

**Why Missiles Fail: A Review of Built-In Test (BIT),
Automatic Test Equipment (ATE),
Wireless Health Tag Test (HT)**

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1. Overview

Missile failures are rarely attributable to a single cause. They are almost always the result of component-level damage, degradation, or interaction effects that manifest under extreme environments (shock, vibration, thermal gradients, EMI, and time-dependent aging).



Table 1 lists Mission Failure Rates for three ground-to-air missiles from 6% to a high of 25%. The launch failure rates are much lower, from 2% to a high of 4%, this is an important difference.

Figure 1: Example of a BIT tested US Navy failed missile launch.

Table 1 Mission success and failure rates (order-of-magnitude, unclassified)				
Missile	Mission success rate	Estimated launch-phase failure rate	Mission failure rate	Key drivers of failure
SM-2	~85–92%	~1–2%	~8–15%	Target maneuvering, clutter, seeker/illumination issues, end-game fuzing
SM-3	~75–85%	~2–4%	~15–25%	Multi-stage boost timing, divert/kill-vehicle guidance, test geometry
SM-6	~88–94%	~1–2%	~6–12%	Complex engagement envelopes (Aegis BMD / NIFC-CA), end-game discrimination

Table 2 below provides a brief, component-specific engineering-level breakdown of why missiles fail, with emphasis on what physically goes wrong and which parts are implicated.

Current missile failure protection is detected prior to launch with **Built-In Test (BIT)** at the launch site and other static points in life of the missile. The overarching purpose of BIT is twofold: mission assurance – ensuring the weapon functions properly when needed – and fault isolation – pinpointing subsystem failures so they can be addressed. By automatically diagnosing its own hardware, a missile’s BIT can isolate a fault to a specific module or line-replaceable unit, aiding technicians in repairs and preventing unreliable missiles from being deployed by identifying defective components prior to launch.

In addition, the missile may be tested with external **Automatic Test Equipment (ATE)**. ATE for missiles refers to the external, ground-based test systems used to verify missile health, configuration, and readiness during manufacturing, depot maintenance, shipboard or squadron operations, and pre-launch preparation. BIT and ATE do not store shock or vibration data or any log; they simply represent a snapshot of the device and its ability to achieve Mission Success.

Summary Table 2 (Failure vs Component)	
Failure Type	Typical Root Component
Launch failure	Igniter, battery, SRM, Motor
Missed target	IMU, seeker, GPS, INS
Loss of control	Actuators, FCC, Motor
No detonation	Fuze, S&A device
Mid-flight shutdown	Power system
Erratic behavior	Structural wiring, MEMS, Motor

Finally, the third test is a **Prognostic Health Maintenance (PHM)** detector test tag, or often simply called a **Health Tag (HT)** (see 1-12 references). The major difference between BIT and ATE and the Health Tag is that the HT is not connected to any of the missile’s internal systems, has its own battery, with independent sensors that may include shock vibration, temperature, humidity and pressure, memory for a data log,. The HT has a twenty-year service life and an inductive IEEE 1902.1 (see 2,9&10) data link that can penetrate both the containment vessel and the missile shell. It is certified as safe near fuzed ordnance and explosives (i.e. HERO and HERF Zero).

We summarize the differences of the three test modes below.

2. The Differences Between BIT, ATE, and HT.

2.1. BIT Answers:

“Is the weapon safe and functional right now?”

- Enforces safing and inhibits
- Stops operation if internal faults are detected
- Not designed to explain *why* a fault occurred

2.2. ATE Answers:

“Does the weapon meet all requirements at this maintenance event?”

- Comprehensive, scripted, auditable testing
- Deep fault isolation
- Snapshot in time — no visibility between tests
- External test equipment

2.3. Health Tag Answers:

“What risk happened since the last ATE or before prelaunch BIT?”

- Shock, vibration, thermal, humidity, and handling history
- Detects **unknown abuse**, latent damage precursors
- Enables targeted ATE instead of broad retest
- Does **not** declare readiness by itself
- Predicts damage not detectable by BIT or ATE (e.g. damaged rocket motor, damaged warhead, vibration-compromised electronics)

3. Why the Health Tag Is Additive (Not Redundant)

BIT and ATE are both event-based tests. The health tag is time-continuous from device birth to the final event. The Health Tag fills the largest diagnostic blind spot:

- Transport damage
- Handling shock
- Environmental exposure
- Chain-of-custody ambiguity
- Pick the best device, the one that is most likely to succeed

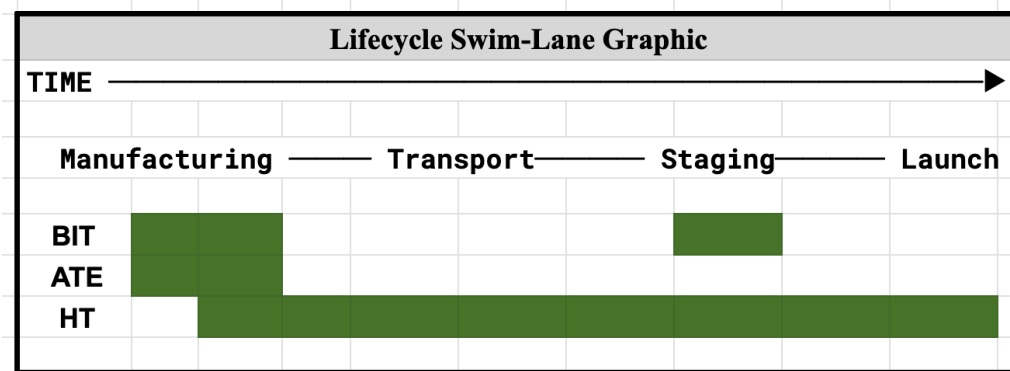
BIT and ATE say “pass/fail.” - Health Tag says “why at risk.

5. Executive Takeaway

BIT keeps the weapon safe, ATE proves it works, and the Health Tag proves it wasn't damaged in between. HT is a proxy for possible undetectable damage. The HT provides optimized kill chain logistics.

We provide a detailed summary in Table 3 below and a swim-lane graphic.

Table 3 BIT, ATE and HT Differences			
Dimension	BIT (Built-In Test)	ATE (Automatic Test Equipment)	Health Tag (Non-Invasive)
Physical location	Inside the weapon	External test station	External strap-on device or embedded
Connection to weapon	Direct electrical & software	Direct electrical via test interfaces	None (no electrical contact)
Primary purpose	Prevent unsafe operation; detect gross faults	Verify readiness; isolate faults	Capture condition history between tests, detect possible events that might disable.
When it runs	Power-up, pre-launch, during operation	Maintenance/turnaround	Continuous (storage, transport, handling)
Fault types detected best	Hard failures, unsafe states	Functional & parametric faults	Latent damage, abuse, and environmental stress
Depth of fault isolation	Shallow–medium	Deep (LRU/SRU-level)	None (contextual only)
Safety role	First line of defense (inhibits)	Certification gate	Evidence & forensics
False-removal reduction	Limited	Moderate	High (context eliminates NFF)
Data persistence	Usually volatile	Test records only	Long-term historical log
Cyber / safety exposure	Internal system risk	Controlled test environment	Isolated, non-interfering



6. References

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