ALP LAB

E1M-X V2N Reliability Report

MTBF / FIT prediction — Telcordia SR-332

Document Number: RL-V2N-001 **Revision:** 0.4 **Date:** November 2026 **Status:** Preliminary

alplab.ai

© 2026 Alp Lab AB. All rights reserved.

Table of Contents

1 Summary . . . 3
1.1 Reference Condition . . . 3
2 Method . . . 3
3 Failure-Rate Budget . . . 3
4 Results . . . 4
5 Temperature & Environment Sensitivity . . . 5
6 Assumptions & Limitations . . . 5
7 Revision History . . . 5

List of Tables

Table 1 Reference condition for the headline prediction . . . 3
Table 2 E1M-X V2N failure-rate budget by class (+40 °C Telcordia reference) . 3
Table 3 Predicted reliability at the +55 °C operating headline (GF) . . . 4
Table 4 Expected intrinsic failures per 1000 fielded units (24/7, +55 °C) . . . 5
Table 5 MTBF vs. ambient temperature (junction ≈ ambient) . . . 5
Table 6 Document revision history . . . 5

Copyright © 2026 Alp Lab AB

1 Summary

This report gives the predicted reliability of the **E1M-X V2N System-on-Module** (Renesas RZ/V2N, **base variant — no on-module DeepX accelerator**) as **MTBF** and **FIT** (1 FIT = 1 failure per 10^9 device-hours). It is a **parts-count prediction** per **Telcordia SR-332 Issue 4**, summing the steady-state failure rate of the module's electrical components. It is an intrinsic, random-failure estimate for the useful-life region; it excludes infant mortality and end-of-life wear-out.

Note: **Headline — at the +55 °C operating reference (GF):** $\lambda \approx 2443$ FIT, giving an **MTBF of ≈ 409 000 hours**, equivalent to a **5-year field survival of ≈ 89.9%** and a **10-year survival of ≈ 80.7%** under continuous 24/7 use. See Section 4 and the +25… +85 °C sweep in Section 5.

Reading this figure: **MTBF is a fleet statistical measure, not a service life.** 409 000 h does not mean a unit lasts 47 years; it means one intrinsic failure is expected per 409 000 cumulative operating hours across a fielded population — i.e. ≈ 102 failures per 1000 units over 5 years of 24/7 use. The figure reflects this module's high complexity (≈1180 parts, dual-PHY, multi-rail power, large memory).

V2N vs V2N-M1: This report covers the **base V2N**. The **V2N-M1** variant (DeepX DX-M1 populated) is covered by RL-V2NM1-001 and predicts ≈ 2842 FIT / ≈ 352 000 h at +55 °C — the DeepX accelerator and its dedicated LPDDR4X + PCIe-mux subsystem add ≈ 122 FIT.

1.1 Reference Condition

Parameter	Value
Prediction standard	Telcordia SR-332 Issue 4, Method I (parts count)
Environment	Ground Fixed, Controlled (GF)
Rated operating range	− 40 °C to +85 °C (industrial extended)
Headline operating ambient	+55 °C (representative loaded operating point)
Component-FIT build-up	+40 °C (Telcordia generic-device reference)
Duty cycle	100% (continuous, 24/7)
Component quality	Commercial, Quality Level II
Confidence level	50% (point estimate)

Table 1 Reference condition for the headline prediction

2 Method

The module failure rate is the series sum $\lambda_{\text{module}} = \sum_i n_i \cdot \lambda_i$ (any one part failing is a module failure; no on-module redundancy), and $\text{MTBF} = 1/\lambda_{\text{module}}$. The per-class FIT is tabulated at the **+40 °C** Telcordia reference (build-up ≈ 1087 FIT) and scaled to the **+55 °C** operating headline by $\pi_T \approx 2.25$ on the silicon subtotal (Section 5), giving ≈ 2443 FIT.

3 Failure-Rate Budget

The base module carries ≈ 1180 electrical placements. Silicon is ≈ 55% of the budget; the Renesas SoC is ≈ 11%. Values at the +40 °C Telcordia reference build-up.

Component class	Qty	FIT total	Share
Ceramic capacitors (MLCC)	810	324.4	29.8%

Copyright © 2026 Alp Lab AB

Component class	Qty	FIT total	Share
Application SoC (Renesas RZ/V2N) †	1	120.0	11.0%
DC-DC switching regulators	5	76.0	7.0%
Wi-Fi / BLE module (Murata) †	1	60.0	5.5%
Flash — eMMC / OSPI NOR / SPI NAND §	3	56.2	5.2%
Chip resistors	370	55.5	5.1%
Load switches	10	50.0	4.6%
Crystals	6	48.0	4.4%
Ethernet PHY (2 × GbE)	2	40.0	3.7%
LDO regulators	6	36.0	3.3%
Clocks / RTC	4	36.0	3.3%
Multi-output PMIC	1	25.0	2.3%
LPDDR4 DRAM (main) §	1	20.0	1.8%
CAN transceivers	2	20.0	1.8%
Ferrite beads	38	19.0	1.7%
Power inductors	19	19.0	1.7%
Board-to-board connector	1	15.0	1.4%
Companion MCU (GD32)	1	15.0	1.4%
EEPROM	2	12.0	1.1%
Secure element	1	7.0	0.6%
Other (level shifter, LED drv, temp, buffer, TVS, supercap, RF conn)	9	32.5	3.0%
Total	**~ 1180**	**≈ 1087**	**100%**

Table 2 E1M-X V2N failure-rate budget by class (+40 °C Telcordia reference)

Notes: † engineering estimate pending vendor reliability report (Renesas SoC, Murata Wi-Fi module). **§** chi-square 60% upper confidence limit from the JEDEC JESD47 HTOL qualification, accelerated to +40 °C with $E_a = 0.7$ eV (memory). The DeepX accelerator and its dedicated LPDDR4X / PCIe muxes are **not** fitted on the base V2N. Shares may not sum to 100% due to rounding.

4 Results

Metric	Value
Total failure rate, λ	2443 FIT
MTBF	409 000 h
MTBF (years, continuous)	47 yr
Survival R(1 yr)	97.88%
Survival R(3 yr)	93.78%
Survival R(5 yr)	89.85%
Survival R(10 yr)	80.74%

Table 3 Predicted reliability at the +55 °C operating headline (GF)

Copyright © 2026 Alp Lab AB

Mission time	Survival R(t)	Fails / 1000 units
1 year	97.88%	≈ 21.2
3 years	93.78%	≈ 62.2
5 years	89.85%	≈ 101.5
10 years	80.74%	≈ 192.6

Table 4 Expected intrinsic failures per 1000 fielded units (24/7, +55 °C)

5 Temperature & Environment Sensitivity

The silicon subtotal scales by $\pi_T = \exp\left[\frac{E_a}{k}(1/T_{\text{ref}} - 1/T)\right]$ with a generic $E_a = 0.7$ eV; passives, crystals, connectors and the PCB are held roughly constant. Each row assumes junctions track ambient; under heavy load the junctions self-heat above ambient, so the hot-corner rows are **ambient-only** and optimistic until the thermal solution is folded in.

Ambient	π_T	λ (FIT)	MTBF (h)	MTBF (yr)	R(5 yr)
+25 °C	0.27	652	1 534 000	175	97.2%
+40 °C †	1.00	1087	920 000	105	95.4%
+55 °C *	3.27	2443	409 000	47	89.9%
+70 °C	9.66	6249	160 000	18	76.0%
+85 °C ‡	26.0	15 006	66 600	8	51.7%

Table 5 MTBF vs. ambient temperature (junction ≈ ambient)

* Headline operating point. † +40 °C Telcordia build-up reference. ‡ Rated maximum ambient.

The Renesas SoC and the multi-rail power section are the hottest parts and dominate the temperature sensitivity — thermal design there is the highest-leverage reliability action for the integrator.

6 Assumptions & Limitations

1. **Parts-count (Method I)**, not parts-stress — accepted at the design/datasheet stage and typically conservative for a derated design.
2. **Series reliability** — no on-module redundancy credited.
3. **Mixed FIT provenance.** Renesas SoC and the Murata Wi-Fi module (†) are engineering estimates pending vendor data; memory FITs (§) are conservative JEDEC-qual chi-square bounds.
4. **Base variant** — the DeepX subsystem is excluded; see RL-V2NM1-001 for the M1.
5. **Excludes** solder-joint thermal fatigue, infant mortality, end-of-life wear-out.
6. **Point estimate at 50% confidence.**

7 Revision History

Revision	Changes	Date
0.1	• Initial parts-count MTBF prediction (Telcordia SR-332 Issue 4) from the released E1M-X V2N netlist (base variant, DeepX subsystem excluded). • Renesas SoC and Wi-Fi module on engineering estimates; memory on JEDEC-qual chi-square bounds.	June 2026
0.2	• Release history: every entry formatted as a bullet list.	October 2026
0.3	• Table of Contents: each entry links to its section; the front-matter lists are set tighter.	October 2026

Copyright © 2026 Alp Lab AB

Revision	Changes	Date
0.4	• Product name on page 1 links to the product page on alplab.ai.	November 2026

Table 6 Document revision history

Copyright © 2026 Alp Lab AB