Evolving Legacy DON Stabilized Small Arms Weapon Systems by Enhancing At-Sea Live-Fire Testing Without Using Water

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Outline/Agenda

- Background
- Historical Testing State
- Current Testing State
- Future Testing State
- Using objective data to improve weapon system reliability
  - Trend charts
  - Mean time between failure (MTBF) and mean time to repair (MTTR)

Background

- USN deploys stabilized small arms weapons mounts on many vessels
- We are always on the lookout for technologies to increase capabilities or reduce costs, so testing is constantly necessary
- Historically there was not a good technique to validate naval stabilized small arms weapon systems on land
  - Stabilization performance
  - Auto-tracking performance
  - Live fire (probability of hit)
- Several factors limit the usefulness of land-based testing
  - Weapon systems perform differently on land than at sea
  - Targets move differently on land than at sea
  - Vessels perform differently in different sea conditions
- At-sea testing is slow, unpredictable (weather, sea-state), expensive, and unrepeatable
- Objective data from the field is often not used to make system improvements

Why Test Away from the Ocean?

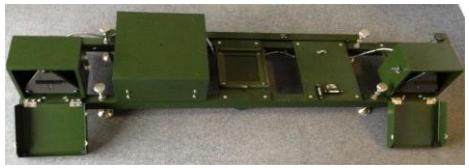
- At-sea testing is EXPENSIVE
  - Typical at-sea test is $250k
  - 1 day prep, 3 days at-sea testing, 1 day teardown
- At-sea testing is UNREPEATABLE
  - Sea state is constantly changing
  - No day on the sea is the same as another
- At-sea test scheduling is UNRELIABLE
  - Weather dependent
  - Scheduled tests can be bumped by higher-priority units
- At-sea testing is necessary before fielding, but it represents a high cost and schedule risk for testing new or developmental systems

Why Test Away from the Ocean?

Historical Test Setup at NSWC Crane

Land-based stationary tests with acoustic bullet sensor

NSWC Crane outdoor firing range



Acoustic bullet sensor

Advantages:

- Probability of hit
- Group size / dispersion
- General performance
- Ease of testing
- Very cost-effective

Disadvantages:

- Does not account for host vessel motion (unrealistic for naval environment!)
- Does not test electromechanical / software dependences
  - Gyroscopes / Sensors
  - Servos / Motors
  - Tracking while firing, lead angle
- Does not test for ease of operator use and situational awareness

Current Test Setup at NSWC Crane (FY17)

Land-based tests with motion platform and acoustic bullet sensor / MILES

- Mobile motion platform (6 degrees of freedom)
- Acoustic hit sensor (live fire)
- MILES equipment (blank ammunition)

Advantages:

- Moving weapon system with stationary target (more realistic for naval conditions)
- Provides probability of hit, group size, dispersion when using live rounds
- Provides hit response when using MILES laser system
- Provides repeatability in motion / sea-state
- Portable, can be easily moved from range to range

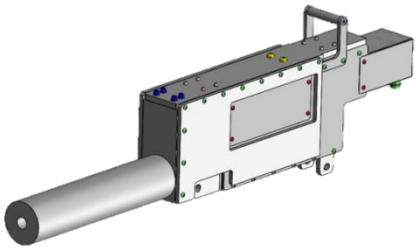
Disadvantages:

- Standard MILES equipment records hits without providing accuracy (one shot, one kill)
- Live fire with projectiles requires a large surface danger zone (large firing range necessary)
- Inaccurate recoil/counter-recoil forces when using blanks with MILES equipment
- Motion platform requires special mounting foundation and heavy forklift

Future Test Setup at NSWC Crane (FY18)

Land-based tests with motion platform and additional features

- Mobile motion platform
- Recoil simulator for accurate recoil/counter-recoil
- MILES transmitter with custom detector array



M2HB Recoil Simulator

Motion Platform

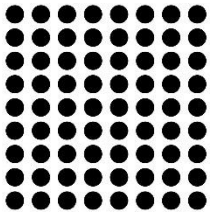
Advantages:

- Moving weapon system with stationary target
- Probability of hit, group size, dispersion
- Provides accuracy data with laser detector array
- Provides actual weapon recoil forces using recoil simulator
- Motion platform + recoil simulator
  + MILES transmitter + custom target sensor grid
  = **high-fidelity, non-ordnance testing operation**

MILES TVS Components

Disadvantages:

- Does not test for all naval scenarios (e.g., moving boat with moving target)
- No evaluation of optic/sensor performance at sea
- No sea-specific meteorological conditions (humidity, etc.)
- Difficult to test ease of use and situational awareness of operators



Custom laser detector array (notional)

Testing Cost Comparison

- Land-based testing (typ. $50k)
  - Five full days of testing
  - Motion platform with laser system and recoil simulator, or live-fire
  - Very few scheduling / planning / weather issues

- At-sea testing (typ. $250k)
  - Three days of actual testing, one day prep and one day teardown
  - Scheduling can be challenging
  - Weather / sea-state can easily derail the entire test

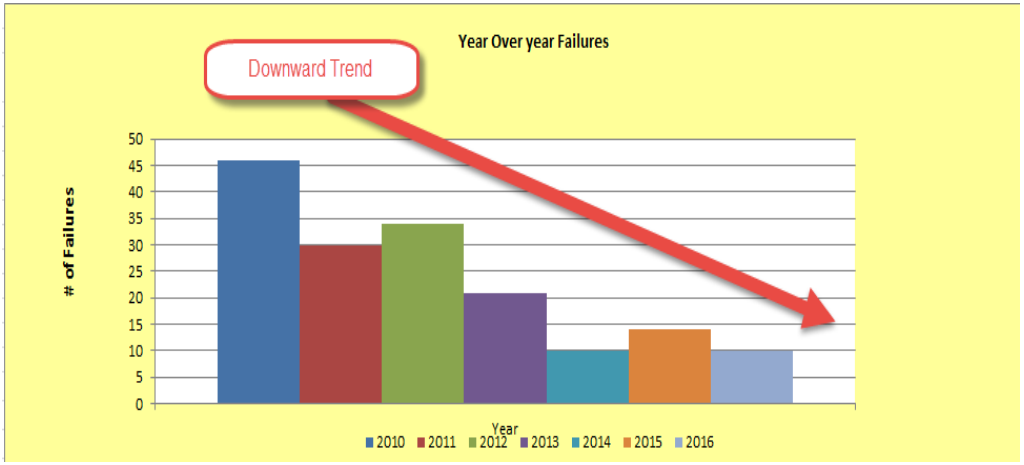
- By using the motion platform and other capabilities at Crane, a cost savings of $200k can be realized for a typical test.
- PM/PMS/PMA savings are significant and recurring.
- This testing is high-fidelity and suitable for new, developmental, or fielded systems.

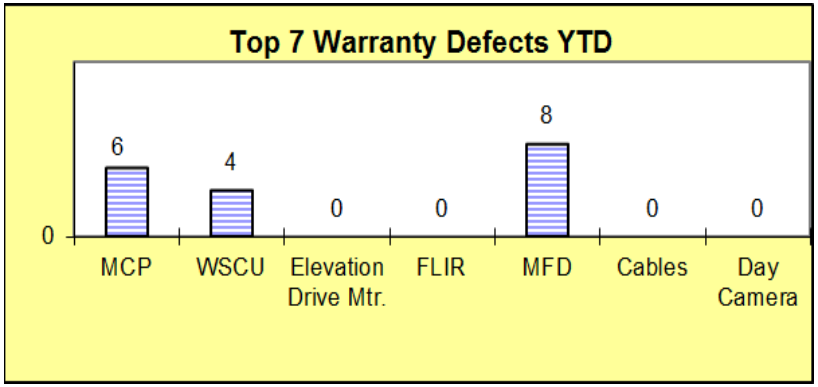
Quality Tracking

Leverage Baseline Data to Improve Reliability

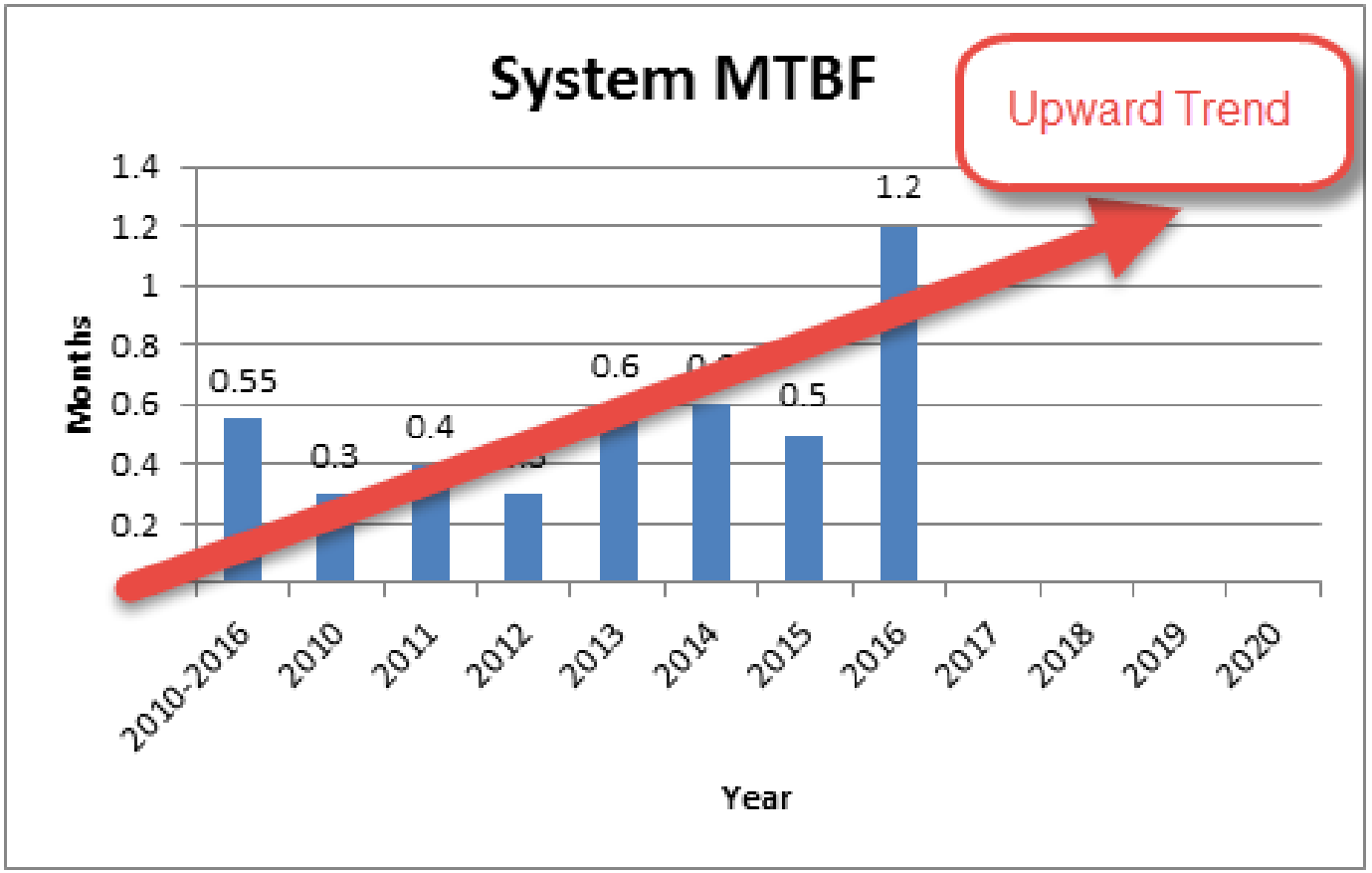
- Tracking failures
  - Identify leading failures
  - Identify root cause of failure, implement permanent corrective actions, validate
  - Mean time between failure (MTBF) and mean time to repair (MTTR)

Results of Leveraging Data and Implementing Corrective Actions





Results From Leveraging Data and Implementing Corrective Actions



Summary

- Historically, land-based testing techniques didn't always correlate to at-sea dynamic testing

- Current and future testing at NSWC Crane can simulate realistic at-sea conditions for live-fire small arms weapon mount testing

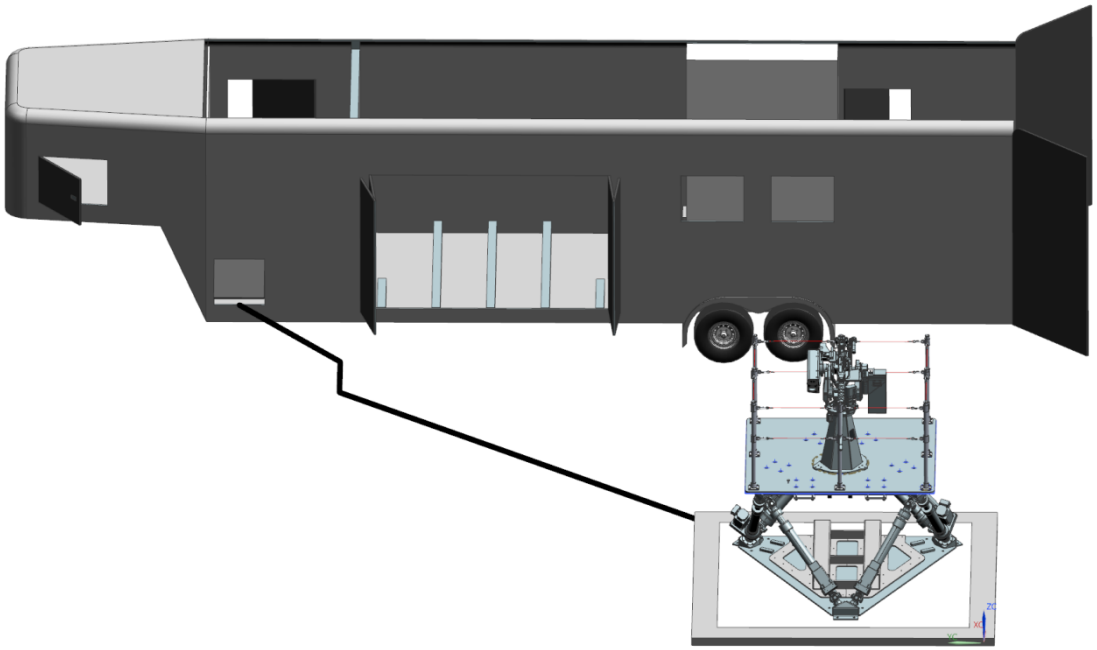
- Portable Motion Platform:
  - Provides relevant, repeatable testing scenarios
  - Is easy to use for testing dynamic weapon systems
  - Is considerably less expensive than at-sea testing

- Objective quality data can be used to successfully identify common failures, implement permanent corrective actions, and improve overall system reliability.

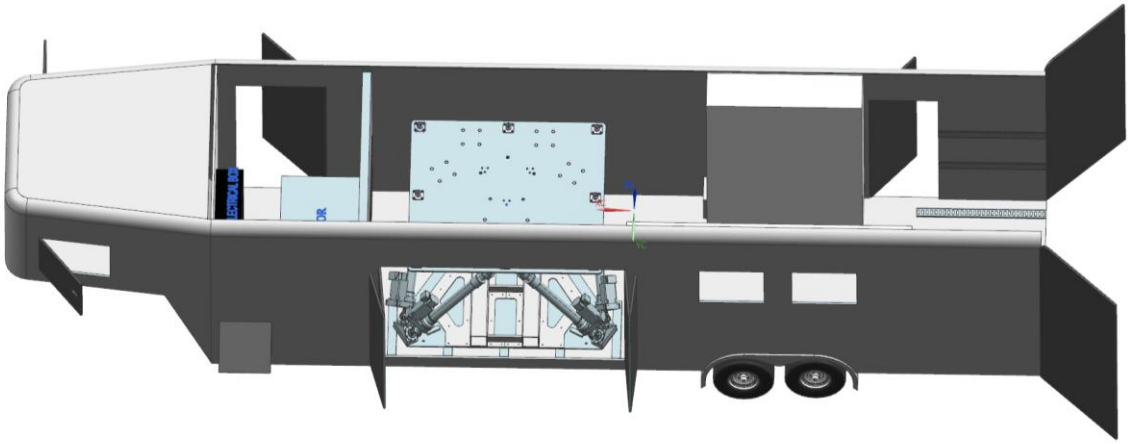
Questions ?

Backup Slides

Portable Motion Platform

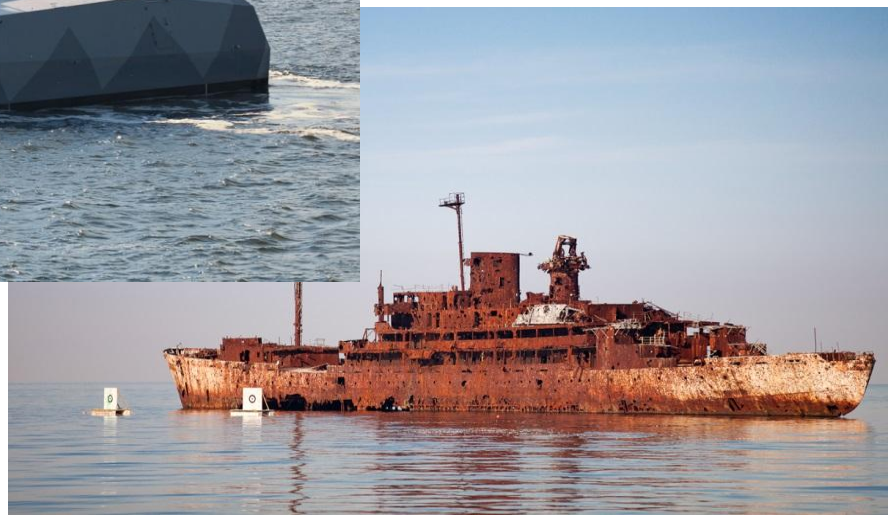


Deployed Configuration



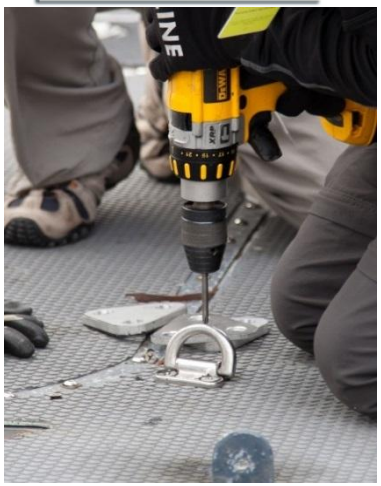
Stowed Configuration

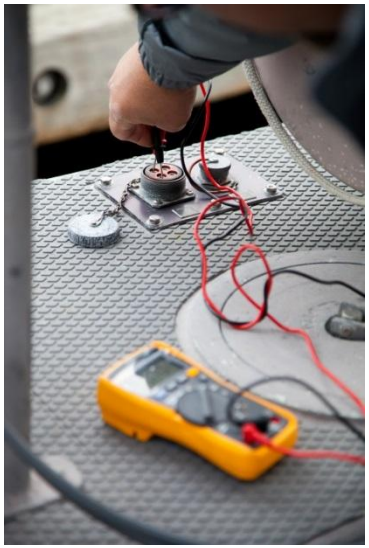
Test Platforms



Test Platforms (continued)

The Joys of At-Sea Testing





COTS 6DOF System and Parameters

Moog MB-E-6DOF/24/1800KG

- Payload: 3968 lbs (1800 kg)
- Actuator stroke: 24 inches
- All electric operation
- Fits within standard trailer width
- Moveable by heavy forklift

Maximum Excursion

	Single	Maximum
Surge	- 0.46 m/ + 0.57 m (-18.0 in/ + 22.0 in)	± 0.57 m (± 22.0 in)
Sway	± 0.46 m (± 18.0 in)	± 0.50 m (± 19.0 in)
Heave	± 0.39 m (± 15.0 in)	± 0.39 m (± 15.0 in)
Roll	± 23.0 °	± 24.0 °
Pitch	- 23.0 ° / +25.0 °	- 27.0 ° / + 31.0 °
Yaw	± 24.0 °	± 27.0 °

Maximum Velocity

Surge	± 0.70 m/s (± 28.0 in/s)
Sway	± 0.70 m/s (± 28.0 in/s)
Heave	± 0.55 m/s (± 22.0 in/s)
Roll	± 34.0 °/s
Pitch	± 35.0 °/s
Yaw	± 36.0 °/s

Maximum Acceleration

Surge	± 6.5 m/s² (± 0.65 g)
Sway	± 6.5 m/s² (± 0.65 g)
Heave	± 9.0 m/s² (± 0.90 g)
Roll	± 220 °/s²
Pitch	± 220 °/s²
Yaw	± 360 °/s²

Operational Requirements

- Mounting location
  - Nominally flat concrete pad (acceptable), min 10 ft x 10 ft
  - Concrete pad with 10ft x 10ft steel mounting plate (preferred)
  - Minimum pad weight is 3x max payload (about 12,000 lbs)
  - Concrete anchors or tapped holes must be installed in appropriate configuration (qty 12, can be match-drilled to lower plate or pre-drilled)
  - No overhead obstacles (awnings, roof overhangs, etc.) unless well above max operating envelope of platform plus test item

- Material Handling Equipment
  - Required to move motion platform from trailer to mounting location
  - Heavy fork truck (payload 6000lbs or more)
  - Long stakes preferred

- No on-site power requirements
  - Trailer houses diesel generator for motion platform and associated equipment
  - 120V 60Hz AC power available inside and outside trailer for test equipment
  - Lighting inside and outside trailer
  - Heat and A/C provided in trailer

Enhanced Testing Capabilities

- The goal of the Mobile Motion Platform project was to provide enhanced testing capabilities for stabilized platforms such as remote weapon stations or electro-optic gimbals in a cost-effective and repeatable manner.
- The Mobile Motion Platform System combines a medium-sized motion platform with a storage and transport trailer. Maximum motion platform payload is 3968 lbs (1800 kg).

Concept of Operations

- These are the primary steps in using the Outdoor 6DOF Motion Platform System:
- Motion platform and testing equipment are stored in trailer and transported to test range
- Motion platform is removed from trailer and mounted to pad at test range
- Device under test (DUT) is removed from trailer and mounted to upper plate on motion platform
- Motion platform and DUT are powered by trailer generator / transformer
- Test personnel control motion platform and DUT from trailer workstations during testing
- After testing, motion platform and DUT are returned to trailer and secured for transit

Pictures

System stowed
and ready for transport

Initial installation at NSWC Crane outdoor range

During integration at NSWC Crane
outdoor firing range