



ASTRA

AEROSPACE STANDARD

PROCEDURE

Environmental Statement Verification and Validation

AF-AST-PR-027

FIRST EDITION

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Aviation / Space / Defense / Future systems

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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

F08 C01–C06 with statement-specific boundary, period, methodology, assurance form and materiality. The competence of a verifier is evaluated separately from the truth of its statements.

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

F08 C01-C06 with statement-specific boundary, period, methodology, assurance form and materiality. The competence of a verifier is evaluated separately from the truth of its statements.

Trigger: An environmental capability, historical statement, reduction claim, prospective plan or energy attribute engagement is proposed.

Accountable process owner: Environment Programme 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-027 – Environmental Statement Verification and Validation

Trigger: An environmental capability, historical statement, reduction claim, prospective plan or energy attribute engagement is proposed.

1. Agree the exact engagement

The environmental lead identifies entity, assets/sites, period, intended users, statement and methodology. Distinguish capability recognition, historical verification and prospective validation. An airport inventory is not automatically the footprint of its tenants or all flights.

2. Define materiality and assurance before work

Set quantitative and qualitative materiality, scope and evidence needs for the intended users and consequences. Distinguish reasonable and limited assurance work and conclusion forms. No universal percentage is imposed; materiality does not permit knowingly false reporting.

3. Map data and boundary completeness

Identify relevant direct, purchased-energy and value-chain categories, source meters/transactions, factors, units, versions, allocations, estimates and exclusions. Review geographic, period, fuel and lifecycle suitability of each factor. Record incomplete categories separately from quantified uncertainty.

4. Plan substantive and control testing

Assess risks of omission, biased estimation, aggregation, fraud and source dependency. Select material categories, sites and transactions using a reasoned population and sample. Verify original evidence and data transformations, including units and independent recalculation where appropriate.

5. Review comparisons and exclusive claims

For reductions, reconcile baseline and current boundaries, structural changes, methods and output mix. Separate absolute/intensity change, gross emissions, reductions, removals, compensation and avoided emissions. For energy claims, distinguish physical delivery from contractual attributes and prevent duplicate exclusive allocation.

6. Evaluate prospective and local claims appropriately

Transition plans require reasonable assumptions, resources, milestones, uncertainties and monitoring; they do not demonstrate achieved reductions. Local environment and climate resilience require relevant receptors, periods, scenarios and methods, not a guarantee against every future condition.

7. Resolve misstatements and review independently

Keep the original statement, identified errors/omissions, corrections and residual limitations. Consider aggregate and qualitative significance against the prospective basis. An independent reviewer verifies sufficient evidence for the chosen conclusion; reporting pressure does not justify an unsupported favourable statement.

8. Issue a bounded conclusion and maintain history

Identify the statement/version, scope, assurance form, period, criteria and limitations. A historical instance statement has no invented continuing certificate duration. Correct later material errors and communicate to recipients. Capability status and verifier accreditation follow separate controls.

Hold / escalation: Missing material evidence, inappropriate factors, incomparable baselines, unresolved double allocation or unsupported forecast wording prevents an unqualified favourable conclusion.

Record handover: AF-AST-FR-004, AF-AST-FR-010, AF-AST-FR-011, AF-AST-FR-012, AF-AST-FR-025.

3 Completion, holds and handover

Missing material evidence, inappropriate factors, incomparable baselines, unresolved double allocation or unsupported forecast wording prevents an unqualified favourable conclusion.

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-010	Evidence and sample index
AF-AST-FR-011	Technical result and measurement decision
AF-AST-FR-012	Finding, containment and corrective action
AF-AST-FR-025	Environmental statement and verification

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: A synthetic partial inventory totals 77,000 kg CO₂e using teaching factors and 10,000 service events, giving 7.7 kg CO₂e/event. It cannot support a full-flight footprint or zero-emission claim, and the factors are not real emission factors.

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
24.1 / 40	Engagement and statement boundary	Requirement, objective evidence and local child predicates
24.2 / 40	C01 – Inventory and data	Requirement, objective evidence and local child predicates
24.3 / 41	C02 – Reduction and transition	Requirement, objective evidence and local child predicates
24.4 / 41	C03 – Energy and circular resources	Requirement, objective evidence and local child predicates

ASTRA ID / page	Source subject	Implementation use
24.5 / 41	C04 – Local environment	Requirement, objective evidence and local child predicates
24.6 / 41	C05 – Climate resilience	Requirement, objective evidence and local child predicates
24.7 / 41	C06 – Low-carbon energy and supply claims	Requirement, objective evidence and local child predicates
24.8 / 41	Materiality and assurance planning	Requirement, objective evidence and local child predicates
24.9 / 42	Verification execution and independent conclusion	Requirement, objective evidence and local child predicates
24.10 / 42	Overlap, claims and continuing change	Requirement, objective evidence and local child predicates
53.1 / 77	Declared lifecycle and material effects	Requirement, objective evidence and local child predicates
53.2 / 77	Inventory and comparable reduction	Requirement, objective evidence and local child predicates
53.5 / 78	Statements and independent conclusions	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
75.4 / 114	Yield, mass balance and circularity	Explicit verification and acceptance predicate
76.6 / 117	Degradation, environmental claims and retirement	Explicit verification and acceptance predicate
80.4 / 124	Bounded claim and publication	Explicit verification and acceptance predicate

E3 Detailed operating extensions

AF-AST-PR-027 – Environmental Statement Verification and Validation

Implementation basis: 24.1 (p. 40); 24.2 (p. 40); 24.3 (p. 41); 24.7 (p. 41); 24.8 (p. 41); 24.9 (p. 42); 53.2 (p. 77); 62.2 (p. 88); 62.3 (p. 88); 75.4 (p. 114); 76.6 (p. 117); 80.4 (p. 124)

X27.1 Freeze the statement and assurance objective

Distinguish organisational capability, historical verification, prospective validation and verifier competence. Set boundary, period, intended users, materiality and criteria before substantive work.

Completion / hold: A future plan or partial inventory cannot be relabelled as an achieved complete reduction.

X27.2 Reconstruct source-to-total calculations

Check actual activities, factors, units, data quality, allocation, baseline comparability, corrections and covariance. Preserve omitted material categories separately from numeric uncertainty.

Completion / hold: Correct arithmetic cannot compensate for an unsupported factor, wrong boundary or missing mandatory category.

X27.3 Reconcile physical and exclusive claims

Keep physical delivery, ownership, contractual attributes, cancellation and resource quality distinct. Avoid duplicating exclusive quantities or counting recirculation as new output.

Completion / hold: No favourable public conclusion while relevant allocation, eligibility or technical reuse conditions remain unresolved.

X27.4 Review and communicate the bounded conclusion

Independently evaluate identified and residual misstatement, evidence limitations and permitted wording; retain original and corrected statements and notify recipients.

Completion / hold: Do not issue an unqualified favourable conclusion solely to meet a reporting deadline.

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.

P01 — Mission and scope

Legal owner, performer, family/module, object, domain, configuration, location, duration and modes.

Derivation and evidence: Scope tuple and mission concept; approved applicability matrix.

Completion test: No undefined essential object, duty, phase or exclusion.

P02 — Environment and exposure

Quantity, spatial/temporal boundary, distribution or bound, source/model, uncertainty and coupled effects.

Derivation and evidence: Mission environment baseline and qualified specialist rationale.

Completion test: Selected conditions bound each claimed use; unknown critical mechanisms remain 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.

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.

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.

P17 — Logistics and environmental claims

Identity, amount, units, condition, losses, allocation, lifecycle boundary, factor provenance and exclusive attributes.

Derivation and evidence: Reconciled custody/quantity records and separate suitability/statement evaluation.

Completion test: Quantity and claim integrity pass independently of technical eligibility.

P18 — Decision, continuity and terminal duties

Closed findings, reviewer competence, independence, authority, status clocks, final-state criteria, custody and open obligations.

Derivation and evidence: Authenticated decisions and verified terminal/transfer evidence.

Completion test: Every mandatory gate is complete; incomplete or unknown terminal state remains explicit.

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
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.
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.
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.
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.
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.
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

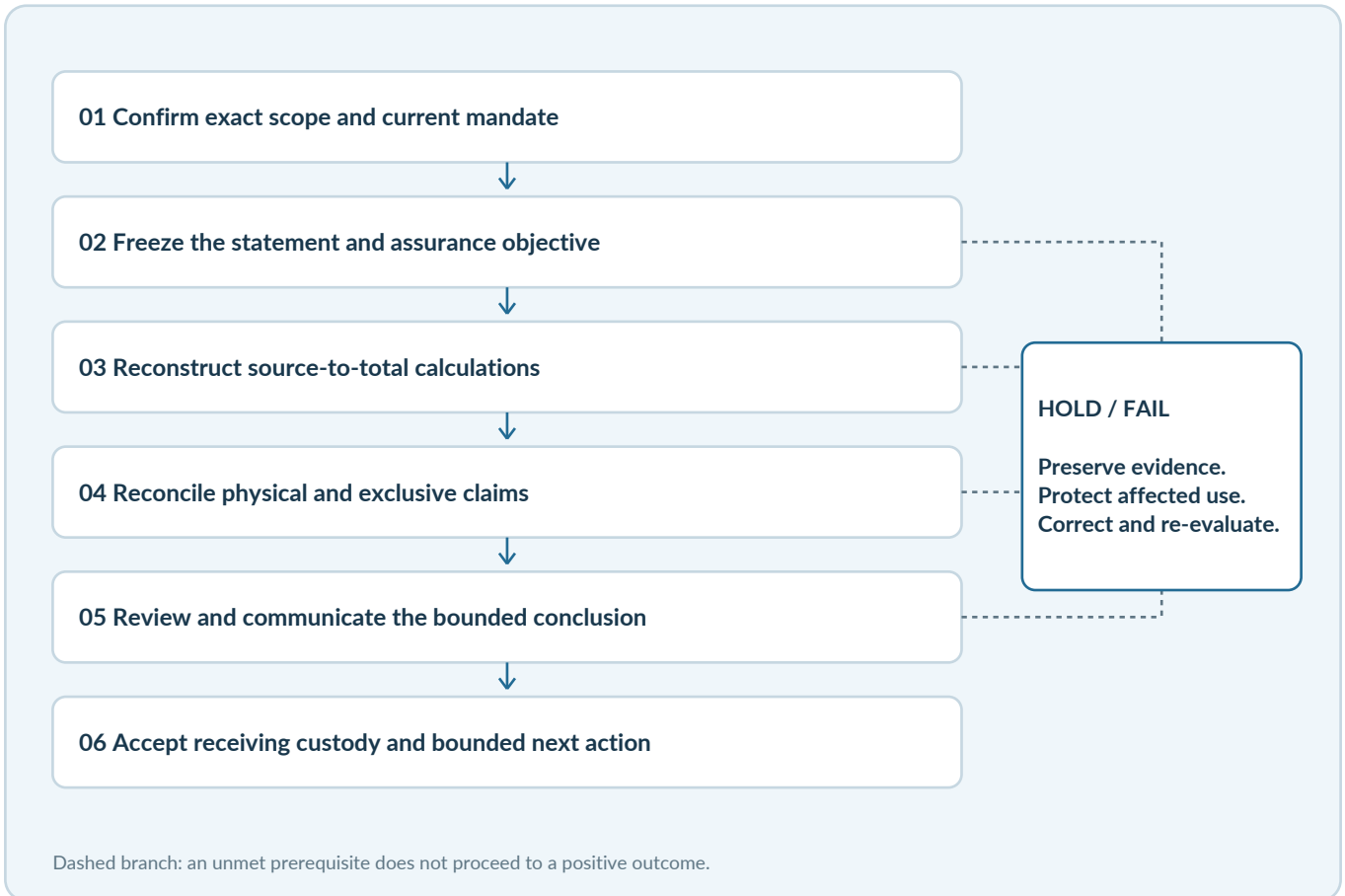
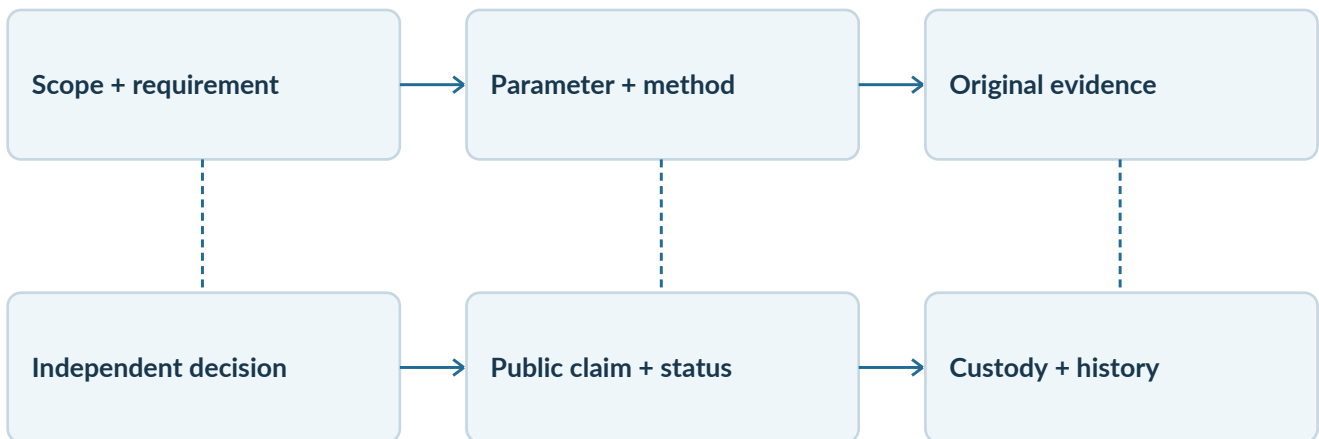


Figure — Implementation sequence for AF-AST-PR-027. Explanatory diagram; the source prerequisites and actual authority remain controlling.



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

Standard and expanded uncertainty

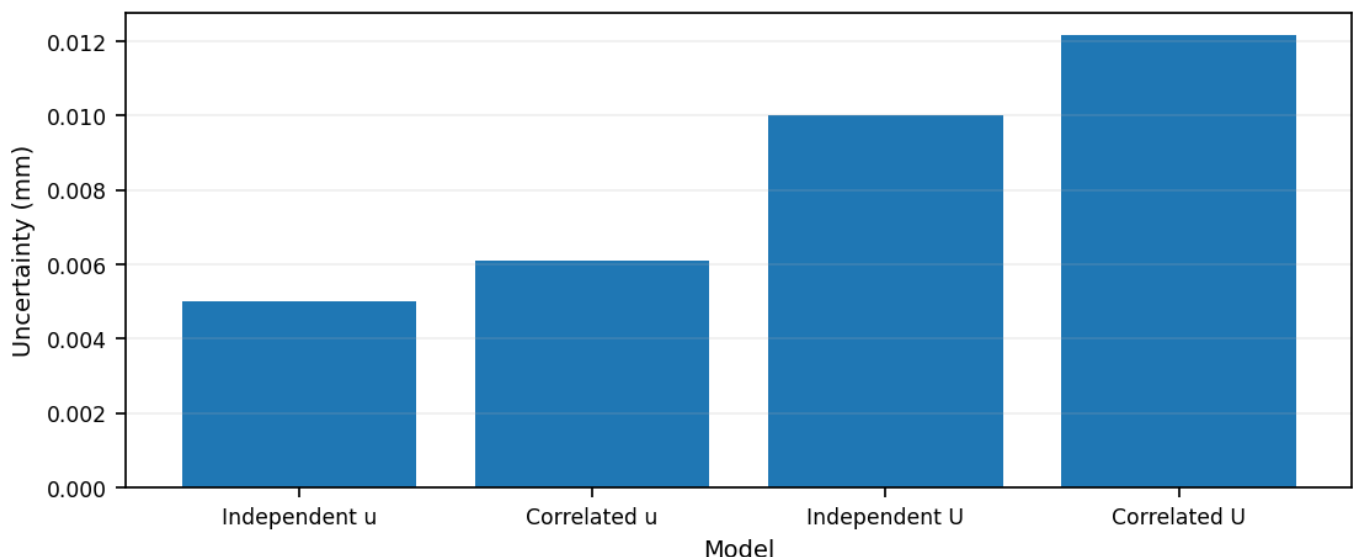


Figure Q01 — Synthetic visualisation. The axes and stated scenario define the quantity; no graph is an accreditation score, approved operating envelope or evidence of a real mission.

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.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

1. $\ln(0.05)/\ln(0.90) = 28.433158...$; round upward to $n=29$.
2. $P(\text{detection at } n=29) = 1 - 0.9^{29} = 0.9528987130$.
3. 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

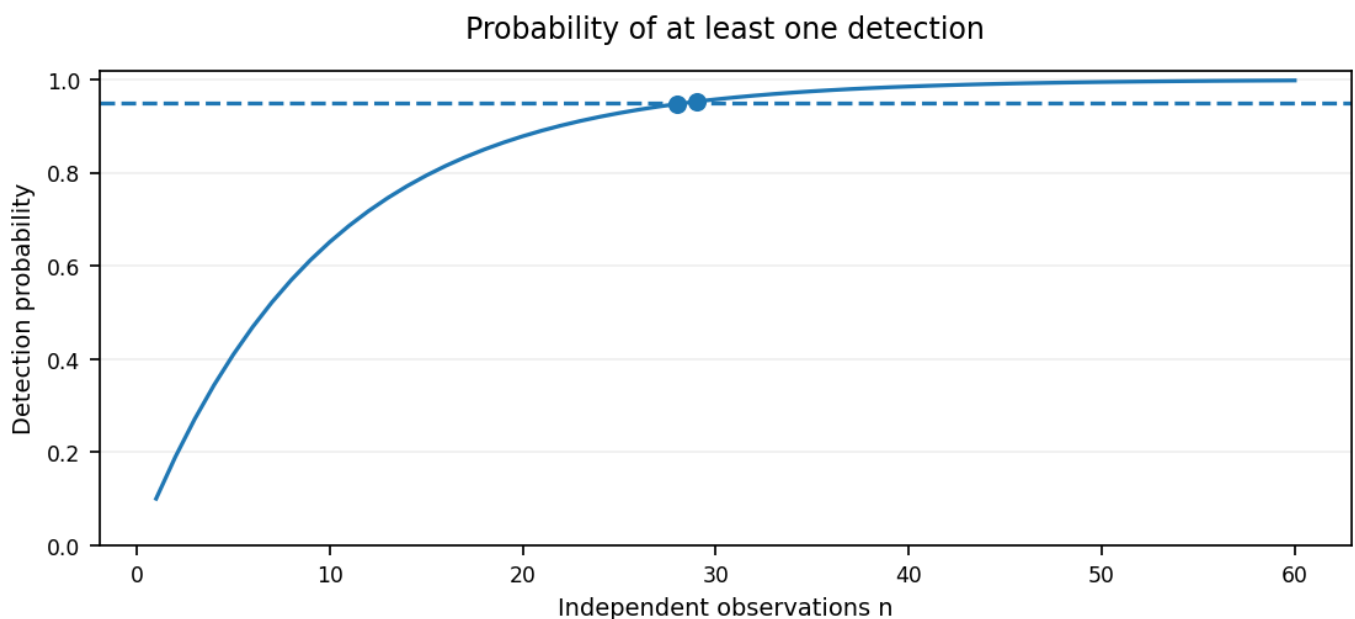


Figure Q06 – Synthetic visualisation. The axes and stated scenario define the quantity; no graph is an accreditation score, approved operating envelope or evidence of a real mission.

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.Q22 Process consumables, recovery and unusable inventory

Source: ASTRA Annex AM, Q22, page 221. All numerical inputs in this example are synthetic.

$$\text{Gross demand} = \text{number_of_units} \times \text{unit_rate} \times \text{duration}$$

$$\text{Usable feed need} = \text{gross demand} \times (1 - \text{recovery_fraction})$$

Stock requirement = feed need + unusable allowance + reserved amount

Variables and units

This is a non-physiological process-resource example. Recovery is credited only when quantity, quality and availability are demonstrated for the same duty.

Example inputs

Synthetic four identical process units; 2 kg/day/unit for 10 days; validated illustrative recovery=60%; unusable allowance=5 kg; reserve=8 kg; stock=50 kg.

Calculation and checks

1. Gross demand= $4 \times 2 \times 10 = 80$ kg.
2. Fresh usable feed need= $80 \times (1 - 0.60) = 32$ kg.
3. Stock requirement= $32 + 5 + 8 = 45$ kg.
4. Headroom= $50 - 45 = 5$ kg.

Decision interpretation: The example quantity requirement is met. It supplies no crew-consumption rate or health criterion.

Validity limits: Availability, recovery timing, quality, contamination, storage losses and common-resource failure are separate checks. A calculated recycling benefit cannot substitute for demonstrated usable output.

ASTRA connections: 64.4; 73.3; 75.4–75.5

Usable consumables and retained reserves

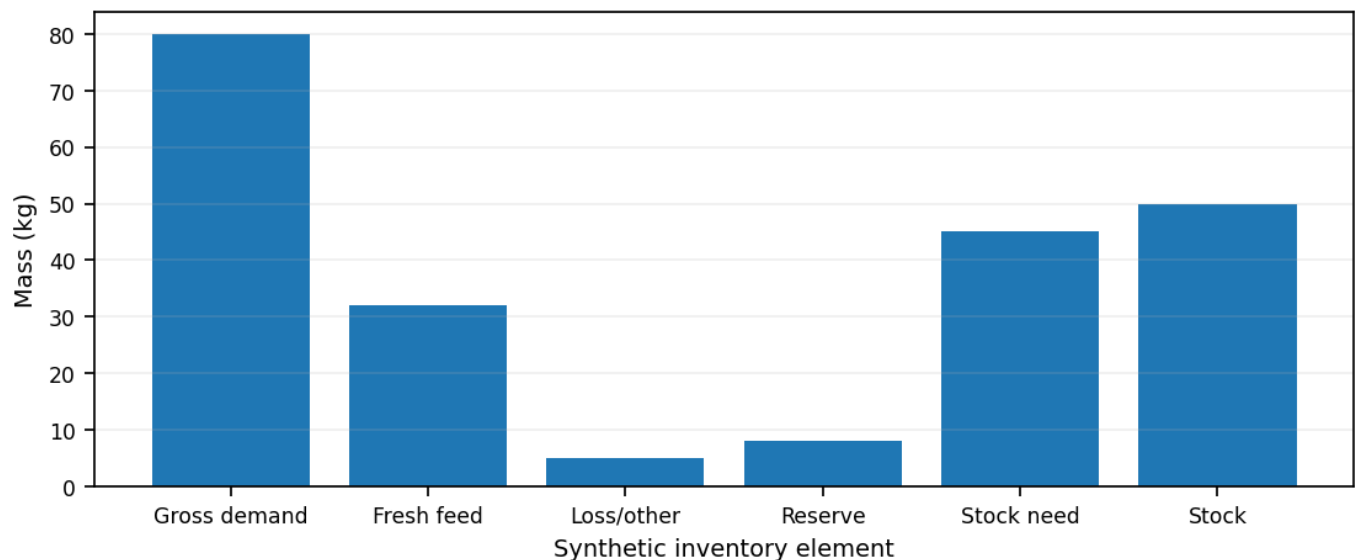


Figure Q22 – Synthetic visualisation. The axes and stated scenario define the quantity; no graph is an accreditation score, approved operating envelope or evidence of a real mission.

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.Q23 Material genealogy, yield and retained work

Source: ASTRA Annex AM, Q23, page 222. All numerical inputs in this example are synthetic.

Input = good + reject + tests + losses + work_in_progress

First-pass yield = $\text{accepted_first_pass_output} / \text{input}$

Variables and units

All quantities shall use a consistent lot and period. Recovered material remains linked to its origin and is not counted twice as new production.

Example inputs

Synthetic input=500 units; good first-pass=410; reject=30; destructive tests=10; process losses=20; work in progress=30.

Calculation and checks

1. Reconciliation=410+30+10+20+30=500 units.
2. First-pass yield=410/500=82%.
3. If 20 rejected units are later recovered, the recovery does not increase original input or first-pass output.

Decision interpretation: The quantity balance closes. Technical identity, condition and acceptance evidence still determine whether the 410 outputs are eligible.

Validity limits: A closed balance does not prove authenticity, completeness or material quality. Mixing quantities with different units or unverified scrap/recovery transfers invalidates the reconciliation.

ASTRA connections: 18.4; 48.4; Annex AC; 75.4

Original input reconciliation

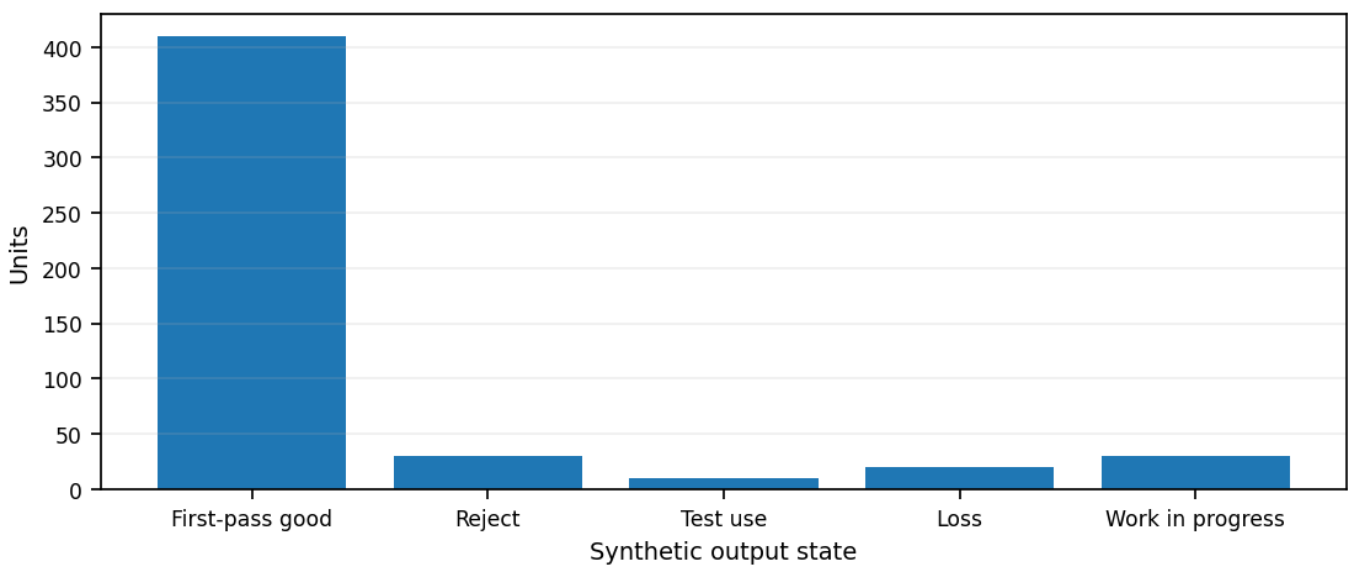


Figure Q23 — Synthetic visualisation. The axes and stated scenario define the quantity; no graph is an accreditation score, approved operating envelope or evidence of a real mission.

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.Q24 Environmental inventory and uncertainty

Source: ASTRA Annex AM, Q24, page 223. All numerical inputs in this example are synthetic.

$$E = \sum(A_i \times EF_i)$$

$$u(E) = \sqrt{\sum u_i^2}$$
 only for independent components

Variables and units

A_i are activities and EF_i compatible factors for the same declared boundary. All factors below are deliberately fictional and shall not be used for actual emissions.

Example inputs

Synthetic 200,000 kWh×0.25 kg CO₂e/kWh; 10,000 L×2.50 kg CO₂e/L; 20,000 tonne-km×0.10 kg CO₂e/tonne-km.
Relative standard uncertainties=5%, 10%, 20%.

Calculation and checks

1. Category totals=50,000; 25,000; 2,000 kg CO₂e. Total=77,000 kg CO₂e.
2. For 10,000 defined service events, intensity=7.7 kg CO₂e/event.
3. Standard components=2,500; 2,500; 400 kg CO₂e.
4. $u(E)=\sqrt{(2,500^2+2,500^2+400^2)}=3,558.089375$ kg CO₂e.

Decision interpretation: The arithmetic is correct for this limited synthetic boundary. No real environmental achievement or full lifecycle footprint is asserted.

Validity limits: Covariance is required where sources are dependent. Quantified uncertainty does not absorb omitted lifecycle stages, unsuitable factors, double allocation or missing mandatory categories.

ASTRA connections: 24; 53; Annex L

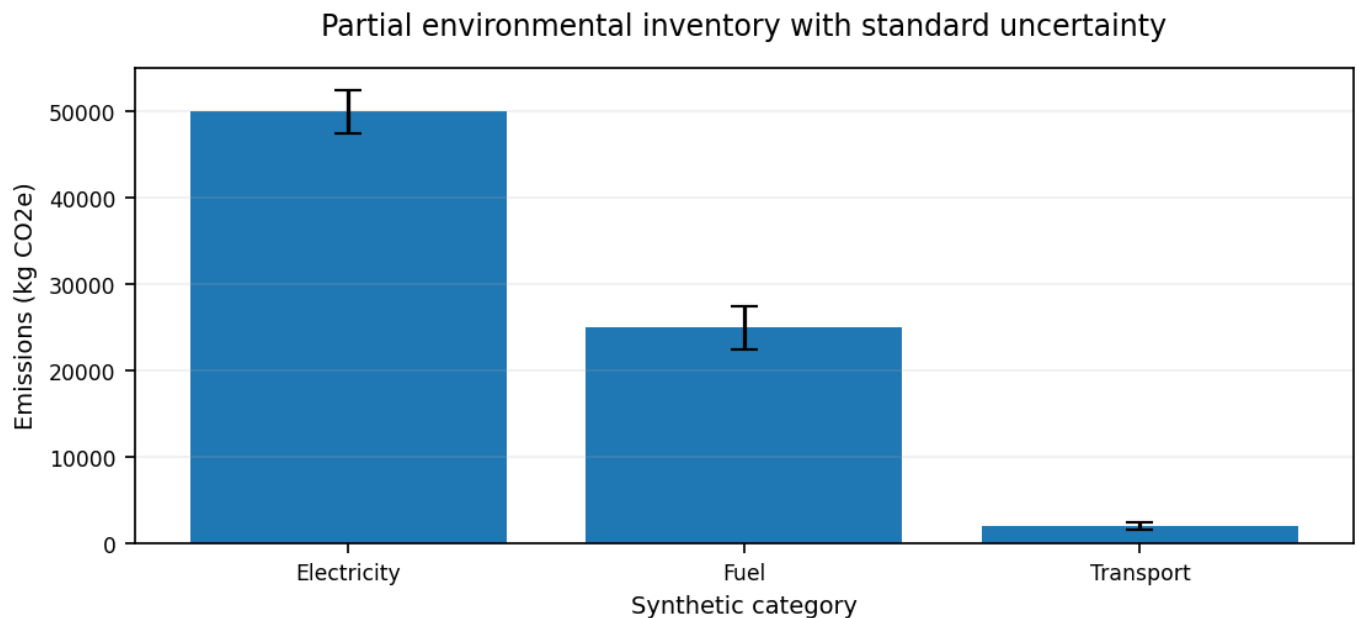


Figure Q24 – Synthetic visualisation. The axes and stated scenario define the quantity; no graph is an accreditation score, approved operating envelope or evidence of a real mission.

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-027: Freeze the statement and assurance objective – required basis missing	A future plan or partial inventory cannot be relabelled as an achieved complete reduction.	Original input, unresolved value, affected requirement and scope; named action owner.
PR-027: Review and communicate the bounded conclusion – handover or review incomplete	Do not issue an unqualified favourable conclusion solely to meet a reporting deadline.	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.

24.1 — Engagement and statement boundary

Source: AF-AST-STD-001, page 40.

Identify the responsible entity, assets/sites, reporting period, intended users, statement, methodology, criteria and required form of assurance. Separate capability evaluation from statement verification and prospective validation. Approve the boundary, exclusions, materiality approach, data access and reporting conditions before evaluation. An airport operator's inventory is not automatically the inventory of every aircraft, tenant or service provider connected to it.

Required evidence: Engagement record; exact statement; boundary and period; agreed assurance objective.

24.2 — C01 — Inventory and data

Source: AF-AST-STD-001, page 40.

Identify direct emissions, purchased-energy emissions and relevant value-chain categories with consistent CO₂-equivalent treatment where applicable. Retain activity data, factors, units, versions, allocation, estimates, gaps and uncertainty. Explain excluded categories and shared sources. Trace material figures to actual meters, transactions or justified estimation models. A factor supplied for another geography, fuel, year or lifecycle boundary shall not be adopted without a suitability review.

Required evidence: Inventory model; activity/factor evidence; category and boundary rationale; data-quality assessment.

24.3 — C02 — Reduction and transition

Source: AF-AST-STD-001, page 41.

Verify historical reductions against a controlled comparable baseline and disclose structural changes, method changes, output mix and recalculation. Separate absolute and intensity changes and distinguish operational reduction from removal, compensation and avoided emissions. A future transition plan shall state assumptions, milestones, finance/resource dependencies, uncertainties and monitoring. Validation of that plan is not verification of achieved reduction and shall not be labelled as a net-zero achievement.

Required evidence: Baseline/recalculation; comparable actual results; transition assumptions; separate conclusion types.

24.4 — C03 — Energy and circular resources

Source: AF-AST-STD-001, page 41.

Define energy, water, waste, hazardous-material, repair, reuse and recovery indicators with boundaries, denominators and measurement methods. Track material flows and avoid counting internal recirculation repeatedly as new recovered output. Evaluate environmental improvements alongside product eligibility, life history, safety and contamination. A recycled-content or recovery percentage does not establish fitness of a critical part for reuse. Statements shall identify technical and environmental limitations separately.

Required evidence: Resource flow; measurement basis; repair/reuse eligibility; bounded environmental statements.

24.5 — C04 — Local environment

Source: AF-AST-STD-001, page 41.

Evaluate local air, noise, discharges, spills and biodiversity interfaces using appropriate location, baseline, sampling and approved methods. Address seasonal/operational variability, receptors, source attribution and uncertainty where relevant. A reduction in one metric shall not conceal an increased material effect elsewhere. Operational controls and incident response shall remain active irrespective of a favourable inventory. Specialist permissions and technical criteria shall be established for each claimed local-environment conclusion.

Required evidence: Local methods; sampling and receptors; baseline/uncertainty; operational controls and incidents.

24.6 — C05 — Climate resilience

Source: AF-AST-STD-001, page 41.

Assess relevant heat, flood, storm, wildfire, water-stress or other physical-risk scenarios across asset life and service dependencies. Explain scenario choice, time horizon, vulnerabilities, uncertainty and adaptation decisions. Exercise continuity and verify critical protective measures against the stated basis. A scenario study is not proof that an asset will survive every future climate condition. Update assumptions after material evidence or infrastructure change.

Required evidence: Scenario/vulnerability assessment; adaptation decisions; exercises; limits and review triggers.

24.7 – C06 – Low-carbon energy and supply claims

Source: AF-AST-STD-001, page 41.

Trace fuel or energy provenance, chain of custody, transfers, conversion, allocation and contractual attributes. Distinguish physically delivered material from a separated contractual attribute. Check ownership, eligibility, retirement or cancellation where relevant and prevent duplicate allocation of an exclusive claim. A purchased credit or fuel invoice alone does not prove that the complete service is zero-emission. Publish the actual mechanism and limits of the claim.

Required evidence: Custody/attribute ledger; eligibility and allocation; exclusive-claim checks; transparent statement.

24.8 – Materiality and assurance planning

Source: AF-AST-STD-001, page 41.

Set quantitative and qualitative materiality for the intended users, statement and consequences before substantive work. Plan evidence accordingly and consider aggregation, bias, omissions and fraud indicators. There is no universal five-percent materiality or assurance percentage in this standard. Materiality does not authorise knowingly false reporting, omitted mandatory categories or ignoring a significant qualitative issue. Reasonable and limited assurance engagements shall have separately defined work and appropriately worded conclusions.

Required evidence: Materiality rationale; assurance level; strategic and evidence plan; aggregated/qualitative issues.

24.9 – Verification execution and independent conclusion

Source: AF-AST-STD-001, page 42.

Evaluate data controls and substantive evidence, challenge estimates, reconcile interfaces and sample material categories. Preserve identified misstatements and corrections with the original statement. The independent reviewer shall confirm sufficiency for the agreed assurance form. If residual misstatement or missing evidence prevents a supportable conclusion, require correction, qualify the conclusion within permitted rules, or decline it; do not issue an unqualified favourable statement to meet a reporting deadline.

Required evidence: Verification trail; misstatement register; revised statement; independent conclusion and limitations.

24.10 – Overlap, claims and continuing change

Source: AF-AST-STD-001, page 42.

Overlapping direct and value-chain inventories of different entities are not automatically erroneous, but portfolio aggregation and exclusive reduction claims shall avoid inappropriate double counting. Report gross quantities, reductions, removals and compensation separately. Later evidence invalidating a historical statement requires correction and recipient communication; an instance statement does not require an invented continuing validity period. Capability status follows its separate surveillance and change controls.

Required evidence: Overlap/aggregation analysis; separate totals; claim approval; historical correction and capability status.

53.1 – Declared lifecycle and material effects

Source: AF-AST-STD-001, page 77.

The organisation shall define the product, asset, service or institutional boundary, functional unit, period and environmental responsibilities. It shall identify material upstream, operational and end-of-life effects relevant to that boundary. Data gaps, allocation, estimates and exclusions shall be transparent. A partial operational inventory shall not be presented as a full lifecycle footprint. Technical safety and quality requirements shall remain active during environmental improvement; an unassessed risk shall not be traded for a favourable metric.

Required evidence: Lifecycle boundary; materiality and category rationale; technical/environmental interface review; disclosed gaps.

53.2 – Inventory and comparable reduction

Source: AF-AST-STD-001, page 77.

Quantification shall retain actual activity data, suitable factors, units, versions, source quality, corrections and relevant uncertainty. Comparisons shall use a coherent baseline and address structural, methodological and output-mix changes. Absolute and intensity changes shall be reported separately where material. Gross emissions, direct reductions, removals, compensation and avoided emissions shall not be merged into an unexplained net result. Numerical examples in this standard are synthetic and are not real-world factors.

Required evidence: Inventory model; data and factor provenance; baseline/recalculation; separated quantities; uncertainty and claim review.

53.5 – Statements and independent conclusions

Source: AF-AST-STD-001, page 78.

Capability recognition, historical verification, prospective validation and verifier accreditation shall remain distinct. Each engagement shall define the statement, criteria, intended users, assurance form, materiality and reporting boundary before substantive work. Errors, omissions, bias and residual uncertainty shall be evaluated independently. A favourable transition-plan review is not an achieved reduction. Later evidence invalidating a historical statement shall lead to appropriate correction and recipient communication without rewriting the original decision history.

Required evidence: Engagement terms; statement versions; misstatement and limitation record; independent conclusion; correction and notices.

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.

75.4 – Yield, mass balance and circularity

Source: AF-AST-STD-001, page 114.

Material accounting shall separate input, good output, reject, sample consumption, process loss, recovered material, work in progress and unknown difference. Internal recirculation shall not be counted repeatedly as new resource production. Mass closure and yield are different measures; neither proves safety or material performance. Units and measurement uncertainty shall be explicit.

Verification: Independently reconcile the material ledger and separately review quality acceptance.

Acceptance / hold rule: Balances meet the approved uncertainty-based criterion and all claimed good output is technically accepted; unexplained losses or duplicate recovery remain open.

76.6 – Degradation, environmental claims and retirement

Source: AF-AST-STD-001, page 117.

Capacity, conversion and loss models shall reflect ageing and relevant exposure. Environmental claims shall use a separately defined lifecycle boundary and shall not imply technical interchangeability or complete safety. Retirement shall preserve hazardous inventory, terminal protection, custody and monitoring duties.

Verification: Reconcile actual condition, model validity, separate environmental statements and final disposition.

Acceptance / hold rule: Technical life and terminal conditions are met independently of environmental metrics; unknown inventories remain open obligations.

80.4 – Bounded claim and publication

Source: AF-AST-STD-001, page 124.

The outcome shall identify legal holder, issuer, object, configuration, family/module, domain, site or remote responsibility, criteria, limitations, actual dates and ongoing or instance basis. Public wording shall not imply unrestricted coverage of all space, universal safety, statutory permission or external recognition without evidence. The approved cover and edition label do not change those boundaries.

Verification: Compare the actual decision with credential, registry and all proposed public representations.

Acceptance / hold rule: Published scope and status exactly match the authorised decision and preserve every material restriction.

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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