse evidence and recipient communications.
Controlling clocks and genuine event timestamps	Actual due/completion records in SC-003 and the relevant register; no administrative reset.

2 Operating sequence

PR-010 – Measurement Traceability, Uncertainty and Decision Rules

Trigger: A measurement, calibration, calculated technical result or quantitative conformity decision is planned or reviewed.

1. Define the measurand and decision

The technical owner states the property, units, object/configuration, conditions, population and acceptance need. Identify specification limits and whether bounds are inclusive. Separate the measured characteristic from broader claims about the product or organisation.

2. Verify the measurement chain

Check instrument suitability, range, resolution, reference basis, calibration result and actual status at the time of use. Review uncertainty and conditions of external calibration, not merely a logo. Document justified alternative reference bases where direct reference traceability is not technically possible.

3. Establish the model and corrections

Record the model connecting inputs to the result, significant bias corrections, sensitivity coefficients, preparation and environmental effects. Identify distributions and common sources. A material known bias must not be concealed by choosing a convenient uncertainty allowance.

4. Evaluate dependence and uncertainty

Distinguish standard and expanded uncertainty, covariance, coverage factor and units. Use input evidence applicable to the actual method and range. Do not copy a calibration-scope uncertainty into an unrelated measurement. Preserve assumptions and limits of a numerical propagation model.

5. Approve the decision rule prospectively

Agree uncertainty treatment and false-acceptance/false-rejection considerations before results are evaluated. Apply the full-interval rule when required by Annex G, or obtain the specified independent prospective approval for an alternative. An alternative cannot be selected after seeing a borderline result.

6. Calculate with unrounded inputs

For inclusive bounds L and H, conformity under the full-interval rule requires $y-U$ at least L and $y+U$ at most H. An interval wholly outside a bound demonstrates nonconformity; overlap remains indeterminate. Use actual endpoints for asymmetric uncertainty and the relevant bound for a one-sided limit.

7. Disposition failure and indeterminacy

Do not round into acceptance, widen the requirement or repeat until a favourable value appears. A repeat requires an approved method, preserved originals and review of selection effects. Improve the method or obtain a valid prospective alternative where the acceptance region is unusable.

8. Review and communicate the bounded result

An authorised technical reviewer checks model relevance, arithmetic, actual inputs and the intended claim. Report corrections, uncertainty and coverage where needed, the decision rule, result and limitations. An adverse instrument finding triggers prior-result review and recipient correction, not only recalibration.

Hold / escalation: Invalid calibration, an incomplete uncertainty model, an unapproved retrospective rule or an indeterminate essential characteristic blocks acceptance for the dependent claim.

Record handover: AF-AST-FR-004, AF-AST-FR-011, AF-AST-FR-012, AF-AST-FR-019.

3 Completion, holds and handover

Invalid calibration, an incomplete uncertainty model, an unapproved retrospective rule or an indeterminate essential characteristic blocks acceptance for the dependent claim.

Decision and authority boundary

A positive grant, renewal or extension requires valid scope, every applicable criterion fulfilled, sufficient usable evidence, closure of every in-scope nonconformity, current competent independent decision authority and effective required permissions. No score, majority vote, membership status or future corrective promise replaces a missing gate. An operational technical release, a programme outcome and an administrative publication are separate actions.

Required record	Capture responsibility
AF-AST-FR-004	Technical-profile and criterion schedule
AF-AST-FR-011	Technical result and measurement decision
AF-AST-FR-012	Finding, containment and corrective action
AF-AST-FR-019	Laboratory/inspection competence and validity

The performer hands the actual record to the designated owner or reviewer. The receiving function verifies scope, version, usable evidence, open conditions, original dates and the action it may take. Sending an email, completing a form or setting a database flag is not acceptance of that handover.

4 Timing and escalation

Control / source	Trigger and interval	Required response
Ongoing outcome Core 16.1	Independent conformity decision Maximum 24 months	Shorter profile permitted; AF 9100 retains its own controlling rules. Instance results have no invented ongoing validity.
Routine surveillance Core 16.2	Decision / last completed surveillance Maximum 12 months	Complete evaluation; booking is not completion.
High-consequence / novel / integrity exposure Core 16.2	Decision / last completed surveillance Maximum 6 months	Use the shortest triggered interval for inseparable mixed scopes.

Use actual awareness, notification, completion, decision, issue and expiry timestamps with a declared time zone. Days are calendar days unless explicitly stated otherwise. Month intervals end on the corresponding date, or month-end where that date does not exist. Earlier applicable duties prevail. Source: Annex H.

5 Worked application and failure response

Synthetic example: For synthetic inclusive limits 49.970-50.030 mm and $U=0.004$ mm, $y=50.024$ mm supports conformity; $y=50.028$ mm is indeterminate; $y=50.036$ mm supports nonconformity under the full-interval rule. These are teaching values, not product limits.

Before closure, challenge a missing essential input, an expired or conflicted role, wrong configuration, contradictory evidence and an incomplete receiving handover where applicable. Record expected and actual behaviour. A completed synthetic exercise tests reasoning or workflow only; it cannot replace required technical witnessing.

E1 Explicit acceptance and evidence contract

Apply the following logic to the exact evaluated object and responsible function. A procedural checkpoint, product characteristic, competence decision and public credential are different objects. Their states shall not be collapsed into one score. Source: ASTRA 62.1–62.7 and Annex AL.

State	Sufficient basis	Required next action
PASS	Applicable; current approved predicate met by valid, purpose-specific evidence.	Retain the original evidence and bounded inference. Other mandatory gates still apply.
FAIL	Applicable; valid evidence demonstrates that the approved predicate is not met.	Contain affected use; retain the failure; assess cause, extent and required corrective verification.
HOLD	Applicability, criterion, method, evidence, uncertainty or authority is unresolved.	Resolve the missing basis. Do not manufacture a value, favourable default or product-defect conclusion.
N/A	Activity trigger and retained responsibility are absent; independent exclusion approval exists.	Retain the scope-specific reason and reassess when activity or responsibility changes.
UNSET	Only an uncompleted field in this PDF; not a conformity state.	No conclusion is recorded. Complete review before the field can support a decision.

For a compound source clause, create a child-condition ledger containing every separately testable condition, location, phase and operating mode. A sentence-level checkpoint is a navigation aid, not permission to merge unrelated predicates. Each child receives an ID, responsible owner, criterion, method, source evidence, uncertainty where relevant, current state and independent review. The parent cannot PASS while any mandatory child is FAIL, HOLD or UNSET.

An acceptable measurement interval and an acceptable authority chain are independent prerequisites. Use finite, unit-consistent, unrounded values; negative uncertainty, reversed limits, unknown version or wrong-object evidence produce HOLD. For inclusive [L,H] and accepted interval [a,b], PASS requires $a \geq L$ and $b \leq H$; FAIL requires $b < L$ or $a > H$; otherwise HOLD. Approved one-sided or exclusive boundaries retain their own declared predicate.

Positive-decision conjunction

Every applicable mandatory child is PASS AND each N/A is independently justified AND every in-scope nonconformity is verified closed AND scope, competence, independence and actual authority are valid AND required panel participation and voting rules are satisfied. No average, majority preference or payment supplies missing evidence.

E2 Source-to-implementation crosswalk

The references below use the supplied 248-page FIRST EDITION. Each row retains the original clause identifier and source page. The operating instructions in this document elaborate implementation; they do not replace the full source condition or its applicable annexes. A reference to a whole chapter requires selection of every triggered subclause, not only the examples printed here.

ASTRA ID / page	Source subject	Implementation use
8.2 / 18	Equipment identity and fitness	Requirement, objective evidence and local child predicates
8.3 / 18	Traceability and calibration	Requirement, objective evidence and local child predicates
8.4 / 19	Intermediate checks and due dates	Requirement, objective evidence and local child predicates
8.5 / 19	Adverse equipment findings	Requirement, objective evidence and local child predicates

ASTRA ID / page	Source subject	Implementation use
9.4 / 20	Measurement model and uncertainty	Requirement, objective evidence and local child predicates
9.5 / 20	Decision rules and boundary results	Requirement, objective evidence and local child predicates
42.4 / 64	Data acquisition, uncertainty and protective limits	Requirement, objective evidence and local child predicates
55.1 / 79	Define the claim before the calculation	Requirement, objective evidence and local child predicates
55.3 / 80	Demonstration and inference limitations	Requirement, objective evidence and local child predicates
62.2 / 88	Mandatory parameter completion	Explicit verification and acceptance predicate
62.3 / 88	Evidence validity before conformity	Explicit verification and acceptance predicate
62.4 / 88	Four requirement states	Explicit verification and acceptance predicate
62.7 / 89	Decision replay and consistency	Explicit verification and acceptance predicate
64.2 / 92	Geometry, reference frames and event time	Explicit verification and acceptance predicate
77.3 / 118	Measurement and uncertainty readiness	Explicit verification and acceptance predicate
77.6 / 119	Numerical and attribute acceptance	Explicit verification and acceptance predicate

E3 Detailed operating extensions

AF-AST-PR-010 – Measurement Traceability, Uncertainty and Decision Rules

Implementation basis: 8.2 (p. 18); 8.3 (p. 18); 9.4 (p. 20); 9.5 (p. 20); 62.2 (p. 88); 62.3 (p. 88); 62.4 (p. 88); 62.7 (p. 89); 64.2 (p. 92); 77.3 (p. 118); 77.6 (p. 119)

X10.1 Freeze the quantitative contract

Define the measurand, model, corrected result, units, bounds, inclusivity, actual configuration, uncertainty interpretation and prospective predicate.

Completion / hold: Invalid or missing essential inputs remain HOLD; the assessor does not supply an undocumented limit.

X10.2 Propagate actual uncertainty and dependence

Retain source distributions, sensitivity coefficients, covariance and model discrepancy. Distinguish standard uncertainty, expanded coverage and unbounded knowledge gaps.

Completion / hold: A copied instrument capability or assumed independence cannot replace a use-specific uncertainty budget.

X10.3 Apply state logic without rounding bias

Evaluate the full interval or a prospectively approved alternative with unrounded finite inputs. Preserve PASS, FAIL, HOLD and approved N/A as separate states.

Completion / hold: Boundary overlap remains HOLD; invalid evidence is not converted into a proven product defect.

X10.4 Replay and report independently

Recompute a boundary case with the same frozen inputs, identify any different assumptions and record scope-limited reporting and recipient corrections.

Completion / hold: Unresolved replay disagreement blocks the dependent acceptance even where the nominal arithmetic appears plausible.

Record contract: the actor records the input baseline, actual work, deviations, result and evidence link; the named receiving function acknowledges access and the permitted next action. A returned or incomplete handover retains the original event history. Use the associated FR modules and RG record links; no document or database field confers actual authority.

E4 Application-specific parameter completion

These are required information groups from Annex AO, not pre-approved engineering limits. For every triggered group, populate actual values or observable attributes before evaluation, with unit, inclusivity, phase/mode, technical derivation, uncertainty/dependence, method version, owner, independent review, authentic approval and change trigger. An absent trigger requires an approved exclusion; an unsupported or missing essential value is HOLD.

P03 – Requirements and acceptance

Stable ID, owner, characteristic, units, bound inclusivity, predicate, observation and essential-step marker.

Derivation and evidence: Requirement baseline and Annex AL decision rule.

Completion test: Every condition is evaluable before observations are judged.

P04 – Geometry and reference systems

Frame origin/orientation, epoch, time scale, coordinate units, transformation and covariance.

Derivation and evidence: Validated transformation and independent known-answer checks.

Completion test: Correct frame and time are maintained through every interface.

P06 – Test article and fixtures

Article pedigree, differences from delivered object, mounting, boundary conditions, operating state and exposure history.

Derivation and evidence: Approved representativeness and cumulative-test analysis.

Completion test: No material difference or prior damage invalidates the intended inference.

P07 – Measurement and uncertainty

Measurand, instrument/range, corrections, sensitivity, covariance, coverage, time/space sampling and calibration.

Derivation and evidence: Complete measurement model; valid raw data.

Completion test: Uncertainty and detection capability are fit for the approved decision rule.

P08 – Structure, life and mechanisms

Loads, allowables, factors, life, geometry, material state, mechanisms, detectability and approved reserve.

Derivation and evidence: Qualified structural/life model and representative evidence.

Completion test: Each prospectively defined margin and essential mechanism predicate passes.

P10 – Thermal and environmental control

Node/location, mode, temperatures/gradients, heat inputs, sink/view factors, properties, uncertainty and transient cases.

Derivation and evidence: Correlated thermal model and applicable environment tests.

Completion test: All required hot, cold and transition conditions meet approved limits.

P11 – Communication and timing

Distance, frequency/wavelength, gain/loss, noise, rate, margin, latency, event time, age, clock error and outage.

Derivation and evidence: Validated end-to-end budget and adverse service tests.

Completion test: Required quality, delay and integrity conditions all pass.

P16 – Reliability and availability

Population, exposure, failure definition, observation, dependencies, confidence model, downtime and maintenance exclusions.

Derivation and evidence: Prospective statistical design plus engineering mechanism evidence.

Completion test: The actual demonstrated bound meets the approved claim; zero failures is not zero risk.

E5 All-space applicability and bounded responsibility

The following Annex AK tags are selected because the document can support these responsibilities. Applicability is decided for the actual case. Tags do not expand a family, create an operating permission or place a whole mission inside a supplier's limited scope. Resolve domain, phase, mode, environment and retained duty before accepting a claim.

Domain / source page	Coverage	Required boundary
AK01 / 187 Terrestrial engineering and supply	Design offices, manufacturing, material sources, procurement and integration.	Every delivered characteristic and essential supplier interface is traceable to accepted evidence.
AK02 / 187 Test facilities and technical providers	Environmental, structural, materials, calibration and inspection services, including mobile and remote work.	Actual method competence and valid result evidence are separately demonstrated.
AK03 / 187 Launch sites and spaceports	Site infrastructure, handling, ground services, emergency interfaces and actual permissions.	No site outcome is used as vehicle, launch or mission permission.
AK04 / 187 Launch and deployment interfaces	Vehicle/payload integration, handling, ascent environment, separation and commissioning.	Every required integration and protective condition is met before the actual commitment.
AK05 / 188 Reusable launch and return articles	Cumulative exposure, refurbishment, thermal protection, hidden damage and life decisions.	Reuse is based on actual history and accepted condition, never a reset life.
AK06 / 188 Low Earth orbit systems	Satellites, stations and services in the declared near-Earth operating environment.	Environment-specific qualification and end-of-life capability support the bounded mission.
AK07 / 188 Medium, geosynchronous and high Earth orbits	Navigation, communication, relay and other specified orbit-dependent services.	No lower-orbit or nominal-link evidence automatically covers a different environment.
AK08 / 188 Highly elliptical and transfer regions	Missions crossing materially different exposure, geometry and communication regimes.	Every phase and transition has a supported envelope and verification path.
AK09 / 189 Cislunar and libration-region systems	Lunar vicinity, relays, gateways, transportation interfaces and regional services.	The exact operating domain and service dependencies are technically complete.
AK10 / 189 Constellations and formation services	Distributed functions, inter-satellite links, fleet management and shared ground support.	Distributed performance and independent redundancy assumptions are validated.
AK11 / 189 Orbital traffic and tracking support	Tracking, conjunction information, data services and inter-operator coordination.	A metric is accepted only for its validated data/model scope; missing data are not zero risk.
AK12 / 189 Cooperative docking and servicing	Authorised inspection, connection, transfer, repair and service interventions.	All essential interface and completion states are independently supported.
AK13 / 190 On-orbit assembly and manufacture	Assembly, additive or other production, finishing and output verification in space.	Process execution is not substituted for evidence of required output properties.

Domain / source page	Coverage	Required boundary
AK14 / 190 Stations and inhabited orbital platforms	Habitation, payload integration, visiting vehicles, occupants and support.	Integrated human protection and resources are accepted independently of mission success.
AK15 / 190 Extravehicular and isolated crew work	Individual equipment, user/task, environment, support and rescue dependencies.	Essential individual and integrated protective tasks pass without averaging.
AK16 / 190 Lunar surface systems	Landers, rovers, infrastructure, observation and processing on the Moon.	Destination-specific evidence bounds the actual region, phase and operating mode.
AK17 / 191 Planetary landers and surface vehicles	Surface exploration, scientific instruments, mobility and handling.	Terrestrial analogy is justified; unknown critical surface conditions remain restricted.
AK18 / 191 Atmospheric and buoyant exploration	Planetary atmospheric vehicles, balloons, aircraft and relevant instruments.	All relevant environment-specific structural and functional predicates pass.
AK19 / 191 Small-body and comet operations	Observation, cooperative contact, sampling and resource demonstrations.	Uncertain body/interaction properties are not treated as established terrestrial conditions.
AK20 / 191 Subsurface and ocean-world exploration	Subsurface, liquid, ice and extreme-pressure exploration systems and their interfaces.	Specialist boundary and contamination evidence precedes dependent use.
AK21 / 192 Interplanetary cruise and deep-space missions	Spacecraft, relays, science operations and long-delay mission support.	Human and autonomous actions are feasible within actual timing and resource limits.
AK22 / 192 Solar and heliophysics missions	Solar observations and missions with relevant thermal, plasma and radiation extremes.	Protection and data-quality evidence cover the actual mission envelope, not a screening equation alone.
AK23 / 192 Outer-system and distant observatories	Low-flux, long-life, long-delay science and infrastructure applications.	Required lifetime and survival margins are met with credible continuity and data integrity.
AK24 / 192 Interstellar precursor and future distant systems	Bounded research and demonstrable capabilities for very long-range or novel concepts.	Research promise is not an operational grant; unsupported capability stays in development.
AK25 / 193 Human exploration and surface habitats	Crew transport interfaces, habitation, exploration support and emergency protection.	Every essential human protection and feasibility predicate is supported by specialists.
AK26 / 193 Planetary protection and sample return	Forward/backward contamination, scientific cleanliness, samples and receiving chain.	No dependent commitment precedes complete protection and receiving evidence.
AK27 / 193 Resource utilisation and remote processing	Resource characterisation, processing, quality, storage, use and residues.	Resource yield, product eligibility and permission remain distinct.
AK28 / 193 Space logistics and distributed supply	Warehousing, transfer, spares, custody, condition, receiving and service continuity.	Only physically or otherwise validly confirmed accepted usable inventory supports mission budgets.
AK29 / 194 Specialised energy infrastructure	Generation, storage, conversion, remote delivery and controlled high-hazard power interfaces.	Performance never substitutes for safety, source authority or terminal accountability.
AK30 / 194 Ground, communication and navigation services	Mission control, RF/optical links, timing, data processing, relays and PNT support.	Availability, correctness, authority and completion are separately demonstrated.
AK31 / 194 Digital and autonomous space systems	Software, programmable hardware, AI, models, twins and defensive security.	All essential behaviours and prohibited transitions are verified for the actual deployment.

Domain / source page	Coverage	Required boundary
AK32 / 194 Retirement and long-term stewardship	Disposal, passivation governance, loss-of-contact states, records and residual obligations.	Final-state claims are truthful and every unresolved duty has an accepted owner.

E6 Workflow and evidence relationships

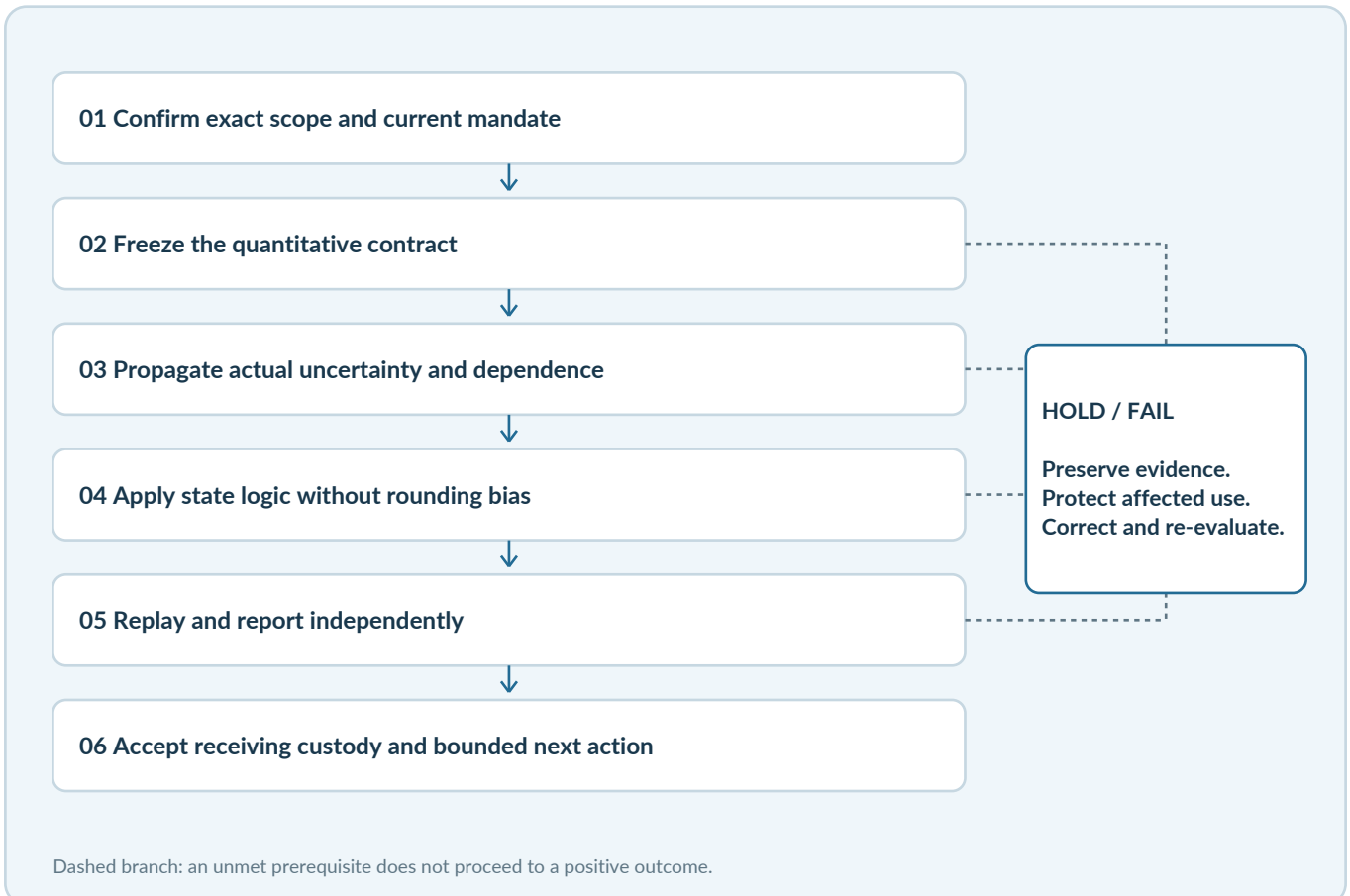
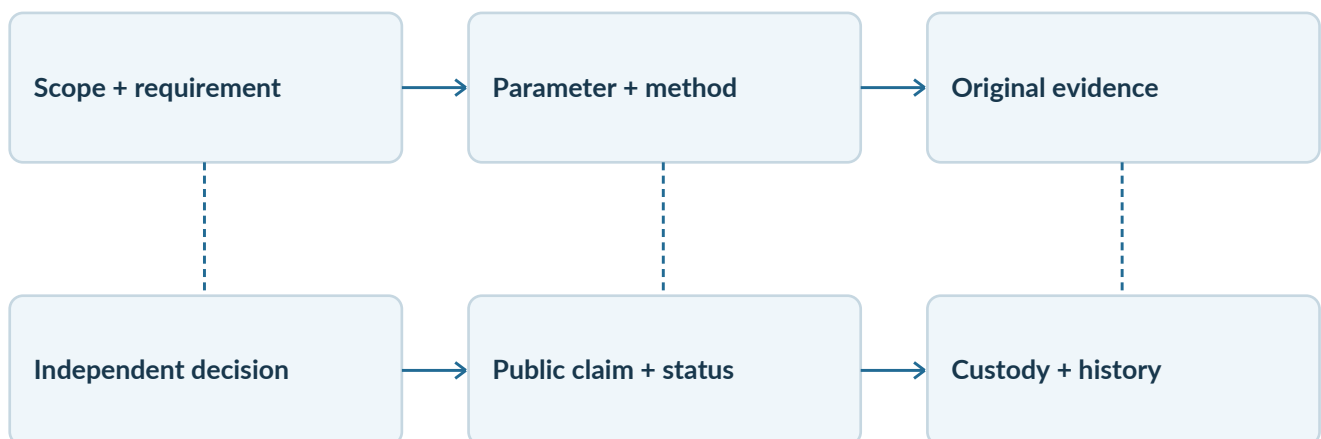


Figure — Implementation sequence for AF-AST-PR-010. Explanatory diagram; the source prerequisites and actual authority remain controlling.



Each relationship carries object identity, controlled version, actual event time and purpose-specific validity.

Figure — Scope-to-custody evidence relationships. A relationship is validated for its decision purpose, not merely because two identifiers exist.

E7 Calculations, assumptions and synthetic charts

The worked calculations below reproduce the supplied standard's Annex AM examples. Charted extensions are newly computed synthetic illustrations of those equations, not measured mission performance or new universal limits. A result is usable only when the actual inputs, model, units, uncertainty and approved application predicate are valid. A successful arithmetic check is not field validation.

AM.Q01 Measurement uncertainty and covariance

Source: ASTRA Annex AM, Q01, page 200. All numerical inputs in this example are synthetic.

$$u_c^2 = \sum (c_i^2 u_i^2) + 2\sum (i < j) (c_i c_j \text{cov}_{ij})$$

$$U = k u_c$$

Variables and units

u_i is a standard uncertainty; c_i is a sensitivity coefficient; cov_{ij} is covariance; k is the justified coverage factor. Variance terms carry squared output units.

Example inputs

Synthetic direct sum: $c_1=c_2=1$; $u_1=0.003$ mm; $u_2=0.004$ mm. First assume independence, then correlation $\rho=0.5$. Illustrative $k=2$.

Calculation and checks

1. Independent variance = $0.003^2 + 0.004^2 = 0.000025$ mm².
2. $u_c = 0.005$ mm; $U = 0.010$ mm for the stated k .
3. Correlated covariance = $0.5 \times 0.003 \times 0.004 = 0.000006$ mm².
4. Correlated variance = $0.000025 + 2 \times 0.000006 = 0.000037$ mm².
5. Correlated $u_c = 0.0060827625303$ mm; $U = 0.0121655250606$ mm.

Decision interpretation: The correlated model produces a larger uncertainty. No PASS/FAIL follows until an approved specification and decision rule are applied.

Validity limits: The linear propagation model requires a valid measurement function and adequate approximation. $k=2$ is not a universal guarantee of 95% coverage. Known bias requires correction or explicitly justified treatment; uncertainty does not conceal missing requirements.

ASTRA connections: 9.4–9.5; Annex G; 62; 77

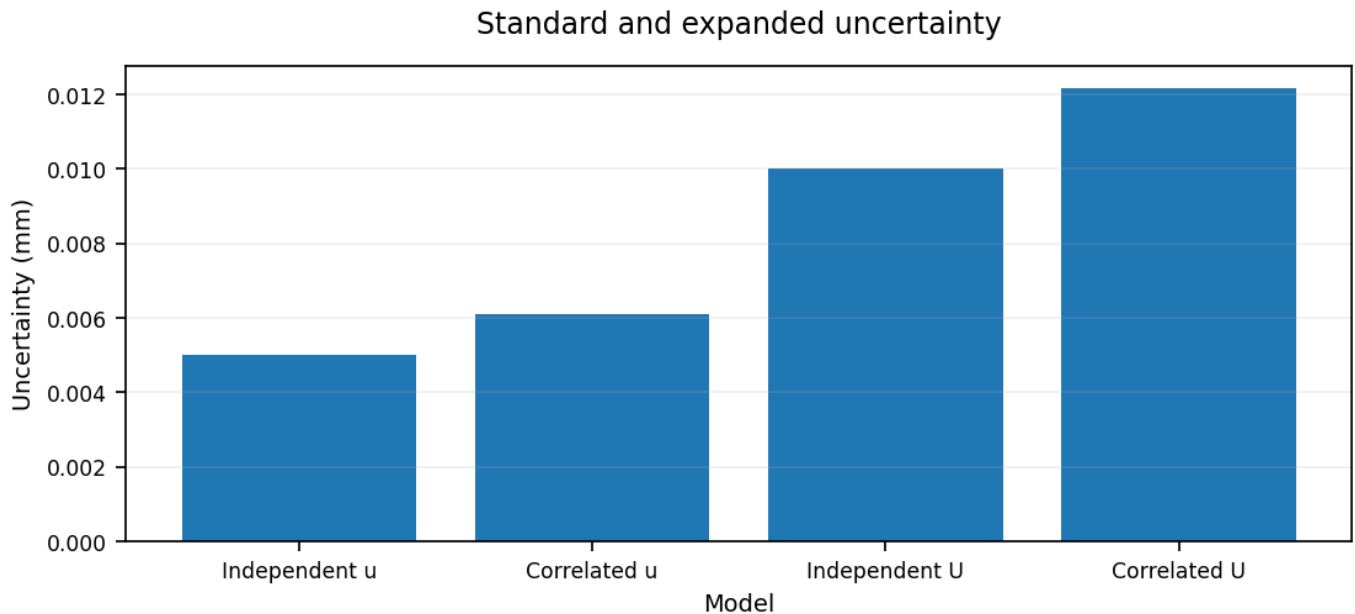


Figure Q01 — Synthetic visualisation. The axes and stated scenario define the quantity; no graph is an accreditation score, approved operating envelope or evidence of a real mission.

Local replay record: retain the actual input manifest, source versions, calculation version, unit checks, independent recomputation, expected/observed boundary results, limitations and decision authority. Do not overwrite the teaching inputs as though they were operational data.

AM.Q02 Inclusive limits and four distinct measurement outcomes

Source: ASTRA Annex AM, Q02, page 201. All numerical inputs in this example are synthetic.

PASS: $y - U \geq L$ AND $y + U \leq H$

FAIL: $y + U < L$ OR $y - U > H$

Otherwise: HOLD; invalid evidence also results in HOLD

Variables and units

L and H are inclusive specification limits; y is a corrected result; U is a non-negative expanded uncertainty with stated coverage.

Example inputs

Synthetic specification [49.970, 50.030] mm; U=0.004 mm. Results y=50.024, 50.028, 50.036 and 50.026 mm.

Calculation and checks

1. $50.024 \pm 0.004 \rightarrow [50.020, 50.028]$ mm: PASS.
2. $50.028 \pm 0.004 \rightarrow [50.024, 50.032]$ mm: HOLD, interval overlaps the upper limit.
3. $50.036 \pm 0.004 \rightarrow [50.032, 50.040]$ mm: FAIL, interval entirely above the limit.
4. $50.026 \pm 0.004 \rightarrow [50.022, 50.030]$ mm: PASS; equality is inside the inclusive upper bound.

Decision interpretation: Neither the overlapping interval nor an invalid run is rounded into acceptance. N/A is an applicability decision, not a measurement outcome.

Validity limits: Use actual endpoints for asymmetric intervals. For an upper-only limit, PASS requires the upper endpoint at or below the limit and FAIL the lower endpoint above it. A coverage interval is not automatically a probability that this particular item conforms.

ASTRA connections: Annex G; 62.3–62.5; 77.6

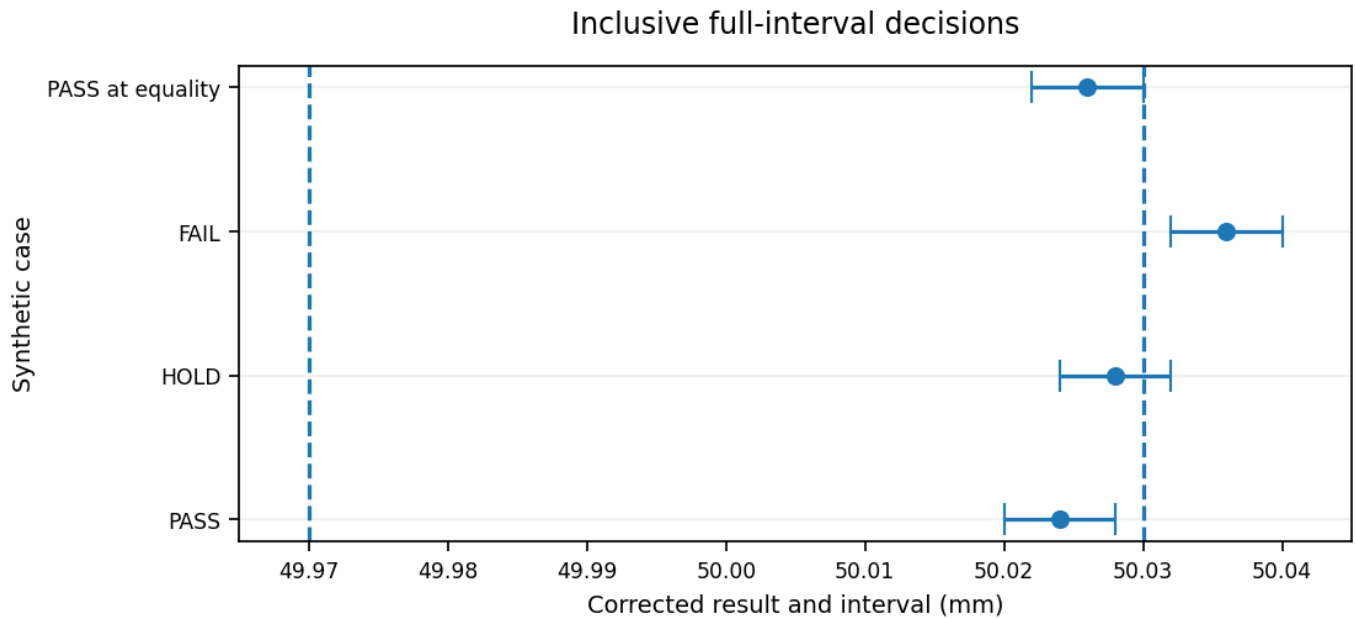


Figure Q02 – Synthetic visualisation. The axes and stated scenario define the quantity; no graph is an accreditation score, approved operating envelope or evidence of a real mission.

Local replay record: retain the actual input manifest, source versions, calculation version, unit checks, independent recomputation, expected/observed boundary results, limitations and decision authority. Do not overwrite the teaching inputs as though they were operational data.

AM.Q06 Random detection sample size

Source: ASTRA Annex AM, Q06, page 205. All numerical inputs in this example are synthetic.

$$P(\text{at least one detection}) = 1 - (1-p)^n$$

$$n_{\min} = \text{ceil}[\ln(1-C)/\ln(1-p)]$$

Variables and units

p is a fixed issue probability per independent representative observation; C is the selected target detection probability; n is a positive integer.

Example inputs

Synthetic $p=0.10$ and $C=0.95$.

Calculation and checks

- $\ln(0.05)/\ln(0.90) = 28.433158...$; round upward to $n=29$.
- $P(\text{detection at } n=29) = 1 - 0.9^{29} = 0.9528987130$.
- At $n=28$, $P = 0.9476652367$, below the specified target.

Decision interpretation: 29 is the minimum integer sample for the stated independent model; the demonstration does not certify 95% conformity.

Validity limits: This calculation is invalid for unexamined dependence, changing p , biased selection or a judgemental sample represented as random. Detection is also conditional on an effective observation method.

ASTRA connections: 9.3; Annex F.5; 55.3

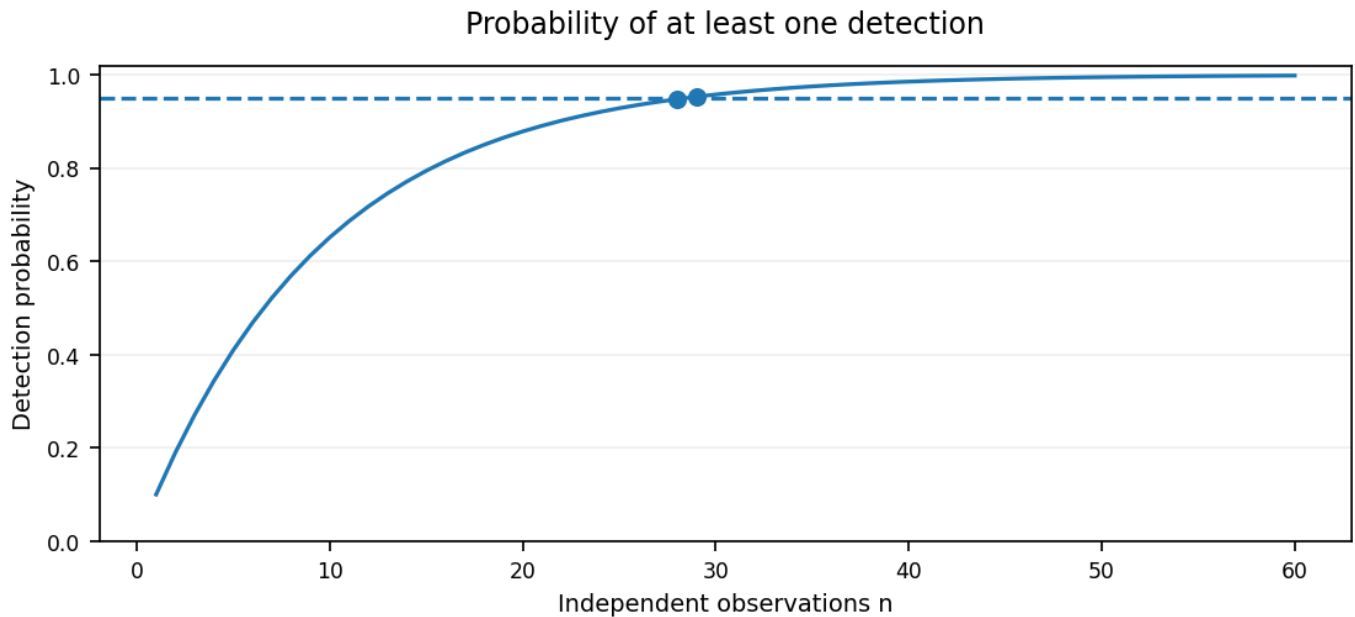


Figure Q06 – Synthetic visualisation. The axes and stated scenario define the quantity; no graph is an accreditation score, approved operating envelope or evidence of a real mission.

Local replay record: retain the actual input manifest, source versions, calculation version, unit checks, independent recomputation, expected/observed boundary results, limitations and decision authority. Do not overwrite the teaching inputs as though they were operational data.

AM.Q07 Zero observed failures and an exact binomial bound

Source: ASTRA Annex AM, Q07, page 206. All numerical inputs in this example are synthetic.

$$p_{\text{upper}} = 1 - \alpha^{(1/n)}$$

$$n_{\text{min}} = \text{ceil}[\ln(\alpha) / \ln(1 - p_{\text{target}})]$$

Variables and units

α =1-confidence; n is a prospectively fixed number of independent comparable binary trials; all n trials have zero observed failures.

Example inputs

Synthetic one-sided confidence 95%, so $\alpha=0.05$. Examine $n=30$ and a target upper failure probability of 0.01.

Calculation and checks

- For $n=30$: $p_{\text{upper}} = 1 - 0.05^{(1/30)} = 0.095033853 = 9.5033853\%$.
- For $p_{\text{target}}=0.01$: $\text{ceil}[\ln(0.05) / \ln(0.99)] = 299$.
- For $n=299$: $p_{\text{upper}} \approx 0.0099691468$, below 1%.

Decision interpretation: Thirty successful trials do not demonstrate a failure probability below 1%. Under the specified model, 299 all-success trials are needed for that particular bound.

Validity limits: A statistical upper confidence bound is not proof of zero risk or total system safety. Nonrepresentative trials, changing configuration, adaptive stopping or unmodelled common causes invalidate this simple inference.

ASTRA connections: 55.1–55.3; 62; 77

Zero failures: one-sided 95% binomial bound

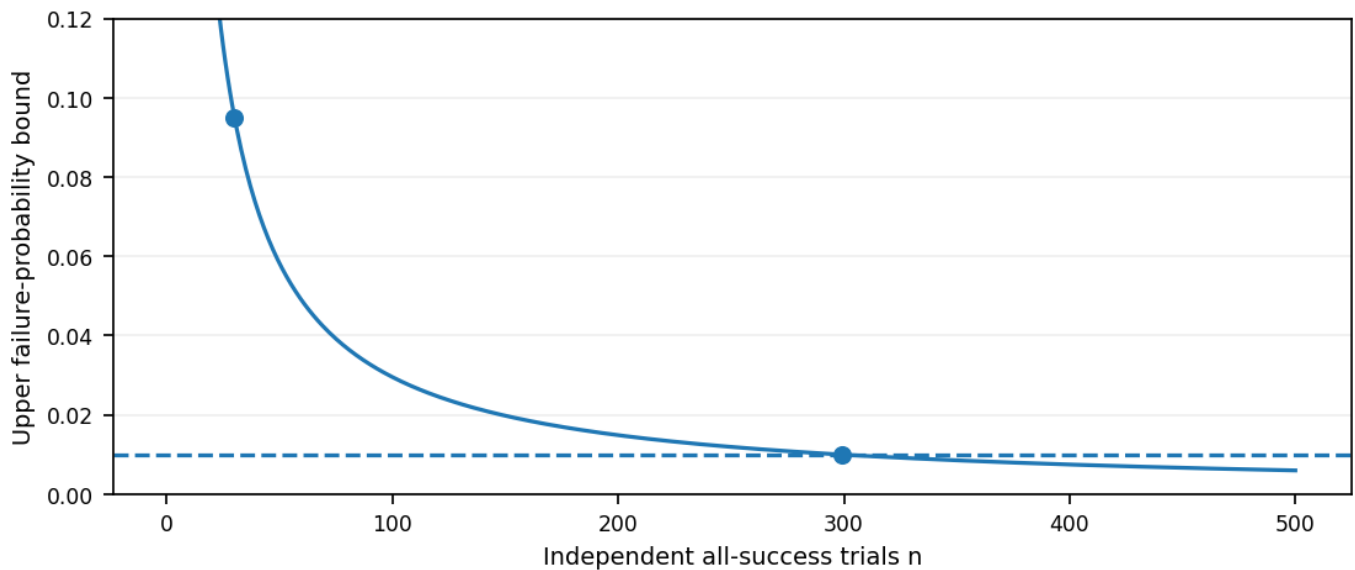


Figure Q07 – Synthetic visualisation. The axes and stated scenario define the quantity; no graph is an accreditation score, approved operating envelope or evidence of a real mission.

Local replay record: retain the actual input manifest, source versions, calculation version, unit checks, independent recomputation, expected/observed boundary results, limitations and decision authority. Do not overwrite the teaching inputs as though they were operational data.

AM.Q17 Clock uncertainty and maximum data age

Source: ASTRA Annex AM, Q17, page 216. All numerical inputs in this example are synthetic.

$u_t = \sqrt{u_{\text{event}}^2 + u_{\text{sync}}^2}$ for justified independence

$U_t = k u_t$

Upper age endpoint = age_estimate + U_t

Variables and units

Time components refer to the same event and time basis. Correlation and systematic conversion errors require appropriate treatment.

Example inputs

Synthetic standard components 3 ms and 4 ms; illustrative $k=2$; maximum inclusive permitted data age=100 ms.

Calculation and checks

- $u_t = \sqrt{3^2 + 4^2} = 5$ ms; $U_t = 10$ ms.
- At age estimate 95 ms, interval=[85,105] ms: HOLD under the full-interval rule.
- At age estimate 80 ms, interval=[70,90] ms: PASS for this age criterion.

Decision interpretation: A recently received packet can still contain stale event data. The 95 ms estimate is not rounded down into acceptance.

Validity limits: This calculation does not account automatically for unrecorded queueing, an incorrect epoch or an unknown time scale. Such validity defects cause HOLD before the age predicate is evaluated.

ASTRA connections: 66.4; Annex G; 77.6

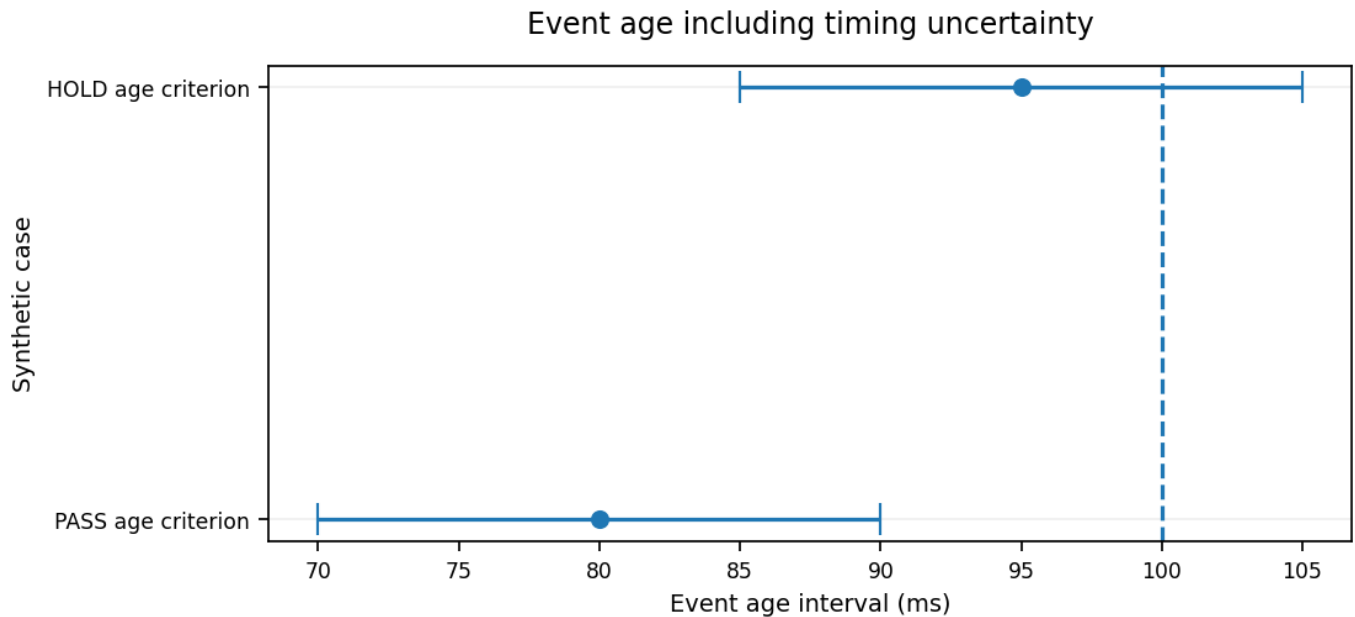


Figure Q17 – Synthetic visualisation. The axes and stated scenario define the quantity; no graph is an accreditation score, approved operating envelope or evidence of a real mission.

Local replay record: retain the actual input manifest, source versions, calculation version, unit checks, independent recomputation, expected/observed boundary results, limitations and decision authority. Do not overwrite the teaching inputs as though they were operational data.

AM.Q18 Structural margin with explicitly assigned factors

Source: ASTRA Annex AM, Q18, page 217. All numerical inputs in this example are synthetic.

$$MS = \text{allowable_lower_bound} / (\text{factor} \times \text{demand_upper_bound}) - 1$$

Variables and units

Use compatible force, stress or other characteristic units and a consistent definition of applied factors. The chosen lower and upper bounds must not double-count uncertainty.

Example inputs

Synthetic allowable lower bound=150 kN; demand upper bound=100 kN; approved example factor=1.25; required example margin=0.10.

Calculation and checks

1. Factored demand=1.25×100=125 kN.
2. MS=150/125-1=0.20.
3. The result 0.20 is at least the example required 0.10.

Decision interpretation: The stated scalar margin passes its example predicate. Every other required load case and mechanism remains separately evaluated.

Validity limits: No factor or margin here is a universal structural design rule. Buckling, joints, thermal loads, dynamics, damage, fatigue and model validity may require distinct analysis and evidence.

ASTRA connections: 33.5; 65.1; 77

Scalar structural margin: approved factors still required

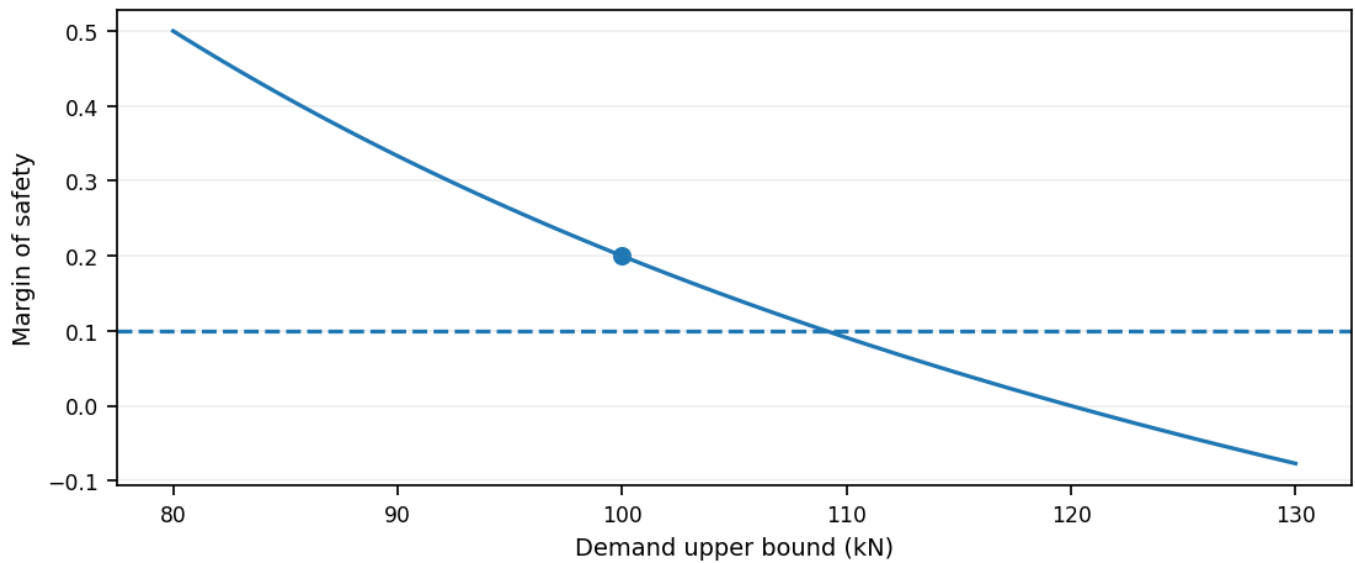


Figure Q18 — Synthetic visualisation. The axes and stated scenario define the quantity; no graph is an accreditation score, approved operating envelope or evidence of a real mission.

Local replay record: retain the actual input manifest, source versions, calculation version, unit checks, independent recomputation, expected/observed boundary results, limitations and decision authority. Do not overwrite the teaching inputs as though they were operational data.

AM.Q19 Vibration spectral integration and units

Source: ASTRA Annex AM, Q19, page 218. All numerical inputs in this example are synthetic.

$$a_{rms}^2 = \int S_a(f) df$$

$$a_{rms} = \sqrt{a_{rms}^2}$$

Variables and units

S_a is acceleration power spectral density. With g^2/Hz and Hz , the integrated variance is g^2 . The specified conventional acceleration conversion is 9.80665 m/s^2 per g .

Example inputs

Synthetic flat PSD= $0.04 \text{ g}^2/Hz$ from 20 to 120 Hz; no content outside that illustrative band.

Calculation and checks

1. Bandwidth= $120-20=100 \text{ Hz}$.
2. Variance= $0.04 \times 100 = 4 \text{ g}^2$.
3. RMS= $\sqrt{4} = 2 \text{ g} = 19.6133 \text{ m/s}^2$.

Decision interpretation: The integration is correct for the stated flat spectrum. It does not define a test severity or establish qualification.

Validity limits: Real piecewise spectra, control methods, fixture dynamics, cross-axis behaviour, time duration and response limits require an approved profile. Do not integrate a logarithmic amplitude representation as though it were a linear PSD.

ASTRA connections: 42; Annex T; 77

Integration of the synthetic flat acceleration PSD

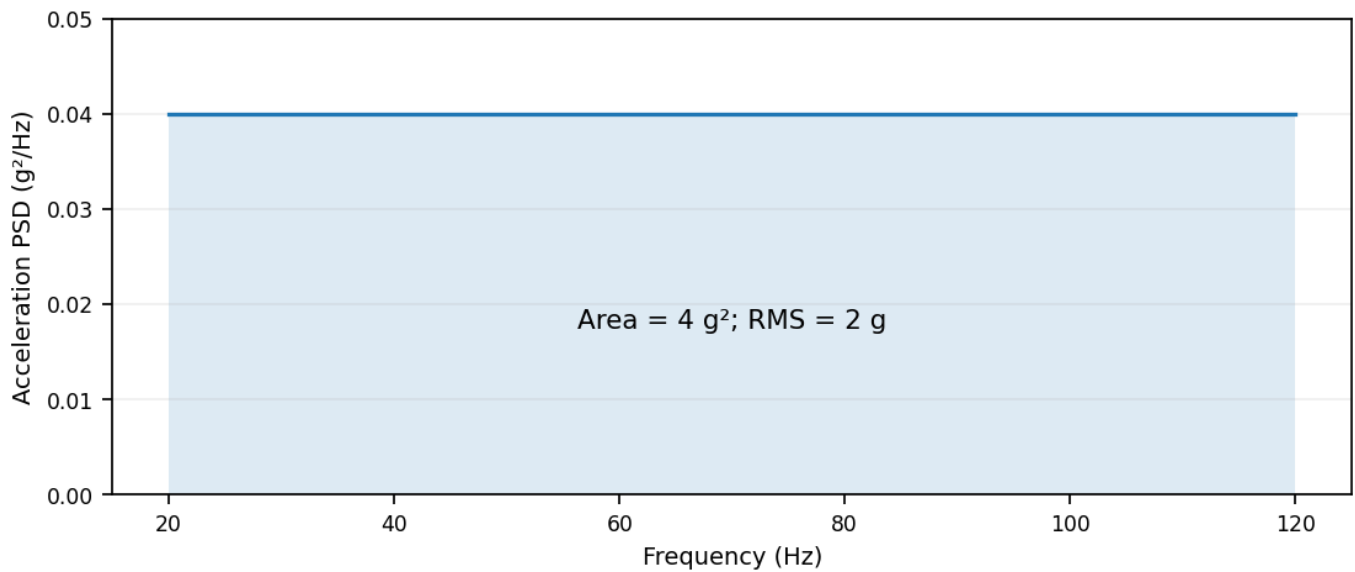


Figure Q19 – Synthetic visualisation. The axes and stated scenario define the quantity; no graph is an accreditation score, approved operating envelope or evidence of a real mission.

Local replay record: retain the actual input manifest, source versions, calculation version, unit checks, independent recomputation, expected/observed boundary results, limitations and decision authority. Do not overwrite the teaching inputs as though they were operational data.

E8 Adverse cases and independent replay

Challenge	Expected handling	Evidence retained
PR-010: Freeze the quantitative contract – required basis missing	Invalid or missing essential inputs remain HOLD; the assessor does not supply an undocumented limit.	Original input, unresolved value, affected requirement and scope; named action owner.
PR-010: Replay and report independently – handover or review incomplete	Unresolved replay disagreement blocks the dependent acceptance even where the nominal arithmetic appears plausible.	Expected and observed state; independent replay; correction/retest; receiving acknowledgement.

Before local reliance, also select every relevant AP01–AP48 challenge in the core. Keep fictional tests isolated from live credentials, commands and recipients. For each test define the requirement, precondition, expected response, execution steps, actual observations, evidence, defect consequence, correction, retest and acceptance. This publication supplies test designs and examples, not completed local validation records.

Appendix A — Controlling source requirements

The following text is reproduced from the supplied ASTRA FIRST EDITION. The clause identifier and page refer to that 248-page source. These excerpts and their evidence fields must be read with all triggered normative annexes. Newly authored implementation steps elsewhere in this document do not amend the core standard.

8.2 — Equipment identity and fitness

Source: AF-AST-STD-001, page 18.

Equipment, software-controlled instruments, fixtures, tools and reference artefacts shall be uniquely identified and suitable for the required range, resolution, accuracy, uncertainty and duty. Verify acceptance before first use, after repair or configuration change, and when validity is questioned. Records shall include version, location, maintenance, checks, restrictions and status. Calendar calibration alone shall not establish fitness for every method or specimen. Out-of-service equipment shall be prevented from supporting an authorised result.

Required evidence: Equipment register; acceptance and checks; method suitability; restricted-use controls.

8.3 — Traceability and calibration

Source: AF-AST-STD-001, page 18.

Measurement results shall have a technically appropriate documented connection to accepted reference quantities or justified reference bases, with uncertainty contributions and competent calibration evidence. Verify the actual service range and result, not only the provider's logo. Where direct reference traceability is not technically possible, document the alternative reference, method validation and limitations. Do not claim metrological traceability from an unverified manufacturer declaration or a broken chain of comparisons.

Required evidence: Calibration chain; certificates/results; uncertainty contributions; justified alternative basis.

8.4 — Intermediate checks and due dates

Source: AF-AST-STD-001, page 19.

The responsible technical person shall set calibration and verification intervals using use, drift, environment, history, consequence and applicable requirements. Conduct intermediate checks where needed to detect loss of capability between calibrations. A due date shall not be extended retrospectively because capacity is unavailable. Any prospective interval change requires recorded technical evidence and approval. Checks shall challenge actual measuring functions rather than merely confirm that the equipment powers on.

Required evidence: Interval rationale; intermediate checks; prospective approved changes; actual-use status.

8.5 — Adverse equipment findings

Source: AF-AST-STD-001, page 19.

When equipment is damaged, out of tolerance, misconfigured or otherwise suspect, stop affected use and determine the last demonstrated valid state. Review prior results, associated lots, decisions and recipients, using the likely error mechanism and uncertainty. Recalibration restores equipment evidence only after acceptance; it does not by itself establish the validity of prior work. Amend or withdraw reports and notify affected parties when their conclusions are no longer supported.

Required evidence: Quarantine; look-back interval; impacted results; corrected reports and notifications.

9.4 — Measurement model and uncertainty

Source: AF-AST-STD-001, page 20.

Evaluate uncertainty appropriate to the reported result and decision. Identify measurand, significant corrections, input distributions, sensitivity coefficients, dependence, sample preparation and environmental effects. The calculation shall distinguish standard and expanded uncertainty, coverage factor, units and coverage interpretation. Known material bias shall be corrected or explicitly handled through an approved model, not hidden in a convenient uncertainty allowance. A result shall not inherit an uncertainty copied from an unrelated calibration capability.

Required evidence: Uncertainty budget; corrections; covariance; units; coverage and applicability justification.

9.5 – Decision rules and boundary results

Source: AF-AST-STD-001, page 20.

Agree the decision rule before evaluation and record its treatment of false acceptance, false rejection, uncertainty and criticality. Annex G sets the full-interval rule and alternative-rule controls. Conformity demonstrated, nonconformity demonstrated and indeterminate are separate outcomes under that rule. Indeterminate work remains held from acceptance pending valid disposition. Repeating observations until one passes, rounding a borderline value into compliance or changing the specification after seeing the result is not a valid resolution.

Required evidence: Pre-agreed rule; unrounded inputs; outcome; hold and authorised disposition.

42.4 – Data acquisition, uncertainty and protective limits

Source: AF-AST-STD-001, page 64.

Instrumentation and software shall be suitable for the required range, bandwidth, accuracy, synchronisation and uncertainty. The organisation shall retain original data, transformations, calibration and configuration evidence. Technical acceptance and safety-stop criteria shall be specified separately. An interruption, missing channel or unexpected protective action shall be recorded and assessed before restart. Restoring the test setup shall not establish that the article remains representative or that the interrupted evidence supports the intended conclusion.

Required evidence: Measurement-chain dossier; raw data; uncertainty and timing; stop/restart records; article-validity review.

55.1 – Define the claim before the calculation

Source: AF-AST-STD-001, page 79.

Every quantitative reliability or availability claim shall identify the population, configuration, operating domain, exposure, duration, failure definition and observation boundary. The organisation shall distinguish predictions, simulations, demonstrations and field observations. Availability shall state which downtime categories are included. A percentage without its denominator, conditions and exclusions shall not be used as acceptance evidence. A changed mission duration or duty shall trigger review of the claim and supporting assumptions.

Required evidence: Metric dictionary; configuration/population; exposure and failure definitions; actual model or observation basis.

55.3 – Demonstration and inference limitations

Source: AF-AST-STD-001, page 80.

Demonstration plans shall establish prospective acceptance rules, representativeness, sample selection, confidence and treatment of incomplete or failed trials. Rare-event claims shall not be inferred from insufficient routine testing without a defensible statistical and engineering basis. Repeated or dependent observations shall not be counted as independent opportunities without justification. Changes to the article or test conditions shall remain visible. Annex AG illustrates calculation logic using labelled synthetic data only.

Required evidence: Demonstration plan; actual exposure and failures; confidence and dependence basis; qualified inference.

62.2 – Mandatory parameter completion

Source: AF-AST-STD-001, page 88.

An application-dependent value shall be entered in a controlled parameter schedule before the relevant test or evaluation. Each entry shall state symbol, meaning, unit, inclusive or exclusive bounds, uncertainty treatment, operating modes, technical derivation, source evidence, approver and change trigger. A declared value is not adequate merely because the applicant selected it. The independent reviewer shall challenge whether it bounds the claimed environment and consequence.

Verification: Recalculate derivations and check mission, interface and obligation coverage.

Acceptance / hold rule: The complete parameter set is approved prospectively. A blank, TBD, unsupported factor or undefined threshold blocks the dependent release.

62.3 – Evidence validity before conformity

Source: AF-AST-STD-001, page 88.

The evaluator shall first determine whether evidence belongs to the correct object, configuration, period, method and authorised performer and whether it is usable for the intended inference. Only valid relevant evidence shall enter a

conformity predicate. Rejected, corrupted, missing, unobservable or wrong-version evidence shall remain identified. Evidence may be valid and show failure; an invalid test is not a valid pass or a valid proof of product failure.

Verification: Check provenance, configuration, method capability, original data and uncertainty separately from result classification.

Acceptance / hold rule: Validity is established before PASS or FAIL is assigned; otherwise use HOLD with an explicit invalidity or evidence-gap reason.

62.4 – Four requirement states

Source: AF-AST-STD-001, page 88.

A requirement state shall be PASS, FAIL, HOLD or N/A. PASS means the approved predicate is satisfied by valid evidence. FAIL means valid evidence demonstrates that the predicate is not satisfied. HOLD means applicability, method, evidence, uncertainty or authority is not sufficiently resolved. N/A means the trigger and retained responsibility are absent and independent approval of that exclusion is recorded. Missing equipment, budget, access or time shall not justify N/A.

Verification: Execute the truth table in Annex AL using actual scope and evidence.

Acceptance / hold rule: Exactly one current state is assigned with reason and traceable evidence. All earlier states are retained.

62.7 – Decision replay and consistency

Source: AF-AST-STD-001, page 89.

A decision shall be reproducible from the same frozen requirements, parameter values, original evidence, calculation version, uncertainty model and role assignments. Two competent reviewers reaching different results shall identify the differing input, predicate, assumption or expertise before closure. Interpretation records may clarify a term but shall not change limits after results are known. Equation inputs shall retain unrounded values.

Verification: Independently replay a selected boundary case and reconcile every difference.

Acceptance / hold rule: The replay produces the same supported state, or the case remains HOLD pending a controlled technical resolution.

64.2 – Geometry, reference frames and event time

Source: AF-AST-STD-001, page 92.

Trajectory- and geometry-dependent information shall identify frame origin, orientation, epoch, time scale, units, state covariance and transformation version. An exchanged position or orientation shall not be accepted without enough metadata to transform it consistently. Surface-relative, body-fixed, inertial and local engineering coordinates shall remain distinct. Event time, receipt time and ground processing time shall not be merged.

Verification: Recompute selected transformations and challenge wrong-frame and stale-epoch inputs.

Acceptance / hold rule: Transformations meet the approved error and time bounds; incompatible or ambiguous metadata produces HOLD.

77.3 – Measurement and uncertainty readiness

Source: AF-AST-STD-001, page 118.

Before execution, verify instrument identity, calibration, range, bandwidth, synchronisation, environment, software, raw-data retention and uncertainty suitability. Sensor placement and spatial coverage shall represent the characteristic being accepted. Protect the article and personnel through separately specified stop conditions.

Verification: Inspect the full measurement chain and execute relevant readiness checks.

Acceptance / hold rule: All required channels are valid for the intended inference; a missing, saturated or misconfigured critical channel prevents that acceptance.

77.6 – Numerical and attribute acceptance

Source: AF-AST-STD-001, page 119.

Quantitative decisions shall use the prospectively selected predicate and uncertainty rule. Attribute decisions shall name observable states and essential steps rather than unstructured judgement. Equality at an inclusive limit is handled as specified; empty acceptance regions, invalid units and non-finite values produce HOLD. Rounding shall not change an outcome.

Verification: Replay boundary, negative and missing-input cases using Annex AL and Annex AM.

Acceptance / hold rule: The correct state follows deterministically from valid unrounded inputs and the approved predicate.

Appendix B — Local adoption, validation and receiving acceptance

Gate	Required evidence	Outcome when incomplete
Authority and identity	Actual operator, scoped mandate, permissible result class, named owner, independent decision and remedy functions.	No live scope release.
Requirement population	All applicable clauses and annexes mapped to child conditions, with reasons and independent approval for exclusions.	HOLD the affected conclusion.
Parameters and methods	Prospective values/attributes; technical basis; valid methods; representativeness; calibration, uncertainty and approved predicates.	No dependent acceptance.
People and evidence	Current demonstrated competence; conflict clearance; original usable source evidence; actual configuration and event times.	Reassign or obtain sufficient evidence.
Local tools and tests	Actual deployment tested with positive, boundary, missing, invalid and prohibited inputs; original failed cases retested.	No consequential reliance on unaccepted tools.
Independent closure	Every mandatory requirement PASS, approved N/A, all in-scope nonconformities verified closed, panel rules where required.	No grant, renewal or extension.
Claims and continuity	Decision-linked scope/status; source history; genuine custody, receiving access, retention, urgent notices and terminal duties.	Restrict publication or transfer until resolved.

Record authentic approval and activation in AF-AST-FR-001 and AF-AST-SC-004 or an equivalent controlled record. The edition label is not an effective date for a particular case. Preserve historical decisions under their actual controlling basis; a newer document does not retroactively create missing competence or evidence. Source: Clauses 4, 31, 61, 62 and 80; Annexes P and AR.

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