



Raytheon



Test Readiness Review Overview

First Nations Launch 2020

Raytheon Missile Systems

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April 2, 2020

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Introduction

- Hometown: Shiprock, NM
- Tribe: $\frac{3}{4}$ Navajo, $\frac{1}{4}$ Apache
- Education:
 - B.S. Physics, Northern Arizona University, 2005
 - M.S. Systems Engineering, Johns Hopkins University, 2018
- Career:
 - Space Interceptors Integration and Verification department, Raytheon Missile Systems, Tucson, AZ
 - Development and qualification testing
 - Flight tests



FTG-11 launch of the trail interceptor at Vandenberg Air Force Base, CA March 25, 2019

Agenda

- Systems Engineering “V”
- Purpose of Test Readiness Review (TRR)

Systems Engineering "V"

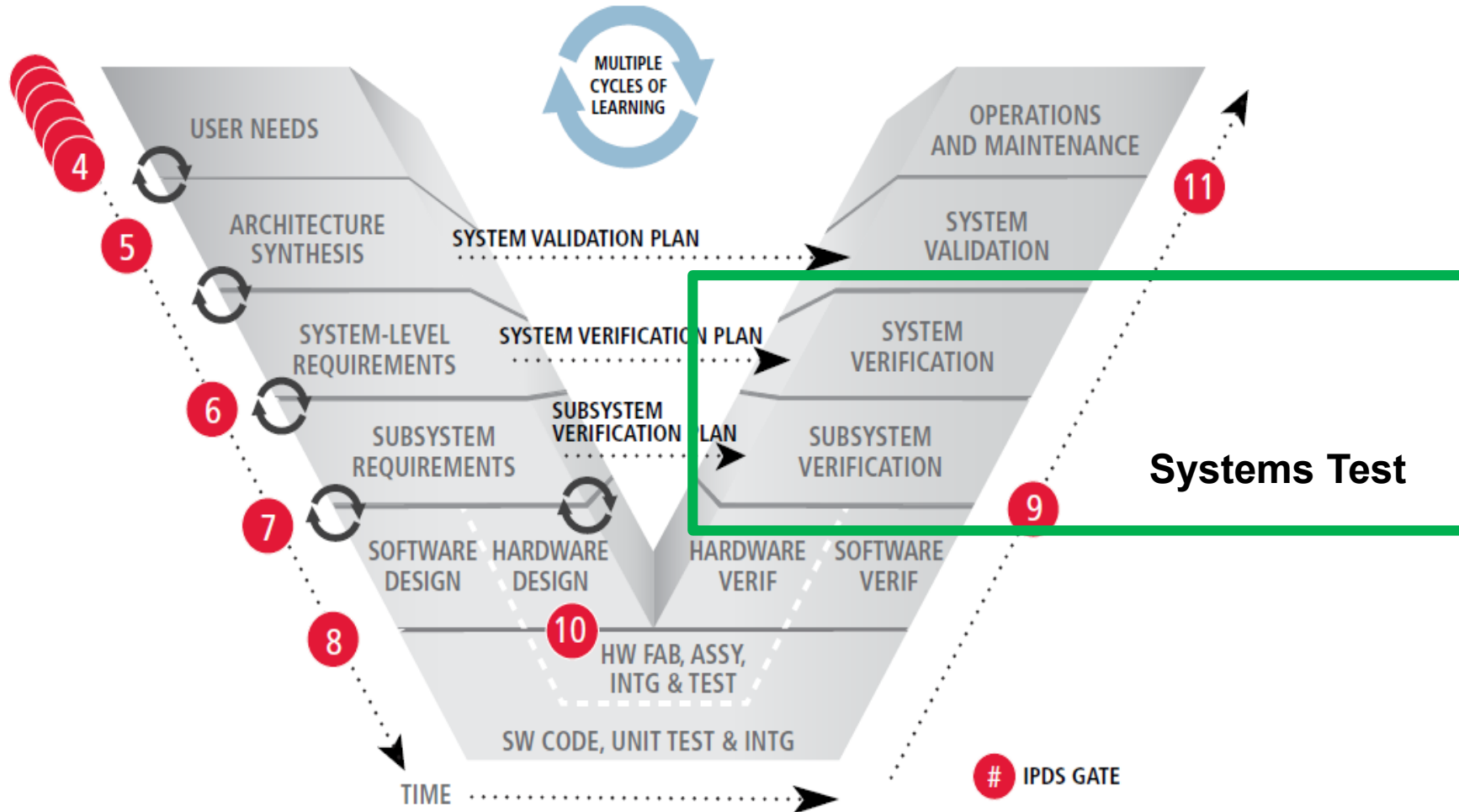


Image Ref. #1

Purpose of a Test Readiness Review

- Documentation for customer delivery
 - Known as a Contract Deliverable (CDRL)
- Ensures the team knows the purpose of the test and their roles
- Informs stakeholders the requirements that are being tested
- Reviews test objectives and success criteria
- Shows what is being tested
- Ensures opportunity for safety and quality to review test
- Stakeholders review and give approval to proceed

Test Readiness Review Topics

- Entrance Criteria
- Stakeholders
- Test Objectives
 - Success Criteria
- Unit Under Test Build & Configuration
- Integration & test run results
- Test flow
- Test Resources
 - Team
 - Facilities
 - Test Documentation
- Safety
- Risk & Mitigation
- Failure Protocol
- Watch Items



Entrance Criteria

- List of work that needs to be completed before entering TRR:

Example:

| Entrance Criteria | Slide # | |
|-------------------------|----------|---|
| Previous Actions Closed | 3 | ✓ |
| Test Flow | 9-11 | ✓ |
| Schedule Defined | 13 | ✓ |
| Dry Runs completed | 14,22,24 | ✓ |
| Check List completed | 29 | ✓ |

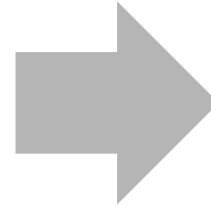
Met the Entrance Criteria to begin Test Readiness Review

Stakeholders

- Stakeholders are individuals, managers, leaders, and/or customers who are directly impacted by the execution and results of the test

Raytheon Stakeholders

- Chief Engineers
- Department Managers
- Engineering leaders
 - Systems engineering
 - Electrical & mechanical engineering
 - Software
- Safety
- Quality
- Mission Assurance
- Customers (i.e. US military, prime contractors)



FNL Stakeholders

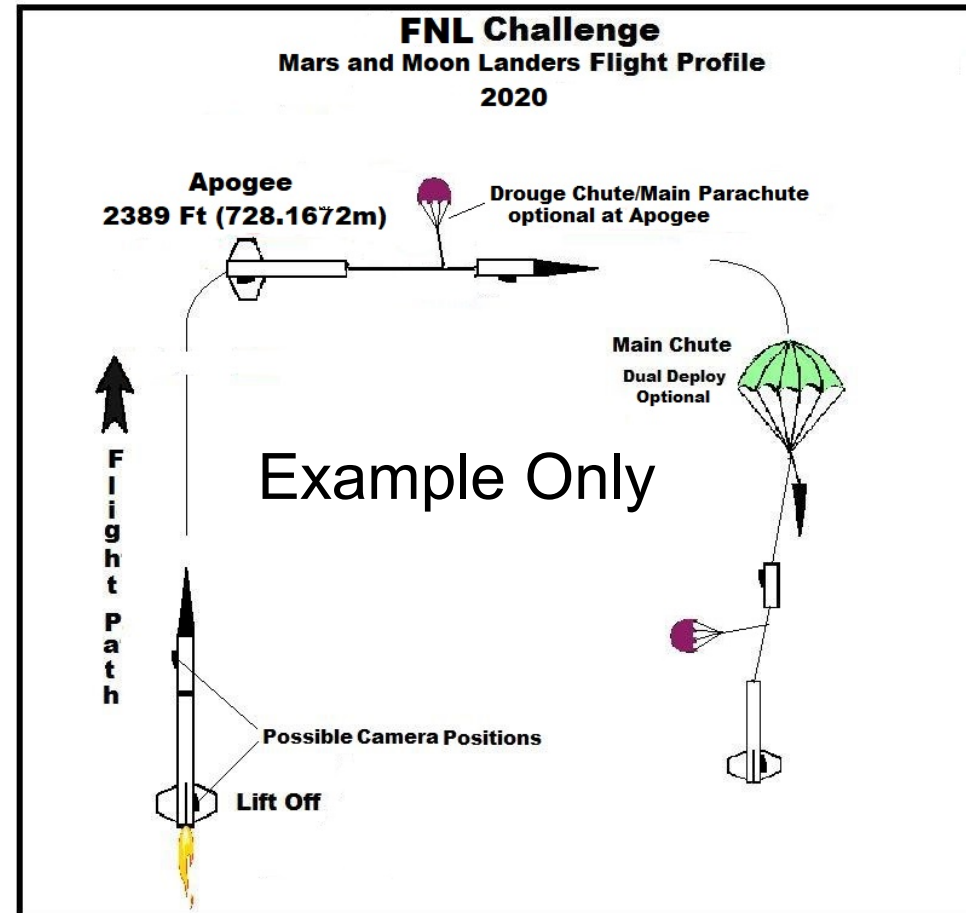
- Judges
- Mentors
- Student Leaders
- Team members
- FNL program
- Carthage College
- RSO
- Launch Director
- Tripoli

Test Objectives & Success Criteria

- A list of goals the test demonstrates and/or captures data to fulfill goal
 - Raytheon flight tests “Demonstrate missile’s capability to negate an incoming threat representative target”
 - FNL objectives (example)
 - Moon Challenge
 - Safe flight
 - Do not exceed 2,389 ft AGL apogee
 - Astronaut “raw egg” payload lands unharmed (not broken)
 - Mars Challenge
 - Safe flight
 - Do not exceed 2,389 ft AGL apogee
 - Deploy a Moon Lander Vehicle in an upright position
- Success Criteria: objective evidence that is collected, recorded to show that the test was successful (i.e. the goals were achieved)
 - Video/Photographic, numerical, recorded data (humidity, temperature, electrical), plots, correlation with simulation results

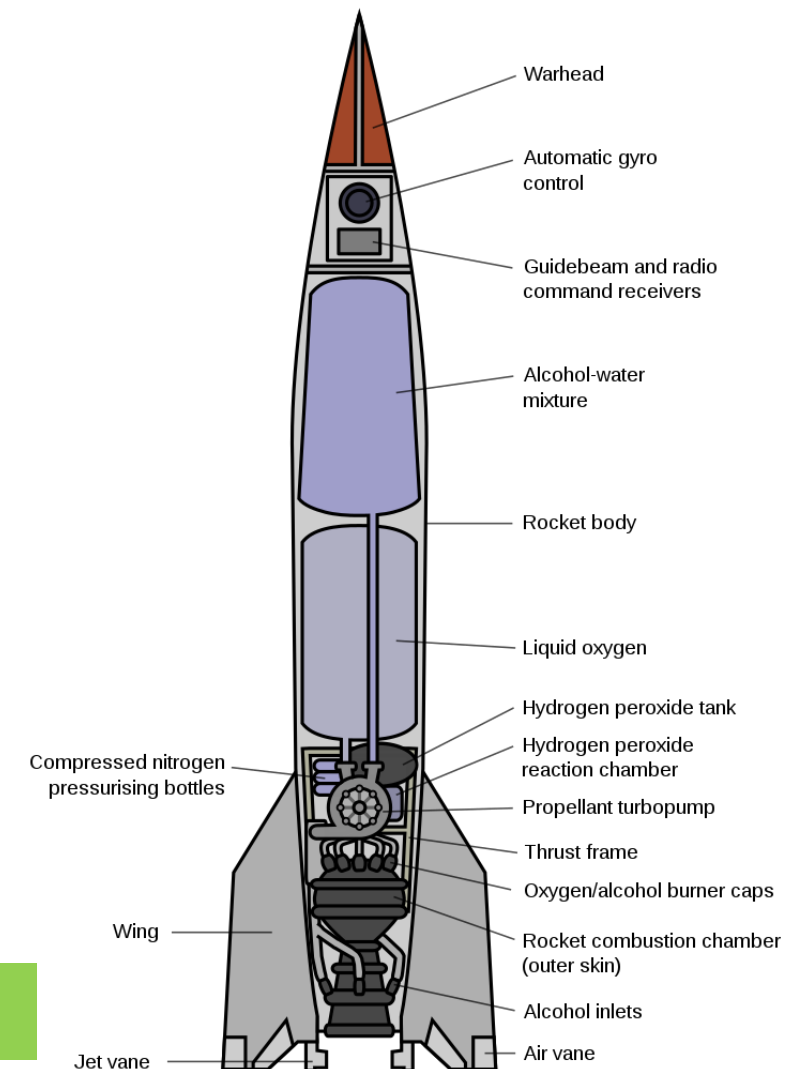
Test/Mission Timeline

- Show the timeline and major events of the test (rocket launch)
- Includes timing, expected results based off simulations or dry runs
 - Events: camera switches on, lander deploys, reaching apogee
- Define a T-0 to help with timing reference
 - Examples: rocket launch time, command to launch sent,



Unit Under Test Configuration

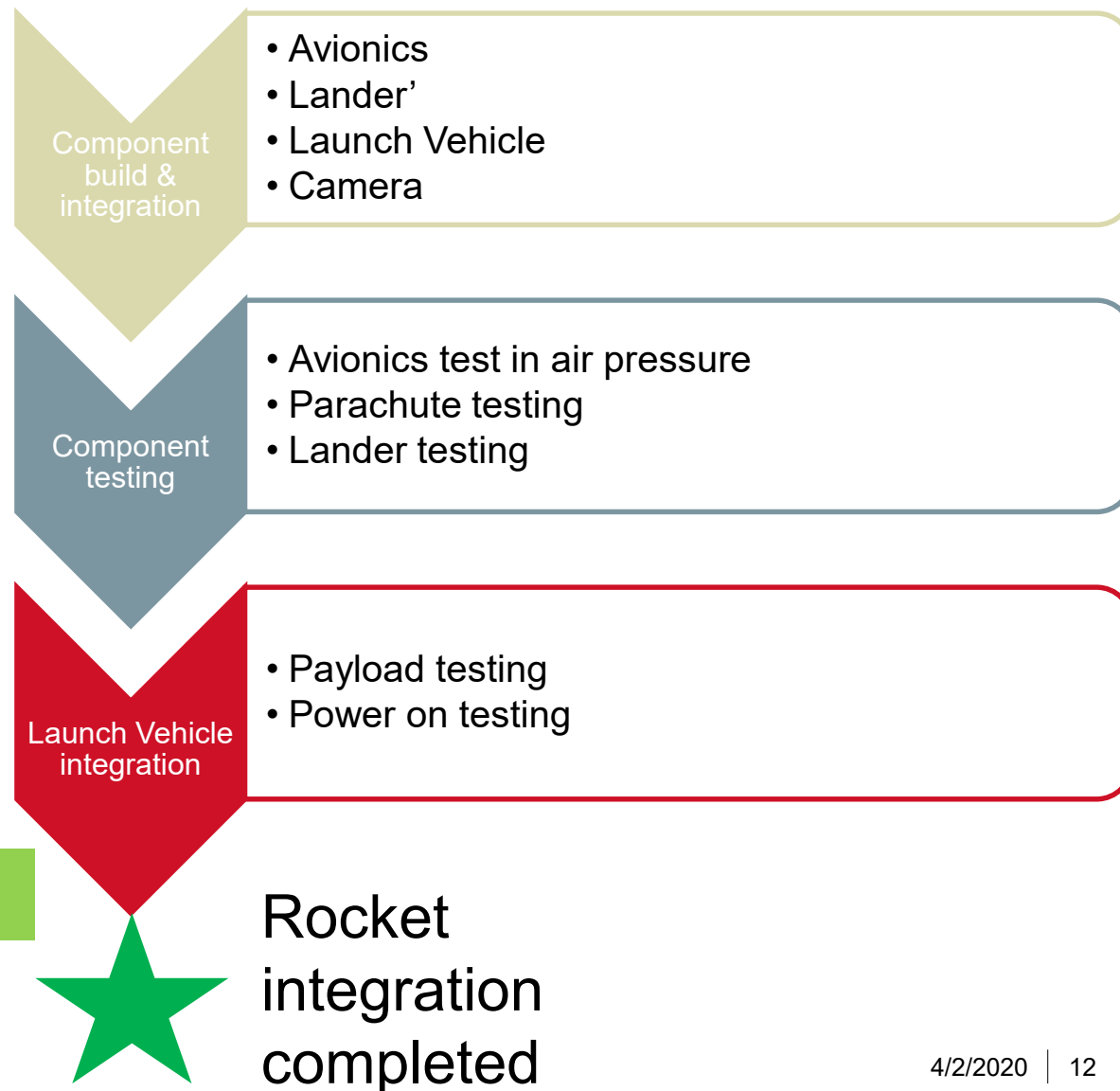
- Define the unit under test configuration
 - Raytheon: missile configuration
 - First Nations Launch: team's rocket and lander
- Final configuration
 - Rocket design changes should be none to minimal
 - Minimal changes may include:
 - Adding rocket motor
 - Adding batteries
 - Should not do major changes including:
 - changing out major components (i.e lander, parachute, data capturing devices)



Define what you are testing & launching

Integration & Test Run Results

- Integration and build results
 - Show the process used to build and integrate the UUT (rocket)
 - Review any changes made from CDR design
 - High-level
 - Review failures and resolutions during integration and build

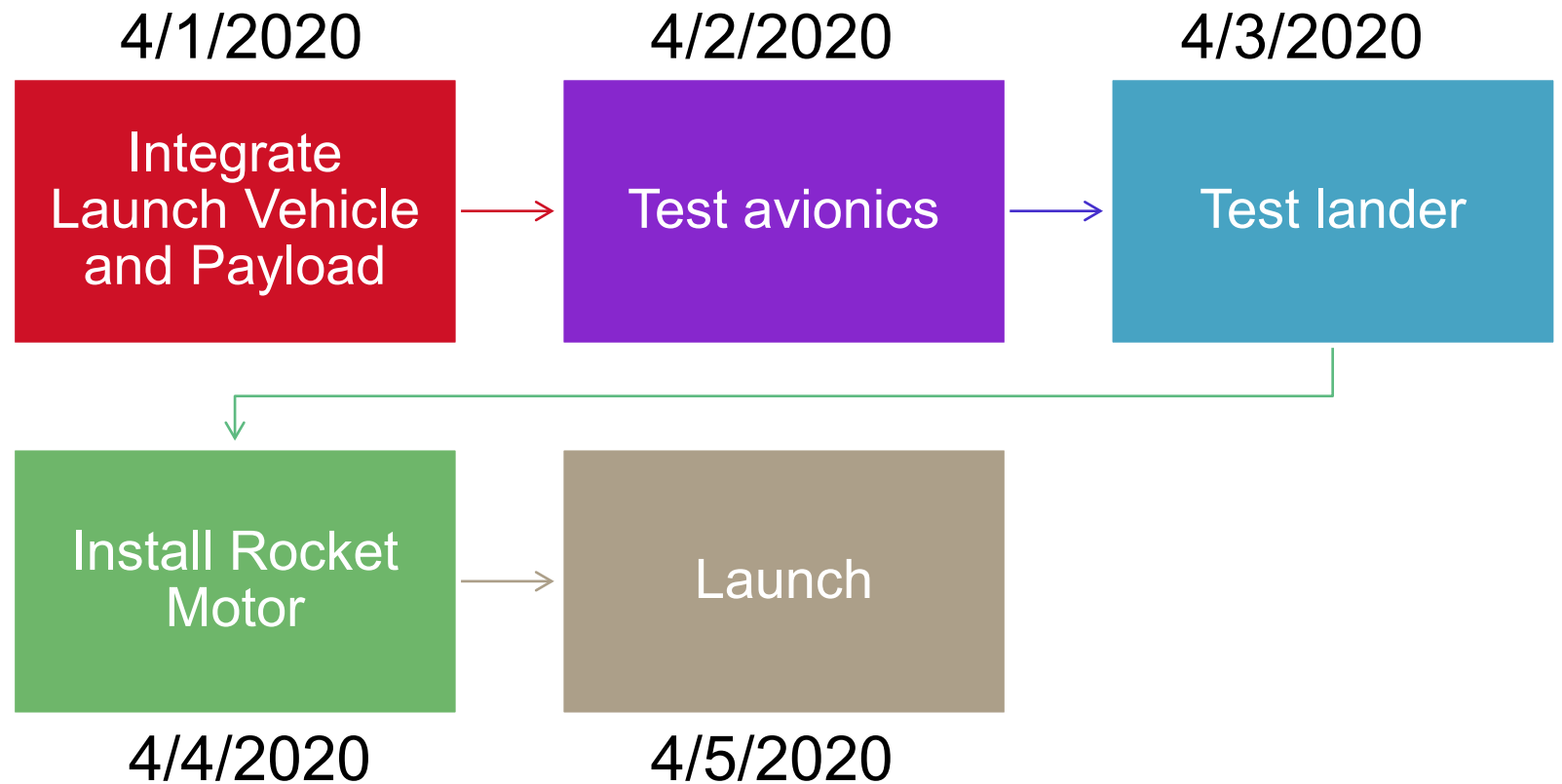


How you got to your current state?

Test Flow & Schedule

Test flow helps stakeholders know the plan forward after the TRR is completed

Helps also to inform the team the expected workflow and schedule



What is the plan to get to the test?

Test Resources

- **Launch Team**
 - Team Roles & function
 - Training completed
- **Test documentation**
 - Test procedure or checklists
 - Reports
 - Presentations
 - Pre-launch deliverables
- **Test facility readiness**
 - Coordination with FNL
 - Materials needed to support test

Launch Team

- Launch director
- Analysts
- Payload lead

Checklists

1. Packing list
2. Launch procedure
3. Review lists
4. Failure procedure

Safety

- Review hazardous activities
- Review procedures to mitigate hazardous activities
- Team member trainings
- Safety devices utilized



Safety is Paramount

Risk & Mitigation (Optional)

1. Launch Vehicle rocket motor fails to ignite

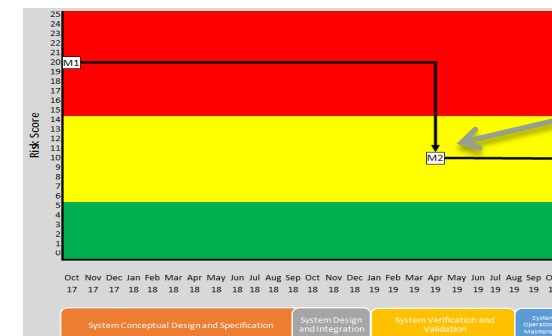
1. Team inspection & verification procedure

2. Parachute fails to deploy

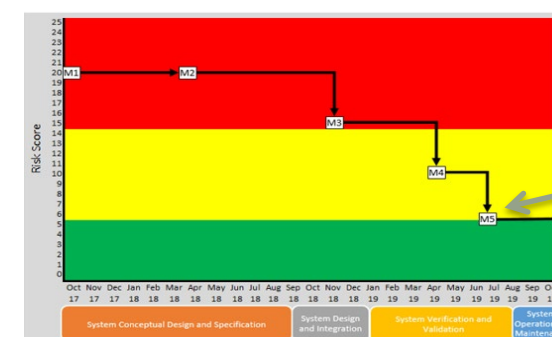
1. Testing parachute deployment before integration

3. Travel delays

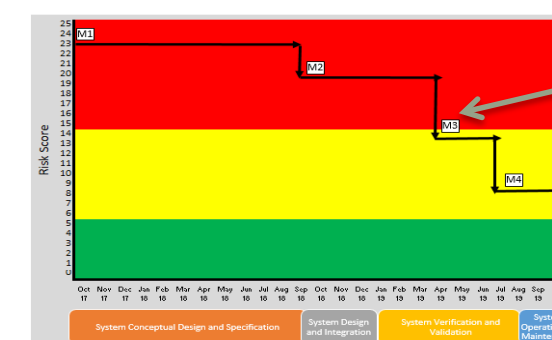
1. Back-up plans



Inspection

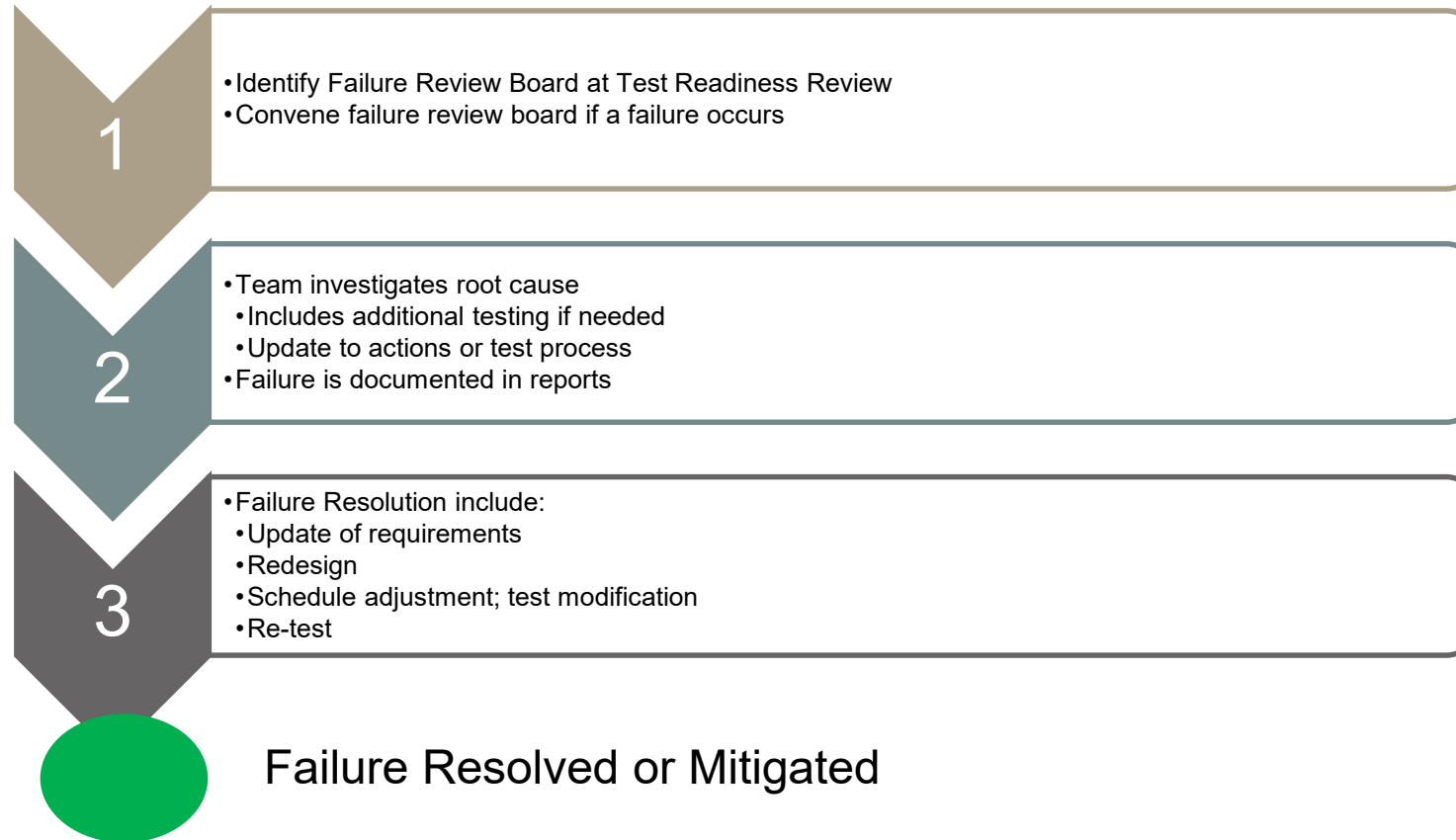


Deployment test



Alternate travel methods

Failure Protocol



Example

Failure Review Board

- Launch director
- RSO
- Mentor
- Tripoli
- FNL

What do you do if a failure occurs?

Watch Items

- Any items or issues that need to be resolved prior to test

- Can be include technical or programmatic
 - Funding
 - Rocket build
 - Team readiness

- Review any action items from last review

References

1. Nora Tgavalekos, Ph.D. “Career Growth Through the Engineering V”. *Raytheon Technology Today*, 2017. Issue 1. Pg 44. Electronic.
2. Raytheon Space & Airborne Instruction, EI-10-03 Rev F. 3/31/2017.

