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2023 NSRP All Panel Meeting

The Center for Naval Shipbuilding and Advanced Manufacturing presents the Navy ManTech Project

S2899 – Virtual Load Out Interference Detection

(A collaboration effort between ONR, NSAM, GDEB, and GDBIW)

POP February 2021 – March 2023

Kyle Green – Bath Iron Works
John Lovezzola – Electric Boat
Scott Truitt – NSAM
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GENERAL DYNAMICS Bath Iron Works
GENERAL DYNAMICS Electric Boat
NAVY MANTECH Manufacturing Technology Program

Agenda

- Objectives
- Acknowledgements
- Background
- Benefits
- Results
- Issues/Workarounds

Objective

- **Provide a device with an augmented reality (AR) application that will identify interferences in the loadout path in real time, on the deck plates, prior to loadout.**
  - Enable better loadout planning by utilizing as-built conditions of the components and the compartments
  - Allowing the user to move a virtual object through the loadout path
  - Aiding the user in identifying objects in way of the loadout

- **This tool will reduce the learning curve associated with build-sequence planning of these load outs for new or heavily-revised platforms, such as the Columbia class submarines and FLTIII Arleigh Burke class ships.**

Acknowledgements

- **Project funding provided by the Office of Naval Research (ONR) Navy ManTech Program**
- **Navy ManTech program oversight provided by**
  - Paul Huang – ONR Program Officer
  - Scott Truitt – Center for Naval Shipbuilding and Advanced Manufacturing Project Manager
  - Ken Brill – Project Technical Representative
- **Bath Iron Works**
  - Kyle Green – Project Manager & Technical Lead
- **Electric Boat**
  - John Lovezzola – Project Manager
  - Heidi Preston – Technical Lead
- **Applied Physical Sciences**
  - Bill Wright – Technical Lead
  - Justin Borodinsky – Lead Developer

Background

- Planned or unplanned loadout/removal of shipbuilding materials is a highly manual effort that encourages conservative (re: excessive) rip-out and subsequent rework due to uncertainty about path clearance within the as-built shipboard conditions
- Rip-out and rework cause disruption and schedule delays
- Designed loadout/removal routes cannot account for manufacturing tolerances
- Misunderstood loadout/removal obstacles risks damage to costly, sensitive, and limited supply/long lead time components

Benefits

BIW

- Inaccurate volume estimates of rip out process
  - 20% reduction of labor
  - 20% reduction of cycle time
- Rework labor and materials required to repair needlessly ripped out material
  - 80% reduction of labor
  - 80% reduction of material
  - 67% reduction of cycle time
- Rework labor and materials required to replace damaged equipment
  - 75% reduction of labor
  - 75% reduction of material
- $1,610,000 savings over five years – ROI: 1.32
- Cycle Time Reduction: 7 days/hull

Benefits

EB

- Reduce VCS/VPM labor due to efficiencies gained by simulating the load path
  - 0.75% reduction of labor
- Reduce CLB labor due to efficiencies gained by simulating the load path
  - 0.75% reduction of labor
- $2,019,280 EROM savings over five years – ROI: 2.27

Technical Approach

Task Name	Start	Finish
(S2899) Virtual Load Out Interference Detection - 2022 08 01	Mon 2/1/21	Fri 3/31/23
Phase I	Mon 2/1/21	Mon 11/15/21
Task 1.0 - Program Management - Ph I	Mon 2/1/21	Mon 11/15/21
Task 2.0 - Current State Analysis and Technical Requirements	Mon 3/15/21	Fri 6/18/21
Task 3.0 - Design Solution	Mon 4/5/21	Fri 7/30/21
Task 4.0 - Go/No Go Review and Phase I Report	Fri 6/18/21	Fri 8/6/21
Phase II	Mon 11/15/21	Fri 3/31/23
Task 1.0 - Program Management - Ph II	Mon 11/15/21	Fri 3/31/23
Task 5.0 - Develop Solution	Mon 11/15/21	Fri 10/28/22
Task 6.0 - Test and Demonstrate Prototype Solution	Mon 9/5/22	Fri 3/3/23
Task 7.0 - Develop Final Business Case, Implementation & Business Plan	Mon 12/12/22	Fri 3/31/23

Technical Approach

- **Key tech/business process changes**
  - Loadout/Removal is requested
  - Rigger Lead examines loadout object
    - Scans it with VLO

    or

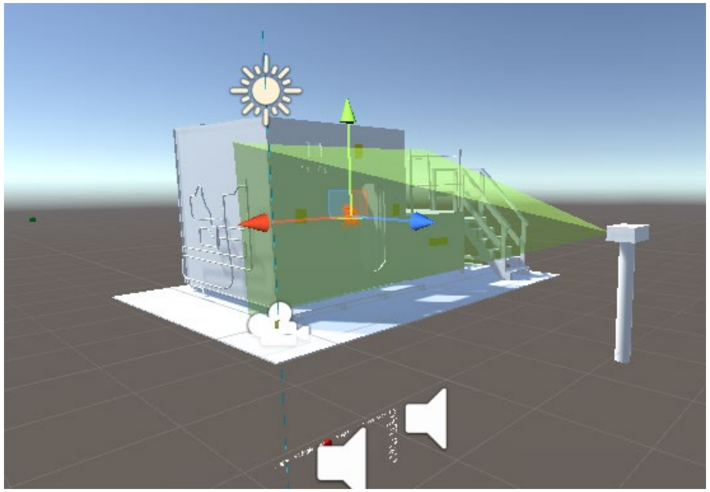
    - Imports CAD model
  - Rigger walks loadout path
    - Scans path with VLO
    - Selects tools in VLO
    - Simulates loadout in VLO
  - Rigger coordinates with other trades for rip-outs
    - Exports & screen captures from VLO
  - Riggers execute loadout

Technical Approach

- **Requirements Matrix**
  - System shall simulate loadout/removal of a ship's component into/out of a congested space using Augmented Reality (AR) technology.
  - System shall indicate collisions or near collisions of the component hologram with the as-built ship condition via color scale.
  - Simulations (environment, object, and created data) shall be savable/exportable.
  - System shall be capable of locking two objects together to move/rotate as one (e.g. equipment on a cart).
  - System shall be capable of creating a ghost path of the loadout/removal object.
  - System shall be capable of running in off-line mode (for security purposes).
  - System shall be able to import object geometry in 3DXML (BIW) and Beamer (EB) format.
  - System shall be manageable through VM AirWatch.

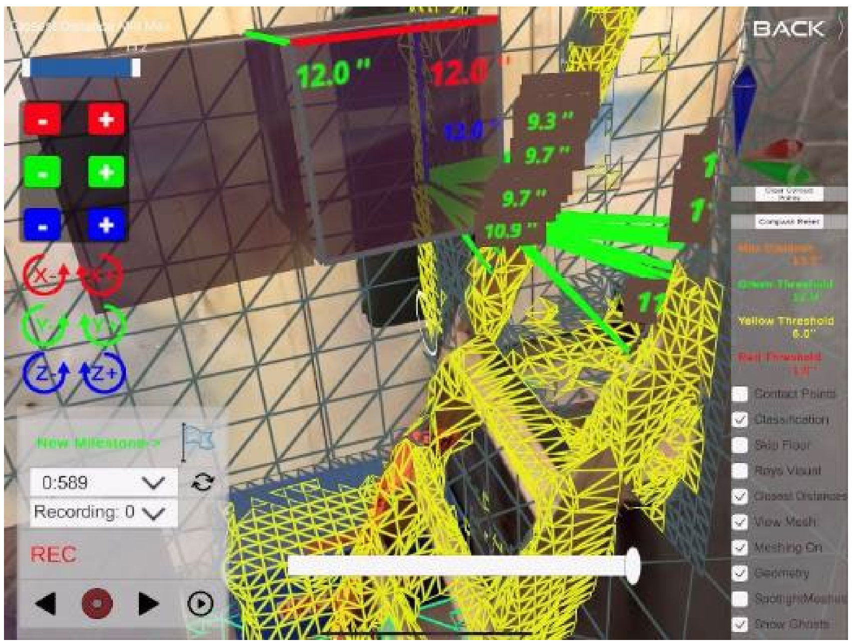
Technical Approach

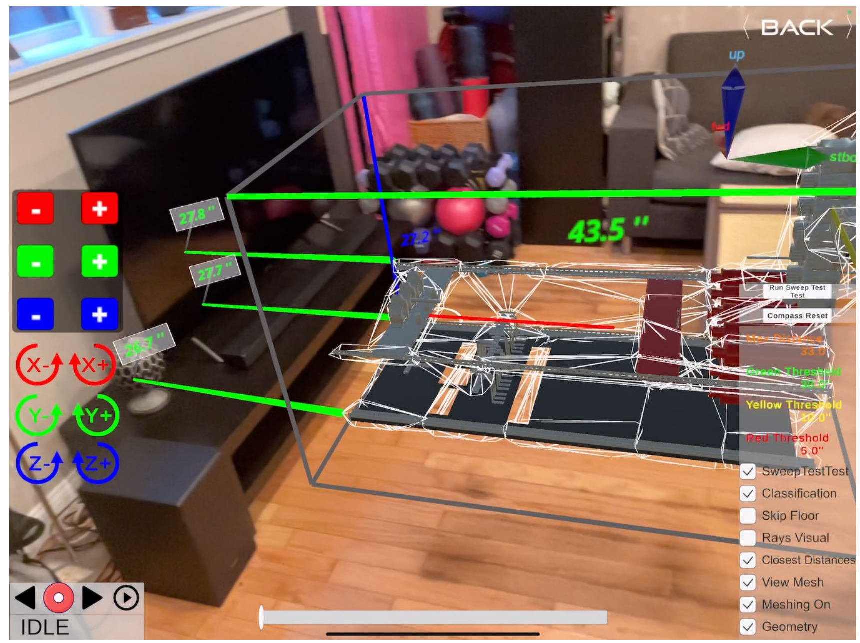
- **Leveraging existing or emerging technology**
  - ↗ 2021 iPad Pro is the foundation of this system
    - LIDAR sensor and new M1 processor
    - Apple guarantees but limits accuracy to 1cm (<1/2inch)
  - ↗ Unity engine and Apple's ARKit is the core of the software solution
  - ↗ EB examined IndoTraq
    - Not viable



Technical Approach

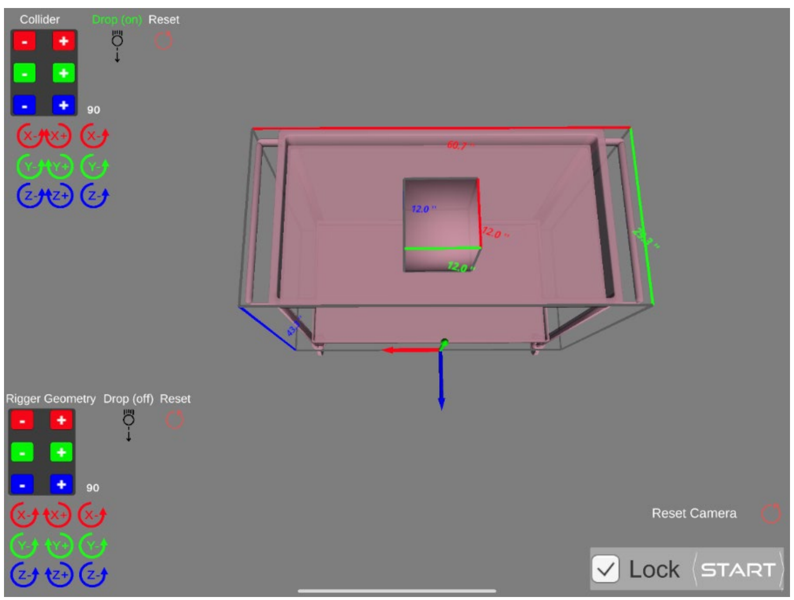
- **Iteration 1: Scan and generate environment mesh, insert, and manipulate test geometry**
- **Iteration 2: Set closest distance thresholds, show rays, indicate interferences, record sessions**

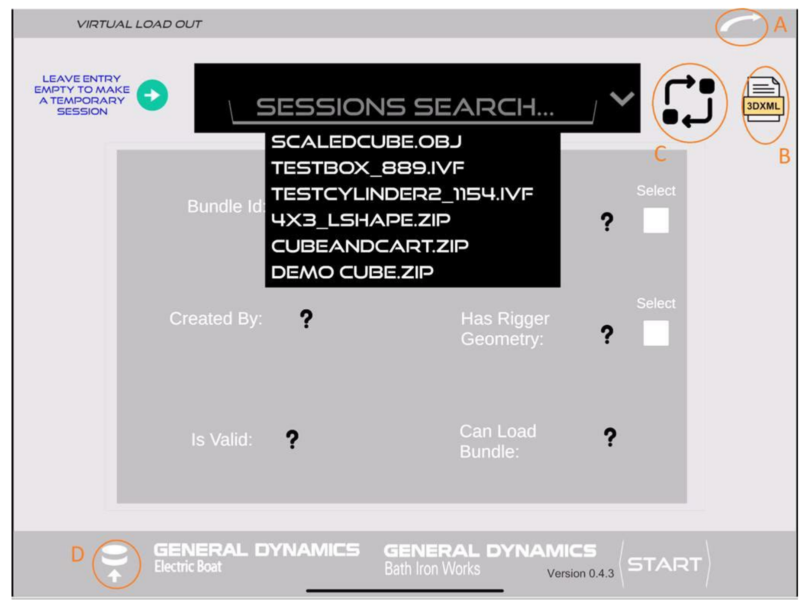




Technical Approach

- **Iteration 3: Reload existing session, select & insert rigger tools, save session bundle locally**
- **Iteration 4: Interface for uploading load-out geometries, rigger tools, and externally saved bundles from shipyard network**

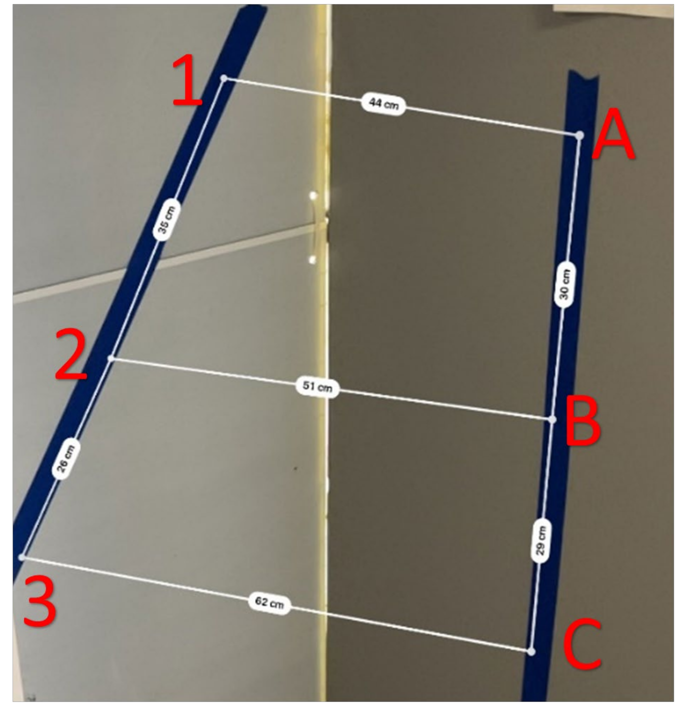




Technical Approach

- **iPad Pro Lidar Scan Accuracy Testing – consistent with published Apple test results**

Perpendicular Surfaces				
Segment	Control	Trial 1	Trial 2	Trial 3
A1	44	44	43	44
B2	51	51	53	52
C3	62	62	62	62
AB	30	30	31	30
BC	30	29	30	29
Units :	cm			



Measurement confirmation with 2 Devices

1cm accuracy constraint is ARKit default
Lab results consistent with 1cm accuracy
Optimal scan distance 10cm and 5m

Status

Project Status

- Solution developed in four iterations, per System Design and Development Plan
  - Iteration 1 – Delivered 04FEB
  - Iteration 2 – Delivered 29APR
  - Iteration 3 – Delivered 29AUG
  - Iteration 4 – Delivered 03NOV
    - BIW working with APS and BIWIT to troubleshoot failure to upload CAD geometries
- EB PMO project continues to evaluate security issues concerning iPad
- EB sent Rigger(s) to BIW in order to participate with testing in production environment

Status

- **Issues**
  - App loading on iOS devices at Electric Boat
    - EB requires a secure method to import model data onto iPad; EB IT is evaluating commercial 3d scanner for capturing collider geometry, which would obviate the need to do any imports
    - EB/ Navy requires two-factor authentication for hardware devices that house sensitive data; EB IT evaluating Yubikey hardware authentication device
    - iPad will operate in “offline mode”; mitigating EB IT Sec concerns.

Results

BIW 5yr ROI = 1.32

Total Investment: $693k

- ManTech invested: $451K + $158k (APS) = $609K
- BIW implementation: $84k
  - Documentation & Training: $10k
  - iPad Hardware: $4k
  - IT Support: $70k

Return $1.61M over 5yrs on DDG51 program:

- $268k per hull
  - $89k unnecessary rip out/reinstall labor
  - $179k replacing damaged material
- Improves delivery schedule 7 days per hull

$$ROI = \frac{RETURN - INVESTMENT}{INVESTMENT}$$

$$1.32 = \frac{(\$1,610,000 - \$693,000)}{\$693,000}$$

EB 5yr ROI = 2.27

Total Investment: $618k

- ManTech invested: $370K + $158k (APS) = $528k
- EB implementation: $90k
  - Documentation: $2.2k
  - Training: $7.8k
  - IT Support: $10k + $60k = $70k
  - HW: $10K

Return $2.02M (EROM) over 5yrs across both programs:

- $155k per VCS/VPM
- $186k per CLB

$$ROI = \frac{RETURN - INVESTMENT}{INVESTMENT}$$

$$2.27 = \frac{(\$2,019,280 - \$618,100)}{\$618,100}$$

Questions?

Integrating mixed reality technologies with as-built ship conditions and CAD product data to detect interferences in real time assessments of equipment load outs or removals to determine minimally necessary rip out requirements.

Project Number: S2899

Title: Virtual Load Out Interference Detection

Performing Activity: Naval Shipbuilding and Advanced Manufacturing Center (NSAM)

Objectives: Develop a device with an augmented reality application that will be used to identify interferences in the load out path in real time, on the deck plates prior to the load out process. The application will utilize a virtual object based on CAD models or a 3D scan of the load out equipment.

Start / End Dates: January 2021 – Mar 2023

Project Cost: $1,307K (ManTech + Implementation)

ManTech Investment: $1,137K

Weapon System: DDG-51 / VCS / CLB

Performing Entities:

- Navy ManTech – Program Oversight
- NSAM – Project Management / Technical Oversight
- PMS 397, 400, 450 – Project Oversight
- GDBIW – Project Co-Lead / Facility Support
- GDEB – Project Co-Lead / Facility Support

Technical Achievements:

Apr 21 **Kickoff Meeting**
Jun 21 **Current State Analysis & Technical Requirements**
Jul 21 **Technology Transition Plans**
Aug 21 **Design Solution**
Nov 22 **Develop Solution**
Mar 23 Test & Demonstrate Prototype Solution
Mar 23 Business Case, Implementation Plan, Final Report
Mar 23 Program Management

Implementation:

System: DDG-51 / VCS / CLB
Site: GDBIW – Bath, ME / GDEB – Quonset Point, RI
Status: Implementation anticipated Q2 FY24 BIW, Q2 FY24 EB

Cost
Schedule
Technical

Payoff:

- BIW saves $268k per hull:
  - $89k unnecessary rip out/reinstall labor
  - $179k replacing damaged equipment/structure
  - Improves delivery schedule 7 days per hull
  - BIW 5yr ROI = 1.34
- EB EROM savings of $2.02M over 5yrs across both programs:
  - $155k per VCS
  - $186k per CLB
  - EB 5yr ROI = 2.27 (Implementation: $90K est'd)

Project Team

Paul Huang– Program Officer

Robert Mashburn – Deputy Director
Scott Truitt – Project Manager
Mimi Vymola – Project Technical Representative

Steve Fuqua – PMS 397

Steve Godin
PMS 450

Lee Fuglestad – PMS 400D

Larry Becker – Orbis

Dave Hart – LCE

David Clark – CACI

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John Iraci – ManTech Program Manager
John Lovezzola – Project Manager
Heidi Preston – Tech Lead

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