



Test Like You Fly: **A Risk Management Approach**

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Failing to *Test Like You Fly*

- Post-mortem analyses of failed missions show violations of the Test Like You Fly approach to be significant contributors to loss of mission

VEHICLE	YEAR	EVIDENCE	TLYF VIOLATION	RESULT
Titan CT-2 Launch	1990	Miswiring prevented satellite separation; Ground test using non-flight software did not identify the problem.	Test <u>What</u> You Fly	Loss of Mission
ESEX Payload	1999	Exploded in space after leaking battery electrolyte caused short circuit; Battery qualified in non-flight condition.	Test <u>Like</u> You Fly	Loss of Mission
Mars Polar Lander	1999	Faulty touchdown sensor logic caused vehicle to crash; Test not rerun with hardware and software after modification.	Test <u>Like</u> You Fly	Loss of Mission
Mars Climate Observer	1999	English-Metric units error crept into modified software; Being deemed non-critical, was never tested.	Test <u>Like</u> You Fly	Loss of Mission
WIRE	1999	Start-up transient in pyrocontroller caused premature telescope cover deployment allowing coolant to escape; GSE power supply hid the problem.	Test <u>What</u> You Fly	Loss of Mission
TERRIERS	1999	Torquer coil installed upside down; Hardware and software never tested together.	Test <u>Like</u> You Fly	Loss of Mission
Milstar 2-F1 Launch	1999	Improper filter coefficient loaded into flight software; No validation of filter constants actually flown.	Test <u>What</u> You Fly	Loss of Mission
Genesis Return Capsule	2004	Four deceleration switches installed backwards causing parachute failure; Never tested in flight configuration.	Test <u>Like</u> You Fly	Significant Loss of Science Product

Failing to *Test Like You Fly*

- **WIRE (1999)** A start-up transient in the pyrocontroller prematurely opened the telescope cover
 - Slow rise time ground power supply used in test hid the problem
 - Result: Loss of mission
- **Milstar 3 (II-2, 1999) Launch:** A single digital filter coefficient in flight software that conditions a rate gyro signal was incorrectly entered
 - Preflight testing used simulated rate gyro data
 - Incorrect orbit
 - Result: Loss of mission



Photo courtesy of JPL/NASA

Failing to *Test Like You Fly*

- **Mars Climate Observer (1999):**
English-metric units error in software
 - Deemed non-critical & not thoroughly tested after modification
 - Result: Loss of mission
- **Genesis Solar Wind Sampling Mission (2004)**
 - Four deceleration G-switches installed backwards; never tested in flight configuration
 - Crashed in Utah desert after parafoil deployment failure
 - Result: Loss of most mission science product



Photo courtesy of JPL/NASA



Photos courtesy of SpaceDaily

Test Like You Fly Approach

- **PRIME DIRECTIVE:** Do not perform mission critical operations for the first time during the mission
- Recommended method for verification, validation and risk decision making based on lessons learned from catastrophic anomalies
- **DEFINITION:** *TL YF* is an approach that examines **all applicable flight characteristics** and determines the **fullest practical extent** to which those characteristics can be applied in test
 - **Concurrent attributes including environments, flight sequences & timelines, commanded operations, activity order & timing, up/down linked telemetry, data product generation, end user services**
 - **Identifies the physical and engineering limitations, and balances what can and cannot be done in a flight-like manner with risk and resources**



Test Like You Fly – An Approach Without a Criteria

- **Not all test organizations or personnel acknowledge the *Test Like You Fly* approach**
- ***Test Like You Fly* requires that non-test people (payload experts, technical specialists, etc.) must be involved in test planning/execution and they may be unfamiliar with the concept**
- **Acceptance may be difficult if resources associated with performing flight-like tests are significant and not identified in early planning**
 - **It may be difficult to insert *TL YF* activities into an extant program**
- **No industry or national standards for *TL YF***



Typical Objections to *Test Like You Fly*

- We can't do it (all), like we fly (so there's no point in doing any of it).
- We don't have the time.
- We'll test it on the vehicle simulator.
- We are testing like we fly. We send flight commands and look at flight telemetry. What else is there?
- We never let operations people run tests on the vehicle in the factory. It's too dangerous.
- It's not on contract.
- It's too difficult.
- It's (fill in the blank).

“....a flight failure in space is seldom cost effective.”

MIL-HDBK-343

Test Like You Fly Terms May Cause Confusion

- Test Like/As/What You Fly
- Fly As You Test
- Fly What You Test
- Days/Weeks/Months in the Life Tests
- Mission-Like Tests
- Mission Simulation Tests
- **Compatibility Tests (Not TLYF)**

Problem: TLYF means different things to different people.

Test WHAT You Fly

- Early tests do not substitute for testing the actual flight hardware and software
- Catastrophic failures have occurred due to lack of retest after a fix or configuration change
- Any unit, or flight software element, that has been changed is not the same as it was before the change
- We fly more than hardware and software
 - This is also about people and processes

Test what you fly.

Test Like You Fly As a Validation Process

- Requirements verification and functional and performance testing may no longer be enough to assure mission success
 - Functional & performance testing typically not done Like You Fly
 - Requirements flowdown may rest on poor or false assumptions
 - The flowdown process may assume ideal conditions when allocating performance characteristics
- *TL YF* approach is not vulnerable to these limitations and assumptions

You are going to Test Like You Fly.

Test Like You Fly is About Risk Reduction

- **Step 1:** Identify where you do not plan to *Test Like You Fly*
 - Develop *Test Like You Fly* exceptions list
 - You've got to manage what you don't do
- **TL YF Exceptions Arise from**
 - Physics (can't be done)
 - Engineering (not practical to do without compromising the results)
 - Programmatic issues (philosophy, cost, schedule or other constraints)

RISK

The risk issue is not what's done that is flight-like, but what is not flight-like.



Test Like You Fly is About Risk Reduction

- **Step 2:** Assess the risks of not testing like you fly
 - Identify risks associated with any *TLYF* exception
 - What is the risk and impact of missing a mission degrading anomaly if the exception is maintained?
- **Step 3:** If the risk is loss of mission or capability, another reasonable verification option must be defined
 - Identify necessary risk mitigating options
 - Additional or modified tests, additional analyses



Test Like You Fly is About Risk Reduction

- **Step 4:** Internal risk assessment performed by the program
- **Step 5:** External risk assessment performed by an independent and cognizant authority
- **Step 6:** Perform a best value assessment of the *TL YF* options
- Risks identified for *TL YF* exceptions should be managed with other program risks

Test Like You Fly Exceptions

RISK ASSESSMENTS			RISK MITIGATION OPTION
TLYF EXCEPTION	INTERNAL	INDEPENDENT	
Days-in-the-Life tests are not included in the system level TV test.	Low	Medium	Include DITL test in TV test. Requires extra nine days of test.
Ground GSE is used to fire separation system in deployment test.	Low	High	Use flight ordnance controller to fire separation bolts.
Solar array acoustics test planned with arrays in deployed mode. Neglects launch loads in pre-loaded brackets.	Low	Medium	Run test with arrays in launch configuration.

Perform a best value assessment on the risk mitigation options.



Key Facets of *Test Like You Fly*

- **Configuration**
 - Units under test
 - End-to-End
 - Environment & stimuli
- **Timeline, duration and timing as for flight**
 - Flight commands planned / grouped / spaced / generated / executed / validated
 - Operations planned, ordered and timed
 - Telemetry generated, recorded, transmitted and evaluated
- **“Days in the Life”**
 - Exercise mission-like transactions between units, subsystems, digital hardware, signal generators and receivers, ground station assets, etc., at significant levels of integration according to flight timelines and timescales

Fly the mission on the ground.



Management Aspects of *Test Like You Fly*

- Resource demands to test in a flight-like manner must be assessed in the context of risk
- Resource demands to mitigate *TLYF* exceptions must also be assessed in the context of risk
- Exceptions to *TLYF* may have different perceived risks depending on the assessor
 - Arrange for independent review

TLYF process includes evaluation of both incremental and accumulated known risks.

Test Like You Fly Summary

- Methodical examination of tests that can and cannot be done in a flight-like manner is necessary to understand program risks
- Development of the *TL YF* Exceptions and associated risks leads to clear options to improve the overall test program
- Management of *TL YF* Exceptions risks brings them into proper decision-making focus
- This process is presently underway on several National Security Space programs

Coming to a theater near you!