S2978: Point Cloud Conversion to Detail Design

NSRP BT/SDMT 2025

Presenter: Ken Crowe

Bath Iron Works

August 2025

Prepared under ONR Contract N00014-19-D-7001 as part of the Navy ManTech Program
Approval Date: 07/29/2025

Agenda

- Overview
- Objectives
- Project Team
- Technical Goals
- Benefits/Pay Off
- Technical Approach
- Project Schedule
- Technical Content and Status
- Transition/Implementation Plan
- Q & A

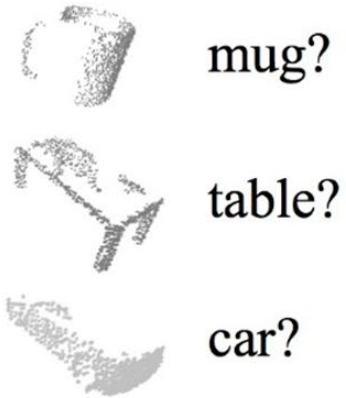
Overview

- Platform: DDG51

- Issue Description:
  - The majority of DDG51 hulls in service do not have 3D models. In order provide superior interference detection in dense spaces these 3D designs are required. DDG51 Planning yard has a robust 3D (LiDAR) scanning process but requires highly technical and manual processes (labor hours). The goal is to automate the conversion of the 3D scan data to CAD-agnostic detailed design 3D model arrangement. This would improve sustainment activity performance and associated reduce labor costs.

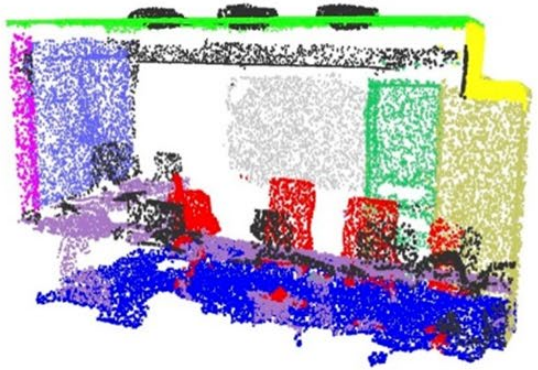
Objectives

- Develop software tools to automate the creation of 3D CAD model arrangements from point cloud data which can then be manipulated, attributed, used for interference checking, and subsequent development of 2D technical drawings.



Classification

Part Segmentation



Semantic Segmentation

Project Organizational Structure

Paul Huang – Program Officer

Robert Mashburn – Deputy Director
Scott Truitt – Project Manager
Jeff Walters – Project Technical Representative

Lee Fuglestad – PMS 400D

David Clark – CACI

Dan Finke – Project Manager
Simon Miller – Tech Lead

Scott Record – Program Manager
Ken Crowe – Project Manager
Casey Norris– Business Lead

Benefits / Payoff / Business Case Update

- Major Benefit: Reduced cost and schedule of creating 3D models, arrangements of models, and responding to Liaison Action Requests (LARs)
- Life-cycle savings over five years, after accounting for software purchases, the ManTech Investment and Implementation costs, reduced the ROI.
- Savings could not be achieved given the current level of automation available to users.
- 5yr ROI = 0.27
- BIW ROI = 2.24

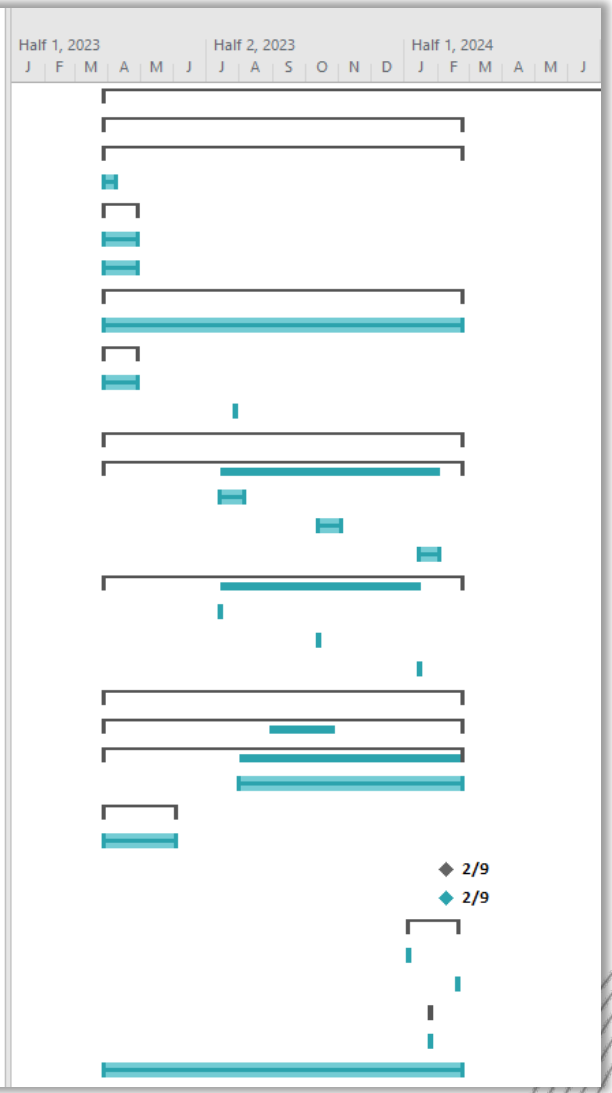
Technical Approach

- Phase I
  - Task 1 – Project Management [BIW/PSU]
  - Task 2 – Investigate Current and Future State [BIW/PSU]
  - Task 3 – Requirements and Concept Design [BIW/PSU]
  - Task 4 – Design Architecture & Development Plan [BIW/PSU]
  - Task 5 – Develop Point Cloud Prototype [BIW/PSU]
- Phase II
  - Task 6 – Project Management
  - Task 7 – Phase ‘A’ System Development to 60%
  - Task 8 – Phase ‘A’ Integration
  - Task 9 – Phase ‘A’ Functional Testing
  - Task 10 – Phase ‘B’ Software Development to 90%
  - Task 11 – Phase ‘C’ User Testing and finalization of Software to 100%
  - Task 12 – Final Documentation
- Required Capability:
  - A tool that decomposes a point cloud into parts in an automated fashion, matches 3D models against that segmented point cloud, and then fits/places found models into a 3D coordinate space assembly while retaining original CAD metadata/origin.

Project Schedule: Phase I Project Management

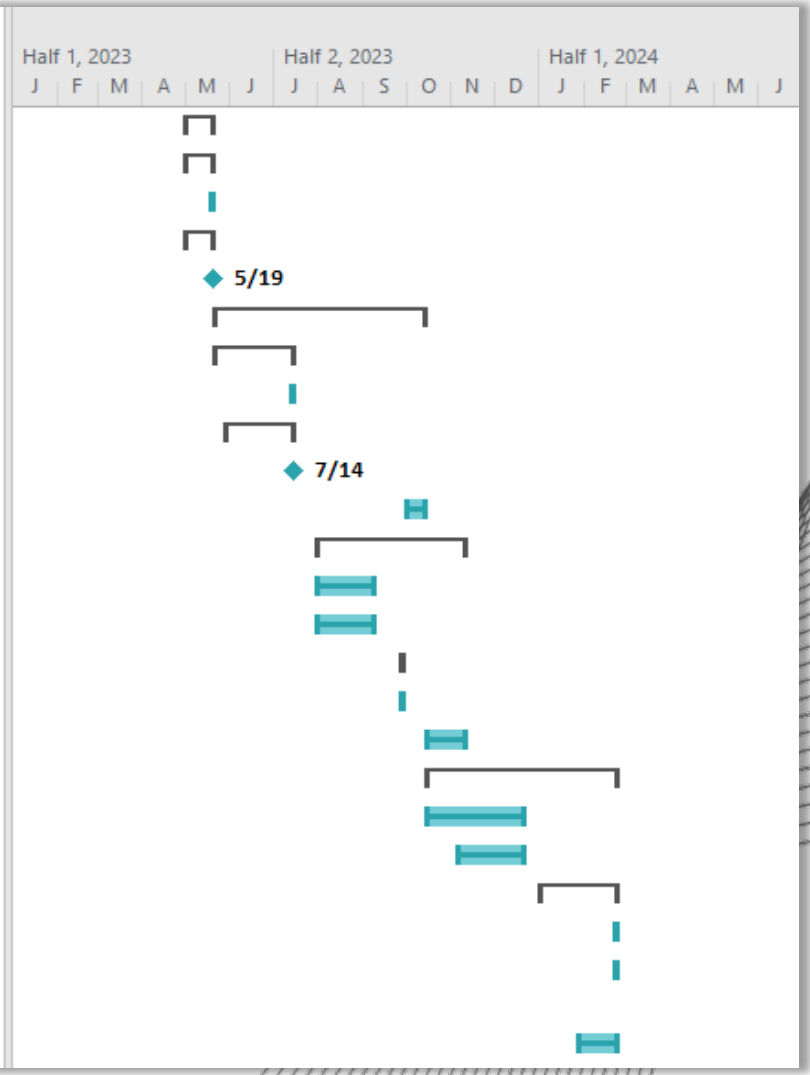
- ONR Period of Performance: 02-24-2023 through 05-31-2025

Task Name	Start	Finish	% Comp
(S2978) Point Cloud Conversion to Detail Design	**Tue 3/28/23**	**Sat 5/31/25**	**100%**
Phase I - Data Collection, Requirements Development, System Design	**Tue 3/28/23**	**Fri 2/23/24**	**100%**
1.0 Project Management Phase I	**Tue 3/28/23**	**Fri 2/23/24**	**100%**
1.1 Project Initiation	Tue 3/28/23	Fri 4/7/23	100%
1.2 Baseline Spend Plan and Master Schedule	**Tue 3/28/23**	**Fri 4/28/23**	**100%**
Deliv 1 - Baseline Spend Plan (30 days after award)	Tue 3/28/23	Fri 4/28/23	100%
Deliv 2 - Master Schedule (30 days after award)	Tue 3/28/23	Fri 4/28/23	100%
1.3 Project Teleconferences	**Tue 3/28/23**	**Fri 2/23/24**	**100%**
Deliv 3 - Telecon Presentations (Bi-weekly)	Tue 3/28/23	Fri 2/23/24	100%
1.4 Kickoff Meeting	**Tue 3/28/23**	**Fri 4/28/23**	**100%**
Deliv 4 - Kickoff Meeting Presentation and Minutes (30 days after award)	Tue 3/28/23	Fri 4/28/23	100%
1.5 Interim Project Assessment (see Subtask 3.3;N/A per NSAM)	Fri 7/28/23	Fri 7/28/23	100%
1.6 Periodic Reporting	**Tue 3/28/23**	**Fri 2/23/24**	**100%**
Deliv 5 - Quarterly Review Presentation	**Tue 3/28/23**	**Fri 2/23/24**	**100%**
Q3 FY23, July Review	Fri 7/14/23	Fri 8/4/23	100%
Q4 FY23, October Review	Fri 10/13/23	Fri 11/3/23	100%
Q1 FY24, January Review	Mon 1/15/24	Fri 2/2/24	100%
Deliv 6 - Quarterly Report	**Tue 3/28/23**	**Fri 2/23/24**	**100%**
Q3 FY23, July Report	Fri 7/14/23	Fri 7/14/23	100%
Q4 FY23, October Report	Fri 10/13/23	Fri 10/13/23	100%
Q1 FY24, January Report	Mon 1/15/24	Mon 1/15/24	100%
1.7 Project Reviews	**Tue 3/28/23**	**Fri 2/23/24**	**100%**
Deliv 7 - Project Technical Presentation (6 mos. after award)	**Tue 3/28/23**	**Fri 2/23/24**	**100%**
1.8 ManTech Program Reviews and Techology Transition Events	**Tue 3/28/23**	**Fri 2/23/24**	**100%**
Deliv 8 - ManTech Program/Tech Transfer Presentation (semi-annual)	Tue 8/1/23	Fri 2/23/24	100%
1.9 Technology Transition Plan (TTP)	**Tue 3/28/23**	**Fri 6/2/23**	**100%**
Deliv 9 - Signed Technology Transition Plan (60 days after award)	Tue 3/28/23	Fri 6/2/23	100%
1.10 Phase I Gate Review	**Fri 2/9/24**	**Fri 2/9/24**	**100%**
Deliv 10 - Phase I Review/Gate Review Presentation (End Task 5)	Fri 2/9/24	Fri 2/9/24	100%
1.11 Phase I Technical Report	**Fri 1/5/24**	**Mon 2/19/24**	**100%**
Draft Phase I Report	Fri 1/5/24	Fri 1/5/24	100%
Deliv 11 - Phase I Report (5 days before PhI end)	Mon 2/19/24	Mon 2/19/24	100%
1.12 Disposition Planning	**Thu 1/25/24**	**Thu 1/25/24**	**100%**
Deliv 12 - Material/Equipment Disposition Plan (30 prior to PhI end)	Thu 1/25/24	Thu 1/25/24	100%
1.13 Project Management Information	Tue 3/28/23	Fri 2/23/24	100%



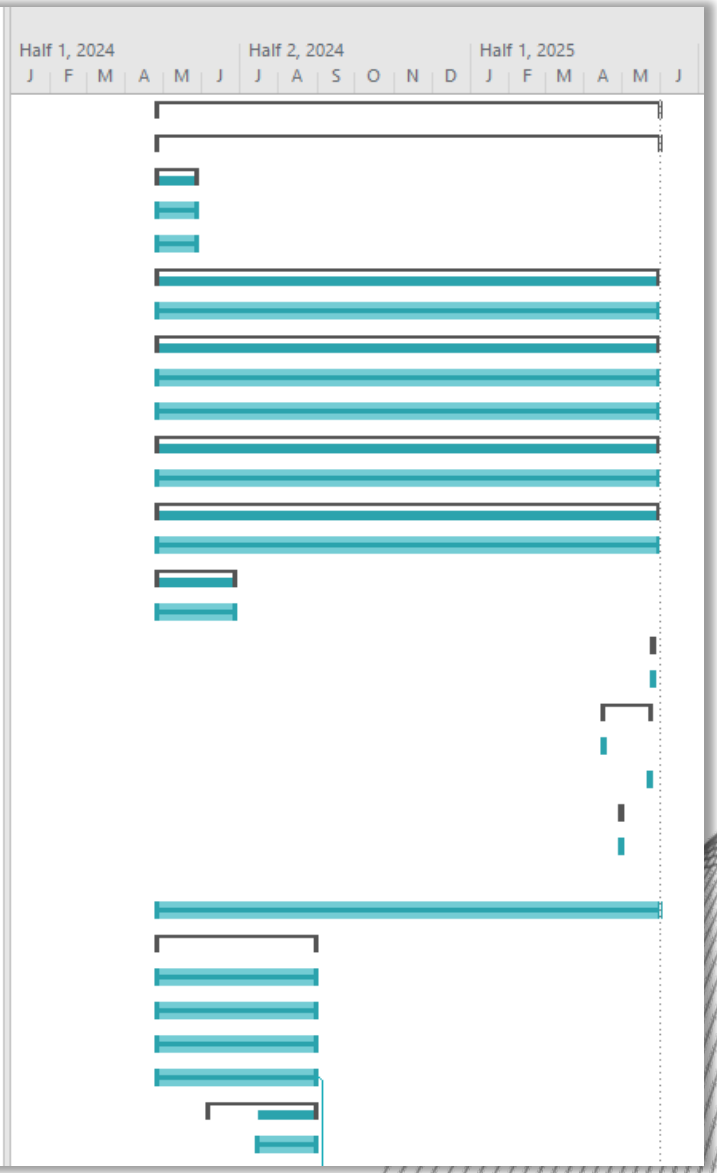
Project Schedule: Phase I Technical Tasks

Task Name	Start	Finish	% Com
2.0 Investigate Current Methodologies and Map Future State	**Mon 5/1/23**	**Fri 5/19/23**	**100%**
2.1 Investigate Current Planning Yard LiDAR Scan Development and Use	**Mon 5/1/23**	**Fri 5/19/23**	**100%**
Deliv 13 - Detailed Process Description	Fri 5/19/23	Fri 5/19/23	100%
2.2 Perform Future State Analysis	**Mon 5/1/23**	**Fri 5/19/23**	**100%**
Deliv 14 - Future State Vision	Fri 5/19/23	Fri 5/19/23	100%
3.0 Requirements and Concept Design	**Mon 5/22/23**	**Fri 10/13/23**	**100%**
3.1 Develop Requirements and Use Cases	**Mon 5/22/23**	**Fri 7/14/23**	**100%**
Deliv 15 - Requirements Document	Fri 7/14/23	Fri 7/14/23	100%
3.2 Develop System Concept Design	**Mon 5/29/23**	**Fri 7/14/23**	**100%**
Deliv 16 - System Concept Design	Fri 7/14/23	Fri 7/14/23	100%
3.3 Conduct Interim Project Assessment	Mon 10/2/23	Fri 10/13/23	100%
4.0 Design Architecture and Development Plan	**Mon 7/31/23**	**Fri 11/10/23**	**100%**
4.1 Design Point Cloud System Architecture	Mon 7/31/23	Fri 9/8/23	100%
4.2 Design Automated Point Cloud to Digital Design Data System	Mon 7/31/23	Fri 9/8/23	100%
4.3 Develop Prototype System Design Document	**Thu 9/28/23**	**Thu 9/28/23**	**100%**
Deliv 17 - Prototype System Design Document	Thu 9/28/23	Thu 9/28/23	100%
4.4 Conduct Ph1 Prelim Architectural Review Board	Mon 10/16/23	Fri 11/10/23	100%
5.0 Develop Point Cloud Prototype	**Mon 10/16/23**	**Fri 2/23/24**	**100%**
5.1 Develop Initial Point Cloud System Prototype	Mon 10/16/23	Thu 12/21/23	100%
5.2 Develop Point Cloud System Logic	Mon 11/6/23	Thu 12/21/23	100%
5.3 Develop Point Cloud Prototype Application	Tue 1/2/24	**Fri 2/23/24**	**100%**
Internal Initial Functionality Demonstration	Fri 2/23/24	Fri 2/23/24	100%
Deliv 18 - Initial Functionality Test Release Candidate System Demonstration	Fri 2/23/24	Fri 2/23/24	100%
5.4 Conduct PhI Architectural Review Board	Mon 1/29/24	Fri 2/23/24	100%



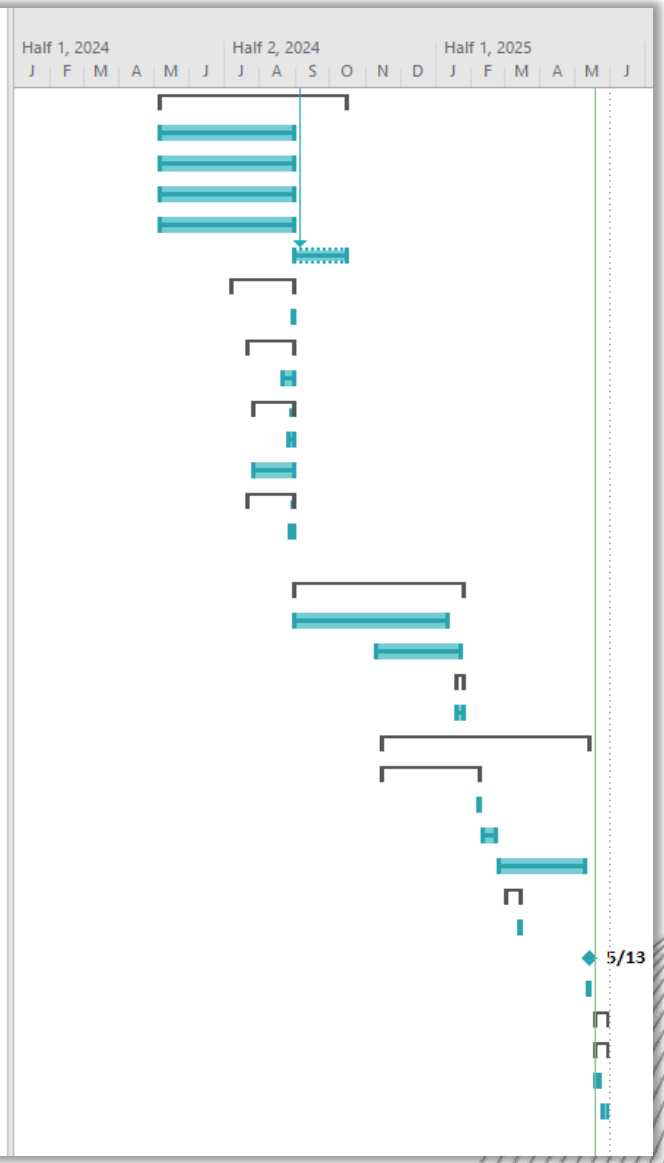
Project Schedule: Phase II Technical Tasks

Task Name	Start	Finish	% Com
Phase II - System Development and Test	**Fri 4/26/24**	**Sat 5/31/25**	**100%**
6.0 Project Management Phase II	**Fri 4/26/24**	**Sat 5/31/25**	**100%**
6.1 Baseline Spend Plan and Master Schedule	Fri 4/26/24	Mon 5/27/24	**100%**
Deliv 19 - Baseline Spend Plan (30 days after start Ph II)	Fri 4/26/24	Mon 5/27/24	100%
Deliv 20 - Master Schedule (30 days after start Ph II)	Fri 4/26/24	Mon 5/27/24	100%
6.2 Project Teleconferences	Fri 4/26/24	Fri 5/30/25	**100%**
Deliv 21 - Telecon Presentationis (Bi-weekly)	Fri 4/26/24	Fri 5/30/25	100%
6.3 Periodic Reporting	Fri 4/26/24	Fri 5/30/25	**100%**
Deliv 22 - Quarterly Review Presentation	Fri 4/26/24	Fri 5/30/25	100%
Deliv 23 - Quarterly Report	Fri 4/26/24	Fri 5/30/25	100%
6.4 Project Reviews	Fri 4/26/24	Fri 5/30/25	**100%**
Deliv 24 - Project Technical Presentation (6 mos. after start Ph II)	Fri 4/26/24	Fri 5/30/25	100%
6.5 ManTech Program Reviews and Technology Transition Events	Fri 4/26/24	Fri 5/30/25	**100%**
Deliv 25 - ManTech Program/Tech Transfer Presentation (Semi-annual)	Fri 4/26/24	Fri 5/30/25	100%
6.6 Technology Transition Plan	**Fri 4/26/24**	**Wed 6/26/24**	**100%**
Deliv 26 - Updated Technology Transition Plan (60 days after start Ph II)	Fri 4/26/24	Wed 6/26/24	100%
6.7 Final Review	**Mon 5/26/25**	**Mon 5/26/25**	**100%**
Deliv 27 - Final Review (5 days before POP end)	Mon 5/26/25	Mon 5/26/25	100%
6.8 Final Technical Report	**Wed 4/16/25**	**Fri 5/23/25**	**100%**
Deliv 28 - Draft Final Report (45 days before POP end)	Wed 4/16/25	Wed 4/16/25	100%
Deliv 29 - Signed Final Report (5 days before POP end)	Fri 5/23/25	Fri 5/23/25	100%
6.9 Disposition Planning	Wed 4/30/25	Wed 4/30/25	**100%**
Deliv 30 - Material/Equipment Disposition Plan (30 days prioir to PhII end)	Wed 4/30/25	Wed 4/30/25	100%
6.10 Project Management Information	Fri 4/26/24	Sat 5/31/25	100%
7.0 Phase 'A' System Development to 60%	**Fri 4/26/24**	**Fri 8/30/24**	**100%**
7.1 Build Independent Modules	Fri 4/26/24	Fri 8/30/24	100%
7.2 Command Line Utility and Toolchain Automation	Fri 4/26/24	Fri 8/30/24	100%
7.3 Develop Unit Tests (alpha)	Fri 4/26/24	Fri 8/30/24	100%
7.4 User Interface Design	Fri 4/26/24	Fri 8/30/24	100%
7.5 Phase 'A' System Development Report	**Thu 6/6/24**	**Fri 8/30/24**	**100%**
Deliv 31 - Phase 'A' System Development Report	Mon 7/15/24	Fri 8/30/24	100%



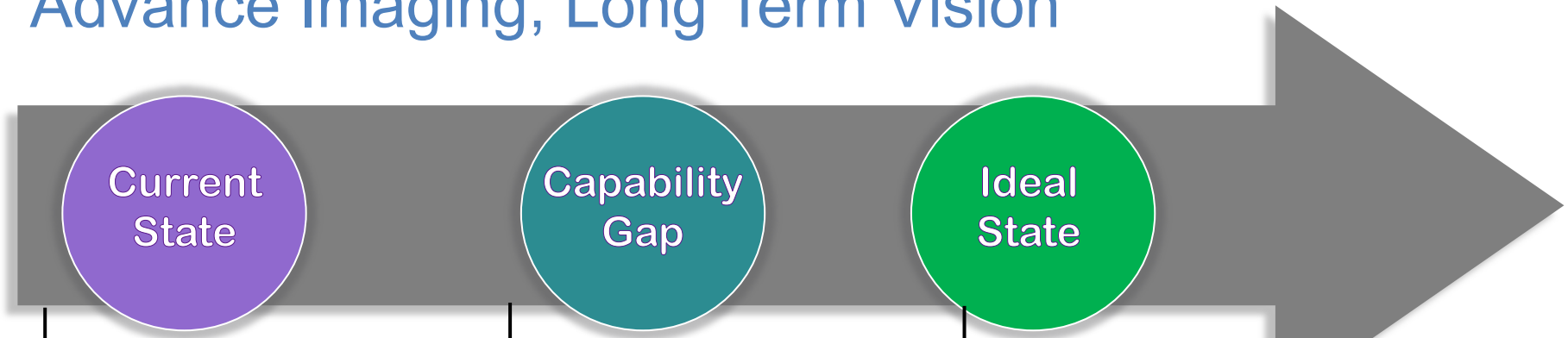
Project Schedule: Phase II Technical Tasks

Task Name	Start	Finish	% Com
8.0 Phase 'A' Integration	**Mon 5/6/24**	**Tue 10/15/24**	**100%**
8.1 Scan Data Collection Process Development	Mon 5/6/24	Fri 8/30/24	100%
8.2 Geometry and MetaData Association	Mon 5/6/24	Fri 8/30/24	100%
8.3 Develop AI Tools	Mon 5/6/24	Fri 8/30/24	100%
8.4 Develop User Interfaces	Mon 5/6/24	Fri 8/30/24	100%
8.5 Conduct IT Architectural Review Board	Sat 8/31/24	Tue 10/15/24	100%
8.6 Phase 'A' Integration Report	**Mon 7/8/24**	**Fri 8/30/24**	**100%**
Deliv 32 - Phase 'A' Integration Report	Fri 8/30/24	Fri 8/30/24	100%
9.0 Phase 'A' Functional Testing	**Mon 7/22/24**	**Fri 8/30/24**	**100%**
9.1 Functional Test Plan Development and User Selection	Wed 8/21/24	Fri 8/30/24	100%
9.2 Establish PSU-ARL Test Environment	Fri 7/26/24	Fri 8/30/24	**100%**
Deliv 33 - Initial Release Candidate Software (Code, run at PSU-ARL only)	Mon 8/26/24	Fri 8/30/24	100%
9.3 Conduct Functional Testing (beta)	Fri 7/26/24	Fri 8/30/24	100%
9.4 Document Gaps and Modifications	Mon 7/22/24	Fri 8/30/24	**100%**
Deliv 34 - Phase A User Identified Gaps and Suggested Modifications Document	Tue 8/27/24	Fri 8/30/24	100%
10.0 Phase 'B' Software Development to 90%	**Sat 8/31/24**	**Fri 1/24/25**	**100%**
10.1 Implement Required Changes	Sat 8/31/24	Fri 1/10/25	100%
10.2 Iterative Functional Testing (gamma)	Sun 11/10/24	Tue 1/21/25	100%
10.3 Install and Configure System for UAT at ARL	Sun 1/19/25	Fri 1/24/25	**100%**
Deliv 35 - Installation Directions and BIW-IT Compliant Software	Sun 1/19/25	Fri 1/24/25	100%
11.0 Phase 'C' User Testing and Finalization of Software to 100%	**Fri 11/15/24**	**Tue 5/13/25**	**100%**
11.1 End User Test Plan Development and User Selection	**Fri 11/15/24**	**Fri 2/7/25**	**100%**
Deliv 36 - Point Cloud System Test Plan	Fri 2/7/25	Fri 2/7/25	100%
11.2 End User Testing (delta)	Mon 2/10/25	Fri 2/21/25	100%
11.3 Point Cloud System Tool Refinement	Mon 2/24/25	Fri 5/9/25	100%
11.4 User Acceptance Test (UAT) at ARL	**Mon 3/3/25**	**Fri 3/14/25**	**100%**
Deliv 37 - UAT Results Report	Fri 3/14/25	Fri 3/14/25	100%
11.5 IT Architectural Review Board	**Tue 5/13/25**	**Tue 5/13/25**	**100%**
Deliv 38 - IT & DXC Architecture Presentation and Minutes	Tue 5/13/25	Tue 5/13/25	100%
12.0 Final Documentation	**Mon 5/19/25**	**Thu 5/29/25**	**33%**
12.1 Develop System Specifications and Installation Documentation	**Mon 5/19/25**	**Thu 5/29/25**	**33%**
Deliv 39 - Point Cloud System Specification and Installation Guide	Mon 5/19/25	Thu 5/22/25	35%
Deliv 40 - Point Cloud Application Software (Code, deliverable to shipyard only)	Mon 5/26/25	Thu 5/29/25	30%



Task 2 Investigate Current and Future State

Advance Imaging, Long Term Vision



Current State

- Over 900 unique compartments have been scanned across 16 hulls
- LiDAR scanning provides interactive point-cloud data
- Point-cloud data utilized for interference detection & verification of shipcheck accuracy
- Limited export functionality
- Point-clouds cannot be directly used to generate smart 3D geometry

Capability Gap

- Segmenting the point cloud per part is a manual process
- Identifying objects within the point cloud is laborious
- Identifying known or similar objects in CAD database does not exist
- Reconstruction of 3D scene from known objects is not possible
- Reconstructing geometry in a (semi) autonomous process does not exist

Ideal State

- Point-cloud data in relevant spaces is converted to smart solid models
- Converted data is the baseline for downstream design activity
- Accurate baselining & automation of geometry creation will result in cost and schedule reduction during the design process
- Early interference detection will pay big dividends in cost and schedule during the execution phase

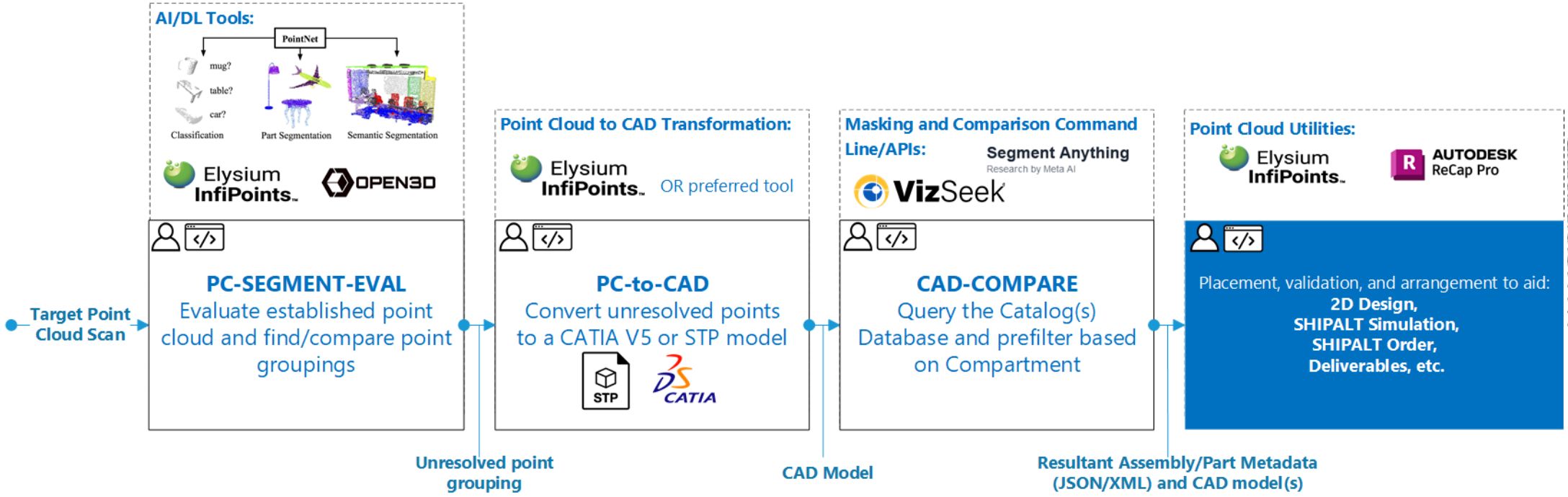
Task 3 Requirements and Concept Design

- Requirements across four categories:
  - End Users – requirements are functional requirements, i.e. what does the system need to do
  - IT/Cyber Security – must follow security standards and be compliant with BIW IT standards and practices
  - Performance – Establishing performance requirements in terms of processing time, number of users, etc.
  - User Experience – drawing from the categories above, these requirements seek to establish how the end users interact with the system

1.0	**STORY: As a Planning Yard Designer I need a software tool that will reduce labor associated with converting point cloud data to 3D geometry.**
1.1	System shall accept current point cloud data as inputs.
1.2	System shall analyze entire point cloud file for parts/assembly comparisons.
1.3	System shall create un-attributed, individual CAD-compatible parts/assemblies models from the point cloud data.
1.3.1	System generated parts/assemblies shall be CAD-neutral (i.e. STEP files) to be used or coverted for specific CAD software (i.e. CATIA)
1.3.2	System shall identify 50% CAD library objects for individual ship equipment/components for equivalent volumetric objects deduced from logical point clouds cluster.
1.3.3	System shall produce solid model geometry for 50% of structure and distributive systems present in point cloud.
1.4	System shall scan match models with library components based on library schema.
1.5	System shall match results back into engineering design space.

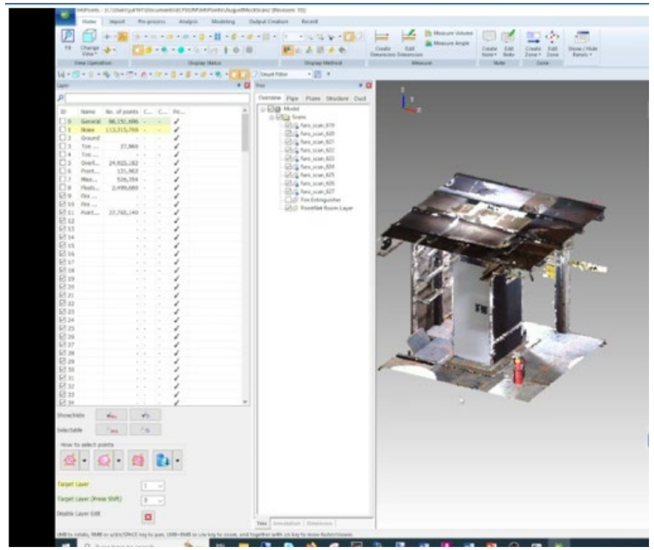
Task 4 Design Architecture & Development Plan

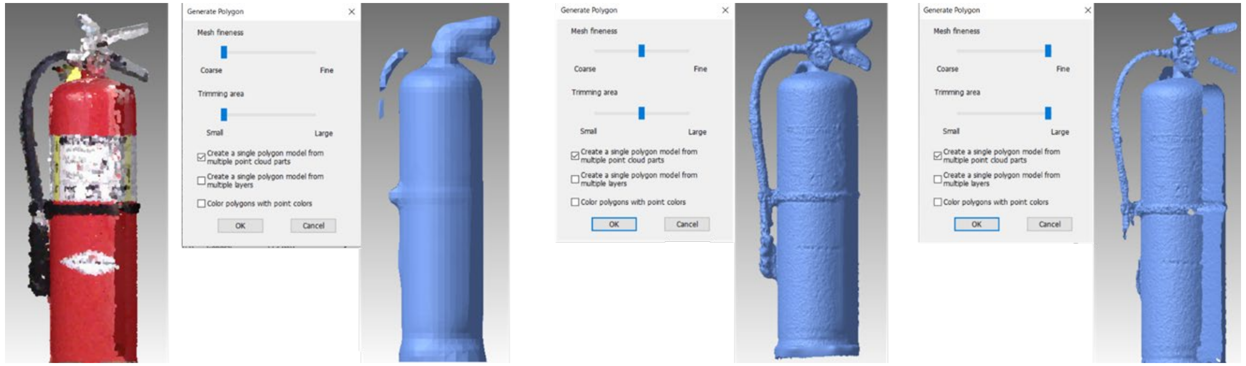
- System is comprised of software modules that reside on desktop workstation and VM CAD server.
- All software and data reside on premise within firewalled environment, no external connectivity required or desired.

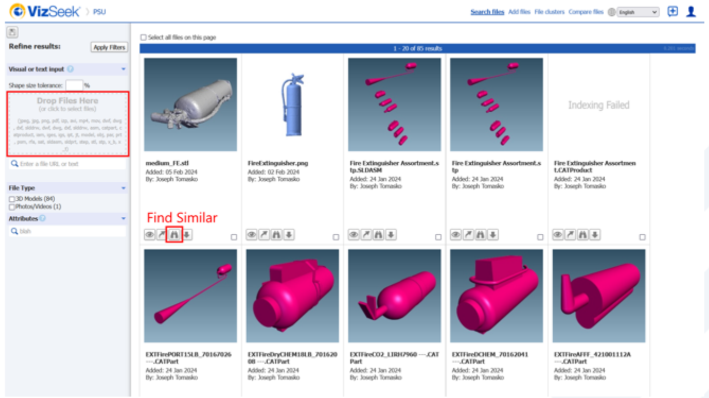


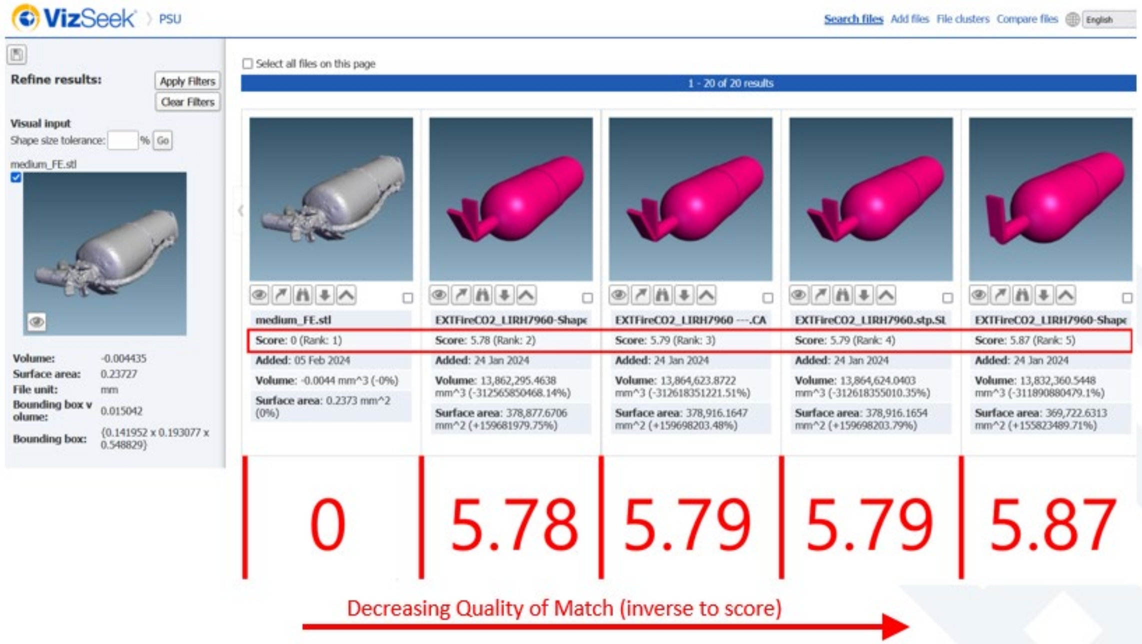
Task 5 Develop Prototype

- Phase I concluded with a proof-of-concept





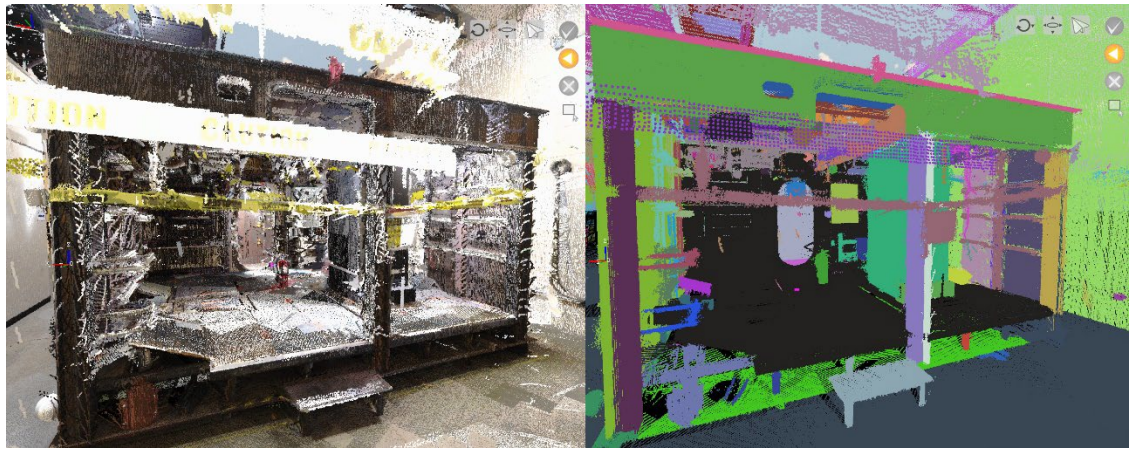


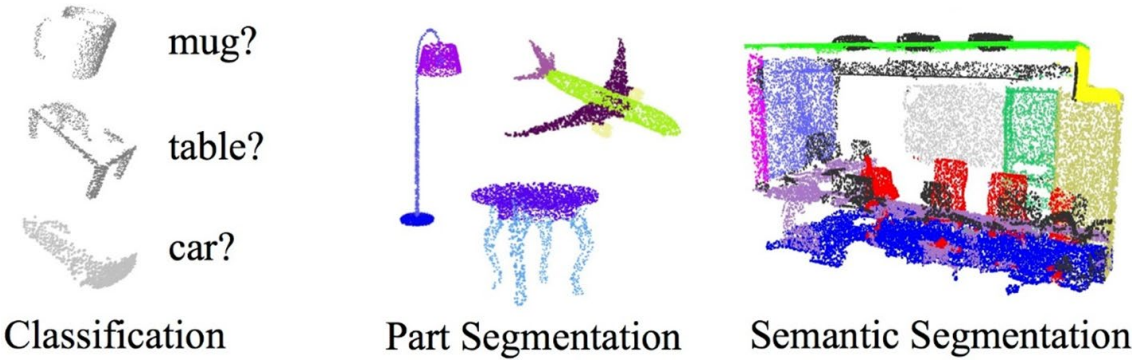


VizSeek is a *visual search* tool that can be hosted on-prem. It loads a database of known CAD objects and the user can upload a new image/object and find *similar* entities in the database. Here we have a number of objects and the point cloud reconstructed fire extinguisher (top left) for comparison.

Task 7–11 Development

- Classifying point clouds into homogeneous regions
- Deep learning can be applied to segmentation, aid in overall identification, and define raw point cloud data



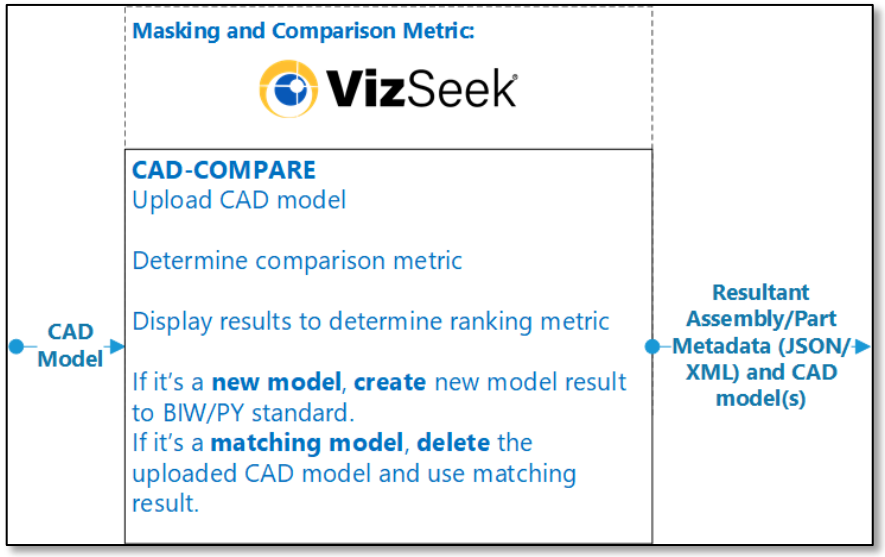


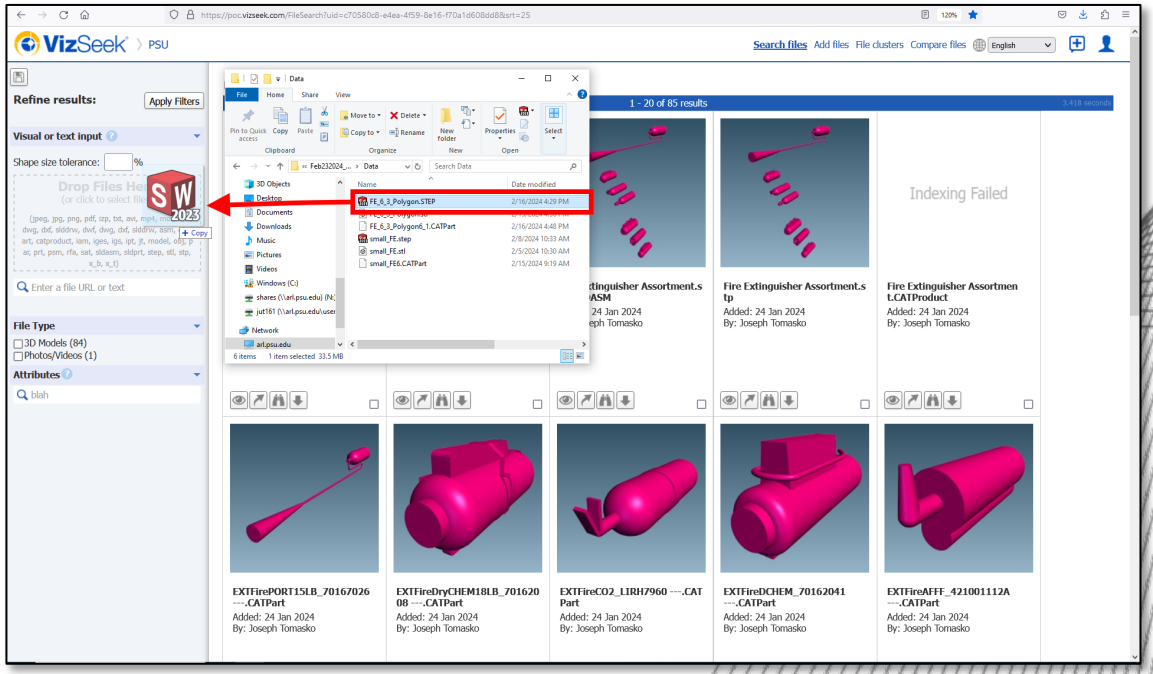
Classification | Part Segmentation | Semantic Segmentation

- Shape Classification
  - Based on trained shapes and their scores, find the best match
- Part Segmentation
  - Fine-grained object parts instead of generic object labels
- Semantic Segmentation
  - Each point is associated with a label or category

Task 7–11 Development

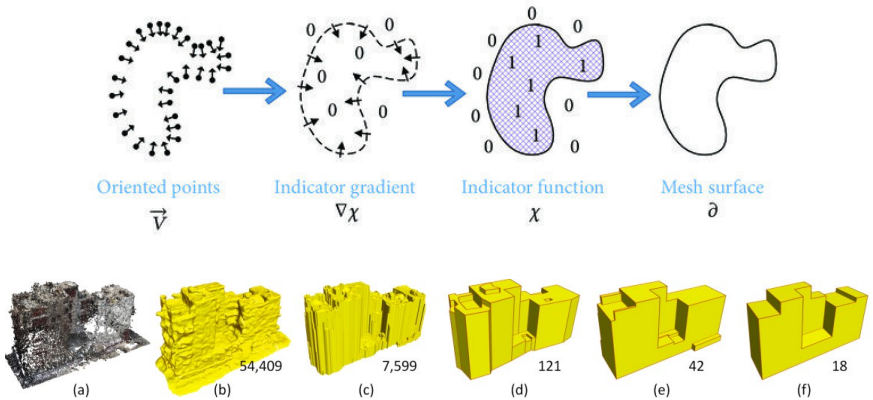
- Visual search is a technique of comparing 2D and 3D objects and identifying the “best” match against a database of objects.
- Using a known CAD database, users can upload an object (i.e. image, mesh) and find entities in the database.
- Metrics and scoring criteria are based on visual cues, meta-data, and user-defined functions.
- Matured system architecture, meeting BIW IT requirements.



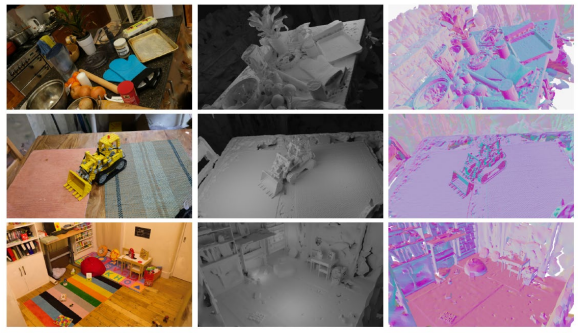


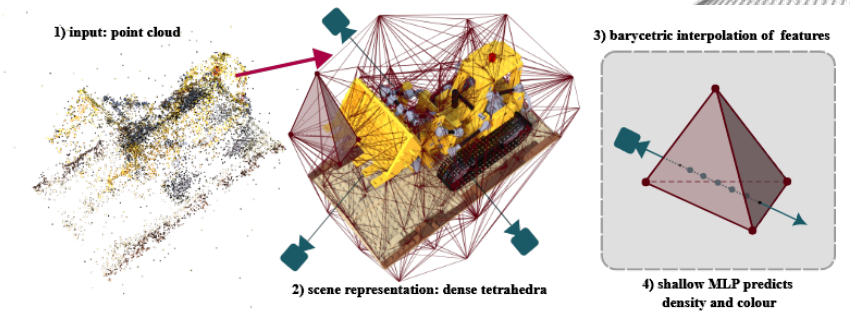
Task 7–11 Development

- Classic methods generate shapes for comparison and new CAD object generation
- Surface Reconstruction techniques, RANSAC, Primitive Fitting, etc., produce data that can be compared for the visual search engine routines



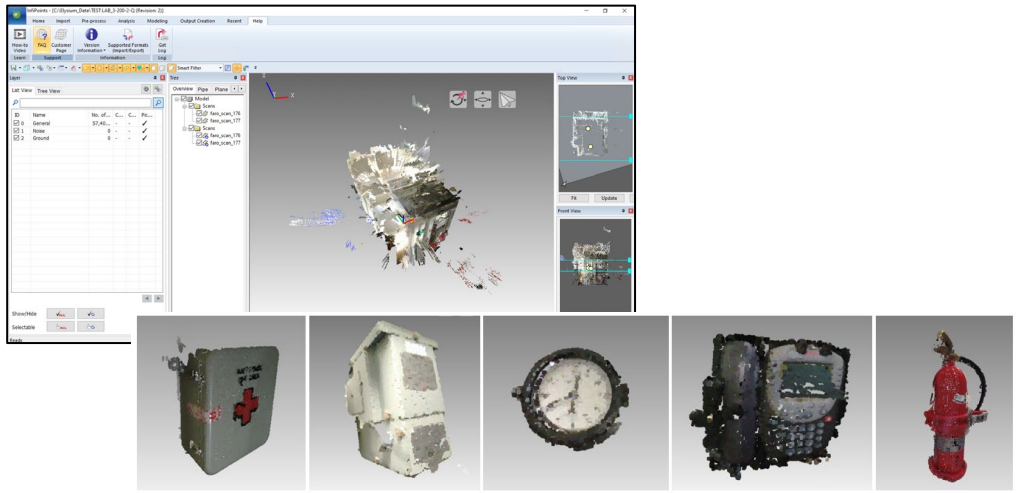
- Modern tools such as NeRF and Gaussian Splatting explored to create image and mesh objects
- Images used for visual search
- Meshes used for visual search and new/updated CAD design

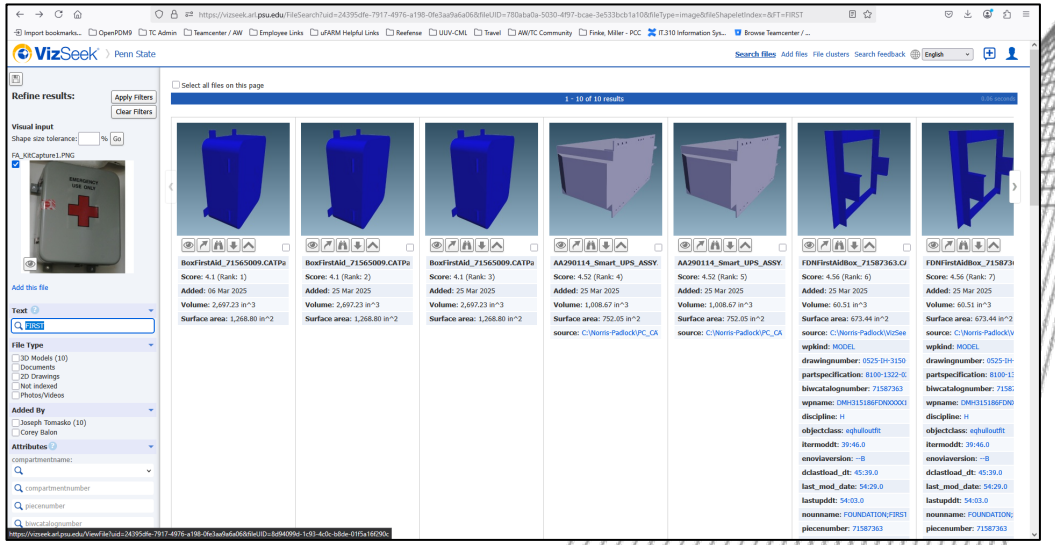




Task 7–11 Development

- Functionality improvements with InfiPoints in Alpha Release
  - Improved segmentation structure in User Interface
  - Used STP, STEP or STL files or image captures to input to VizSeek
- Functionality improvements with VizSeek
  - Filter on attributes selectable by User
- Development used actual ship data (point clouds and library parts)
- Multiple User Acceptance events at Penn State ARL facility
- Distributive Systems highlighted unique challenges





Transition/Implementation

- Transition Event:
  - ManTech Deliverable: Point Cloud System Specification & Installation Guide and Point Cloud Application Software (May 2025)
- Implementation / Implementation Funding:
  - Target: GDBIW PY / IT
  - Time Period: Q3 2025
  - Implementation Funding Estimate, Source(s), and Status:
    - Dependent on future capability development
- Currently Planning Yard does not see sufficient automation to reach objective ROI. BIW is submitting a follow-on project to further develop automation, with focus on distributive systems.