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VRS-SPC-001

Space Sector Standard

Application Rating requirements for robots operating in orbital, extraterrestrial, and launch-support environments — VRS 2026 layout.

VEYRUM RESEARCH INSTITUTE

DOCUMENT	VERSION	STATUS	DATE
VRS-SPC-001	1.0	Draft	16 September 2026

Contents

> **Foreword.** Sector standard for the **Space (SPC)** sector — capability-gated (VRS-GEN-007 §5.1), carrying the continued-validity module in its **qualification-only variant** (Annex A). Unlike Aerial and Marine assets, a space robot **never returns for survey**: continued validity rests on telemetry, fleet-analogue evidence, and the qualification campaign's demonstrated margins, not physical re-inspection. Anchors were verified against issuing-body pages on 2026-09-11 (Bibliography). Numeric thresholds are not set here; they live as priors in the VRS-SPC-501 twin and are fitted only via VRS-GEN-202. A Space AR is an opinion above the compliance floor, not a certification, and no display implies that any real robot holds a Veyrum rating (VRS-GEN-006 §10). Requirements use "shall"; recommendations use "should".

1 1 Scope

This Standard defines the requirements for issuing a **Space AR** for robots operating in orbital, extraterrestrial, and launch-support environments: orbital-servicing and proximity-operations robots, planetary/surface robots, and launch-support robotics. It defines the capability gate and applicability (Clause 4), the sector hazard taxonomy (Clause 5), rubric and grade-band requirements (Clause 6), evidence requirements (Clause 7), the loss-driver mapping that makes a SPC rating usable by an insurer or lender (Clause 8), protocol references (Clause 9), a worked applicability example (Clause 10), and the qualification-only continued-validity module (Annex A). Its clauses follow the universal sector template (VRS-GEN-002 §6.4).

Boundary. Ground-segment robots without launch or space exposure shall be rated under their operating sector (VRS-IND-001 or VRS-HAZ-001), not here. Launch vehicles themselves are out of VRS scope. The scoring mathematics are excluded (VRS-GEN-005/006); the sector's scoring content lives in VRS-SPC-201 and its data twin VRS-SPC-501.

2 2 Normative references

The following documents are referred to such that some or all of their content constitutes requirements of this Standard. VRS documents are dated at the point of assessment unless stated otherwise.

- **VRS-GEN-001**, Vocabulary; **VRS-GEN-005**, IR Methodology; **VRS-GEN-006**, AR Scheme; **VRS-GEN-007**, Sector Classification; **VRS-GEN-008**, Application of Ratings; **VRS-GEN-009**, Passport & Registry Schema; **VRS-GEN-012**, Evidence & Data Requirements.
- **VRS-SPC-201**, Space AR Assessment Protocol (scoring; dated at assessment); its data twin is **VRS-SPC-501**.
- **VRS-GEN-202**, Calibration & Validation Protocol (constant stage labels and fitting).
- Anchor regimes (verified 2026-09-11) — context anchors and evidence lanes, **not** conformity floors that VRS re-certifies:
  - **ISO 8373:2021** — Robotics — Vocabulary (the robot-term basis; VRS-GEN-001 aligns to it).
  - **ISO 24113:2023** — Space systems — Space debris mitigation requirements (3rd ed.); the requirements basis and evidence lane for H2 (debris and collision).

- **ISO 19683:2017** — Space systems — Design qualification and acceptance tests of small spacecraft and units; an ISO-format qualification-campaign anchor (revision in progress).
- **ISO 16290:2013** — Space systems — Definition of the Technology Readiness Levels (TRLs) and their criteria of assessment; the technology-maturity (TRL) basis recorded with qualification evidence.
- **ISO 14224:2016** — Petroleum, petrochemical and natural gas industries — Collection and exchange of reliability and maintenance data; the maintenance/reliability data-coding lane for ground twins and support records.
- **IEC 62443-4-2:2019** — Technical security requirements for IACS components (component security levels SL-C, foundational requirements FR1–FR7); the cyber evidence lane for H4.
- **NASA GSFC-STD-7000B (2021)** — General Environmental Verification Standard (GEVS); the baseline environmental-verification program (mechanical, thermal, EMC + verification planning), tailored by flight projects. Supersedes GSFC-STD-7000A (2013).
- **ECSS-E-ST-10-04C Rev.1 (2019)** — Space engineering — Space environment; the definition of the natural environment (radiation, thermal, vacuum) the qualification margins are stated against (H5).
- **NASA-STD-6001B (2011; w/Change 2, 2016)** — Flammability, offgassing, and compatibility for materials in combustion-supporting environments; the crewed-adjacency materials lane (H3).
- **ECSS-E-ST-10-03**, Testing, and **SMC-S-016**, test requirements for launch, upper-stage and space vehicles, are cited as context test regimes; editions are recorded at assessment.

3 3 Terms and definitions

For the purposes of this Standard, the terms in VRS-GEN-001 (aligned to ISO 8373:2021) apply, together with the following local terms:

- **space qualification** — documented evidence that the model survives and functions through launch loads, vacuum, thermal cycling, and radiation per a recognised environmental- verification program (GEVS-tailored, ISO 19683:2017, ECSS-E-ST-10-03, or SMC-S-016).
- **mission class** — the declared operating context of the assessed model; at minimum one of `orbital-servicing`, `planetary-surface`, `launch-support`, `crewed-adjacent`.
- **fleet analogue** — an on-orbit unit of the same model whose telemetry evidences the assessed model's behaviour where the assessed unit's own telemetry is unavailable.
- **crewed adjacency** — operation on or near crewed platforms.
- **qualification margin** — the margin (in radiation dose, thermal cycles, or lifetime) between the demonstrated qualification envelope and the declared mission envelope.
- **on-orbit exposure** — accumulated operating time and environmental dose accrued in the declared environment, measured in **op-hours**, **thermal cycles**, and **krad(Si)**, used as the exposure denominators for this sector.

4 4 Capability gate and applicability

4.1 SPC is a **capability-gated sector** (VRS-GEN-007 §5.1). A model shall be treated as SPC-applicable only when it possesses **space qualification** (Clause 3). Absent qualification, the model×sector shall be **not-applicable** and displayed "—"; unqualified hardware in space is not a rating question.

4.2 For qualified models, standard determination applies (manufacturer declaration or assessor override with rationale, VRS-GEN-006 §5.2); the default is not-applicable.

4.3 The assessed envelope shall state the **mission classes** covered — at minimum one of `orbital-servicing`, `planetary-surface`, `launch-support`, `crewed-adjacent` — together with the declared radiation, thermal, and lifetime envelope, as protocol applicability fields (VRS-GEN-007 §4.2).

4.4 Robot form is not a sector: a manipulator, free-flyer, rover, or launch-support arm is rated under SPC by this same Standard when 4.1 holds. Where a model is used both on the ground and in space, only its launch/space-exposed operation is rated here; its ground operation is rated under its operating sector (Clause 1 boundary).

4.5 Mission classes are the sector's **segments**: per-mission-class letters where evidence diverges materially, lowest-issued-letter display, and *not-covered* handling of unassessed classes follow VRS-GEN-006 §8.3 (the single home of that rule), as implemented for this sector in VRS-SPC-201 §4.3.

5 5 Sector hazard taxonomy

The Space AR shall weigh, at minimum, the following hazard groups. Each maps to the IR categories (VRS-GEN-005 §5) it draws evidence from and to the loss driver it surfaces; the sector emphasis (weights) is defined in VRS-SPC-201, not here.

#	HAZARD GROUP	ARCHETYPE	PRIMARY IR CATEGORIES	LOSS DRIVER
H1	Mission loss	unit failure with no repair possible; single-event effects; consumable exhaustion	reliability, economics_residual	frequency, severity, recoverability
H2	Debris and collision	debris generation; collision with a client spacecraft during proximity operations	safety_incidents	frequency, correlated/catastrophe
H3	Crewed-adjacency harm	failure on or near crewed platforms; materials offgassing/flammability	safety_incidents, spec_integrity	severity
H4	Command-link and autonomy	command-link loss under long light-delay; unobserved autonomous-behaviour divergence; cyber compromise of the control plane	cyber_posture, reliability	frequency, correlated/cyber-catastrophe
H5	Environmental degradation	radiation dose accumulation; thermal-cycle fatigue beyond qualification margins	reliability, spec_integrity	frequency, exposure
H6	Programme support	manufacturer's ability to sustain multi-year missions (ops support, spares for ground twins)	manufacturer_support, serviceability	obsolescence, recoverability

5.1 The hazard taxonomy shall be treated as the minimum coverage set: an assessment that omits a hazard group applicable to the declared mission classes shall record the omission and its reason.

5.2 H1 and H5 are amplified in this sector because **no repair is possible**: a fault that would be a downtime event in a terrestrial sector is a mission-loss event here. Severity shall therefore be scored against mission-consequence, not repair cost, and the assessment shall record the mission-consequence class alongside any physical-harm severity so the two are not conflated.

5.3 H2 debris generation shall be treated as both a safety_incidents frequency signal and a **correlated-catastrophe** signal (a debris event degrades the orbital environment for other assets); it shall not be netted into a per-unit frequency term but surfaced per 8.4.

6 6 Rubric and grade bands

6.1 The Space sector AR is determined per VRS-SPC-201 from the criterion pool defined there; letters follow VRS-GEN-006 §4. Grade bands are C < B < A < AA < AAA (AAA best), with the AAA band reserved as deliberately hard headroom (anti-inflation). Criterion thresholds, pool ceilings and band boundaries are priors held and fitted only in the VRS-SPC-501 twin (VRS-GEN-202), per VRS-GEN-006 §4.1 and §8.1; no threshold or ceiling is set in this document.

6.2 Space-qualification fit for the assessed mission classes — a documented environmental-verification campaign traceable to a recognised program (GEVS-tailored per GSFC-STD-7000B, ISO 19683:2017, ECSS-E-ST-10-03, or SMC-S-016) — is scored by VRS-SPC-201 as criterion **SPC-1** (a large-range criterion, not a gate): absence of evidenced qualification scores zero on SPC-1 there and does not withhold a letter. The `crewed-adjacent` mission class additionally draws materials evidence (NASA-STD-6001B class or equivalent), scored by VRS-SPC-201 as criterion **SPC-3**; absent that evidence, SPC-3 scores zero for that class.

6.3 Demonstrated qualification margin against the declared mission envelope (radiation dose in krad(Si), thermal cycles, and lifetime) is scored by VRS-SPC-201 as criterion **SPC-5**: a declared envelope that exceeds the demonstrated margin scores low on SPC-5 — the rating rewards demonstrated margin, not declared intent — and is not a gate.

7 7 Evidence requirements

7.1 Evidence shall be graded per VRS-GEN-012. Sector-relevant sources include: qualification-campaign records (test levels and margins), on-orbit telemetry (own units and fleet analogues), anomaly and mission-outcome reports, and end-of-support declarations. Field-return evidence does not exist for this sector; the evidence economy is **qualification + telemetry**.

7.2 For each hazard group, an existing conformity or programme artefact should be mapped to the VRS evidence lane so that adoption costs a space manufacturer a mapping rather than new testing:

HAZARD	EXISTING ARTEFACT (EXAMPLE)	VRS EVIDENCE LANE
H1	GEVS (GSFC-STD-7000B) / ISO 19683:2017 qualification report; on-orbit telemetry (op-hours)	reliability, economics_residual
H2	ISO 24113:2023 debris-mitigation plan; disposal/passivation design records; conjunction-assessment logs	safety_incidents
H3	NASA-STD-6001B materials test report; crewed-platform interface safety data package	safety_incidents, spec_integrity
H4	IEC 62443-4-2:2019 SL-C evaluation of the control/update plane; command-link loss-of-signal telemetry	cyber_posture, reliability
H5	ECSS-E-ST-10-04C Rev.1 environment definition + qualification margins (krad(Si), thermal cycles)	reliability, spec_integrity
H6	Programme sustainment plan; end-of-support declaration (horizon in months); ISO 14224:2016-coded ground-twin maintenance records	manufacturer_support, serviceability

7.3 Sufficiency for `applicable → rated` (per VRS-GEN-006 §6.1c) shall meet the minimum on-orbit observation counts held as priors in VRS-SPC-501 (VRS-GEN-202) and the per-criterion evidence bars of VRS-GEN-012 §4. Where evidence for a criterion is absent, that criterion scores zero (no evidence = 0 points) rather than withholding the letter; where the assessed model lacks sufficient own on-orbit history, its letter rests on the company-wide fallback of VRS-GEN-005 §6.

7.4 Where on-orbit evidence for the assessed unit is unavailable, **fleet-analogue** telemetry may substitute; the assessment shall record the analogue's identity and the basis for comparability, and a criterion resting on analogue-only telemetry shall not exceed the **Verified** tier on that evidence. Uninstrumented recollection is admissible only at the **Unverified** tier.

8 8 Loss-driver mapping (insurance and finance fitness)

8.1 Every quantity that feeds the SPC rating shall be traceable to a loss driver and to a Robot Risk Passport field (VRS-GEN-009), so that an underwriter or lender can compute it from obtainable evidence. The mapping is:

LOSS DRIVER	SPC SIGNAL	EXPOSURE DENOMINATOR	CONSUMES
Frequency	H1 anomalies; H4 command-link losses; H5 dose-driven faults	per 1,000 op-hours on-orbit	reliability, cyber_posture
Severity	mission-loss consequence class; crewed-adjacency harm	per event	safety_incidents, spec_integrity
Recoverability	H1 no-repair reality; H6 spares for ground twins only	per event	reliability, serviceability
Residual value / obsolescence	H6 sustainment horizon (months); remaining margin/lifetime	per model	economics_residual, manufacturer_support
Correlated / catastrophe	H2 debris generation; H4 fleet-wide control-plane compromise	per fleet / per orbital regime	safety_incidents, cyber_posture

8.2 A SPC signal that lacks an exposure denominator shall not be scored as a frequency; it shall be recorded as a descriptive attribute or elevated as a design question (VRS-GEN-202). No loss statistic shall be invented to fill a missing denominator.

8.3 The rating output shall be expressed so that it can feed an underwriting decision (rate relativity, deductible, exclusion, condition) or a credit decision (loan-to-value, residual curve, covenant); the letter alone is insufficient, and the tier and evidence-basis flags shall accompany it in the Passport record (VRS-GEN-006 §9.3, VRS-GEN-009).

8.4 Correlated and catastrophe accumulation (H2/H4) is the loss driver most likely to surprise a space-fleet underwriter. A debris event does not diversify: it degrades the orbital regime for every asset in it, and a shared control or update plane means one adversary action can degrade or capture many units of a model at once. The SPC rating shall therefore surface, as passport-recorded attributes, (a) whether the model shares a fleet-wide control/update plane and whether that plane holds an IEC 62443-4-2:2019 SL-C evaluation, and (b) the orbital regime(s) the model operates in, so an underwriter can set a per-fleet or per-regime accumulation cap rather than pricing each unit independently. These attributes are descriptive, not scored, until a fleet-loss denominator exists (VRS-GEN-202 §8).

8.5 Recoverability and residual value shall be read together: because no on-orbit repair is possible, an asset’s residual value depends almost entirely on its remaining qualification margin and lifetime (H5) and on the manufacturer’s sustainment horizon for ground twins and operations (H6). The rating shall not net one against the other; both shall appear as separate passport fields so a lender can weight them for its own credit policy.

9 9 Protocol references

- **VRS-SPC-201** — Space AR Assessment Protocol (scoring) — dated reference at assessment time; its data twin is **VRS-SPC-501**.
- Space Test Protocols (`VRS-SPC-1xx`) are reserved. They shall specify evidence-consumption requirements over the recognised verification programs (GEVS, ISO 19683:2017, ECSS, SMC-S-016) rather than duplicating those test regimes.

10 10 Worked example (informative) — applicability walkthrough

The following illustrates how an assessor applies Clauses 4–7 to a **hypothetical** model. It is not a real assessment and does not imply that any robot holds a Veyrum rating.

Input. A manufacturer declares a free-flying orbital-servicing manipulator, model code `SPC-EX-01` , for two mission classes: `orbital-servicing` and `crewed-adjacent` . The manufacturer holds a GEVS (GSFC-STD-7000B) environmental-verification report with a qualification envelope of 30 krad(Si) total ionising dose and 5,000 thermal cycles, an ISO 24113:2023 debris-mitigation and end-of-life passivation plan, an IEC 62443-4-2:2019 SL-2 evaluation of its command/update plane, a NASA-STD-6001B materials report, and 2,400 op-hours of on-orbit telemetry from one fleet-analogue unit with 1 recorded command-link loss event.

Step 1 — capability gate (Cl. 4.1). The GEVS campaign satisfies space qualification; SPC is applicable. Envelope records mission classes `orbital-servicing` , `crewed-adjacent` (4.3), with the 30 krad(Si) / 5,000-cycle / declared-lifetime envelope.

Step 2 — qualification-fit → SPC-1 (Cl. 6.2). The GEVS report evidences a recognised qualification campaign, so SPC-1 scores in its upper range; had qualification not been evidenced, SPC-1 would score zero without withholding a letter. The `crewed-adjacent` class draws materials evidence: the NASA-STD-6001B report scores SPC-3 for that class.

Step 3 — margin → SPC-5 (Cl. 6.3). The declared mission envelope (assume 25 krad(Si), 4,000 cycles) sits inside the 30 krad(Si) / 5,000-cycle demonstrated margins, so SPC-5 scores in its upper range. Had the declared dose exceeded 30 krad(Si), SPC-5 would score low for the affected class.

Step 4 — hazard coverage (Cl. 5). H1–H6 all apply. H4 evidence rests on an SL-2 evaluation with no fault-injection trial of the command plane; the assessment records the gap and SPC-4 scores accordingly.

Step 5 — evidence and sufficiency (Cl. 7). On-orbit evidence is fleet-analogue only, so per 7.4 the command-link and reliability criteria resting on it shall not exceed the Verified tier and the analogue identity is recorded. The 2,400 op-hours and 1 event are checked against the VRS-SPC-501 prior minima and the VRS-GEN-012 §4 evidence bars; assume they clear the minimum on-orbit count, so each model×class is `applicable → rated` at the tier its evidence supports.

Output. The rating is computed by VRS-SPC-201 (not in this document). The displayed sector letter is the lowest issued mission-class letter (4.5). The Passport record carries the per-class letters, the mission classes, the qualification envelope, the fleet-analogue basis, the evidence tier, and the H4

evidence-gap note. The numeric score and band boundary come from VRS-SPC-501 priors and are not asserted here.

11 Annex A (normative) — Continued-validity module (qualification-only variant)

A.1 A Space rating is **maintained on telemetry and analogue evidence**, never on physical survey (VRS-GEN-008 §5.2). It shall remain valid only while (a) on-orbit telemetry (own or fleet-analogue) not more than **12 months** old is filed; (b) accumulated environmental exposure (dose in krad(Si), thermal cycles) remains within the qualification margins of record; and © prompt-report events (mission loss, debris event, proximity anomaly) are reported per VRS-GEN-008 §7. Unreported known events shall void the rating for cause.

A.2 When accumulated exposure approaches the margins of record (the proximity threshold is a prior, VRS-GEN-202, in VRS-SPC-501), the rating shall enter continued-validity review (VRS-GEN-008 §7) rather than lapsing outright — the fleet may re-justify margins by analysis.

A.3 A rating whose telemetry is more than **12 months** stale shall **lapse** (displayed as lapsed, never silently as current); re-entry shall require current telemetry and a margin re-check under A.1, by evidence refresh rather than re-assessment from zero where the lapse was administrative.

12 Bibliography

- ISO 8373:2021, Robotics — Vocabulary (iso.org/standard/75539.html) — third edition; robot-term basis.
- ISO 24113:2023, Space systems — Space debris mitigation requirements (iso.org/standard/83494.html) — third edition; H2 requirements basis.
- ISO 19683:2017, Space systems — Design qualification and acceptance tests of small spacecraft and units (iso.org/standard/66008.html) — qualification-campaign anchor; revision in progress.
- ISO 16290:2013, Space systems — Definition of the Technology Readiness Levels (TRLs) and their criteria of assessment (iso.org/standard/56064.html) — technology-maturity (TRL) basis.
- ISO 14224:2016, Collection and exchange of reliability and maintenance data (iso.org) — ground-twin maintenance/reliability data-coding lane (H6).
- IEC 62443-4-2:2019, Technical security requirements for IACS components (IEC/ANSI webstore) — control-plane cyber evidence lane (H4).
- NASA GSFC-STD-7000B (2021-04-28), General Environmental Verification Standard (GEVS) (standards.nasa.gov) — environmental-verification program; supersedes GSFC-STD-7000A (2013).
- ECSS-E-ST-10-04C Rev.1 (2019-01-31), Space engineering — Space environment (ecss.nl) — radiation/thermal/vacuum environment definition (H5).
- NASA-STD-6001B (2011-08-26; w/Change 2, 2016), Flammability, offgassing, and compatibility (standards.nasa.gov) — crewed-adjacency materials lane (H3).
- ECSS-E-ST-10-03, Testing, and SMC-S-016, test requirements for launch, upper-stage and space vehicles — context test regimes; editions recorded at assessment.
- VRS framework research Phase 5 (internal) — SPC scan (no-repair evidence economy).

13 Change history

DATE	VERSION	STATUS	CHANGE	AUTHORITY
2026-09-05	0.1	Draft	Initial draft — third capability-gated sector; qualification-only continued-validity variant (telemetry, margins, no survey)	CEO goal 2026-09-05
2026-09-11	0.2	Draft	DEEPEN: brought to publishable depth. Added dated anchors verified 2026-09-11 (ISO 8373:2021, ISO 24113:2023, ISO 19683:2017, ISO 16290:2013, ISO 14224:2016, IEC 62443-4-2:2019, GSFC-STD-7000B 2021, ECSS-E-ST-10-04C Rev.1 2019, NASA-STD-6001B 2011); updated GEVS 7000A→7000B; added evidence-reuse mapping (Cl. 7.2), loss-driver mapping (Cl. 8), worked applicability example (Cl. 10); added units (op-hours, krad(Si), thermal cycles, months, per 1,000). Retired both bare markers → GEN-202 stage labels. Net +≈2,050 words; shall 3→52. No requirements deleted.	Curator Run #33; charter DEEPEN
2026-09-16	1.0	Draft	REWRITE (VRS 2026, Batch C): recast §6.1 to “AR determined per VRS-SPC-201, letters per VRS-GEN-006 §4”; §6.2 qualification-fit cap → criterion SPC-1 (large range, no gate; crewed-adjacency materials → SPC-3); §6.3 margin-exceedance cap → criterion SPC-5 (low score, no gate); deleted §6.4 (GEN-201 cold-start). Removed retired forms: confidence band (§7.3/§7.4/§8.3/§10), provisional flag (§6.4/§10), cold-start & VRS-GEN-201 (§1/§2/§6.4/§7.3/Annex), assessed-unrated (§6.2/§7.3/Annex), stage-prior markers (Foreword/§6/§7/Annex), “no letter shall be issued”/“capped at B” (§6.2/§6.3/§10) → tiers + evidence bars + company-wide fallback (GEN-005 §6). Deleted cold-start Annex A; renumbered continued-validity Annex C → Annex A. Added §4.5 (per-class letters → GEN-006 §8.3). Worked example re-run against SPC-1/SPC-5 at the Verified tier. No criterion invented/renamed; no constant changed; SPC-501 regenerated by the dispatcher. See GEN-005 §6.	Curator Run REWRITE; charter REWRITE

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