S2981: Portable Shipyard Pipe Inspection

NSRP All Panel Meeting 2025

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Ingalls Shipbuilding

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Agenda

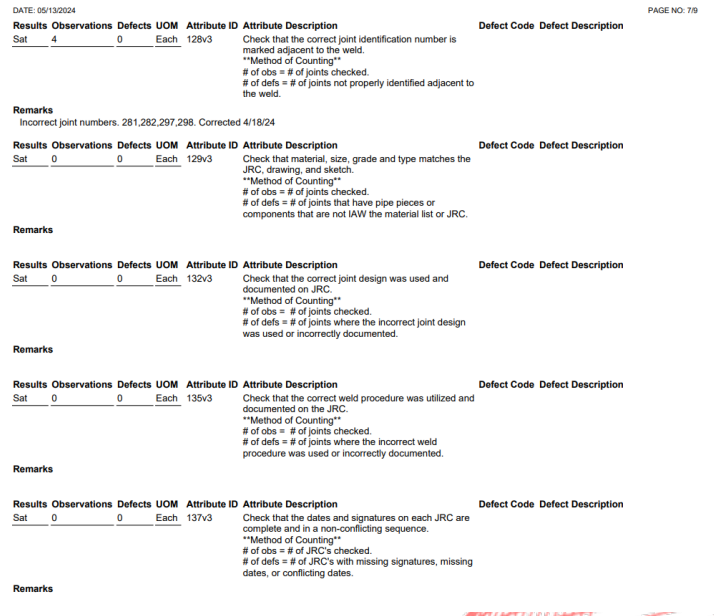
1. Project Team
2. Issue Description
3. Objective
4. Technical Goals
5. Benefits / Pay Off
6. Project Schedule
7. Technical Approach
8. Technical Content and Status
9. Transition / Implementation Plan
10. Next Steps
11. Q & A

Issue Description

- QA inspectors frequently have to crawl in difficult to access areas with a flashlight to complete an inspection of the pipe
- The inspector must make notes on paper as they inspect each pipe system. This information will be used to complete required reports
- The inspector must complete an internal visual cleanliness pipe inspection by shining a flashlight into the pipe system and inspecting it based on what he can see from his vantage point outside the pipe.

Issue Description

- Once the visual inspection is complete, inspectors return to their office and manually input the data into the required inspection forms.
- If the visual inspection reveals that there are item(s) in the pipe, (left behind tools, debris, etc.) the pipe system must be cut, the object(s) removed, and then the pipe pieces re-welded into place.
- This rework causes extra labor hours and delays.



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Results	Observations	Defects	UOM	Attribute ID	Attribute Description	Defect Code	Defect Description
Sat	4	0	Each	128v3	Check that the correct joint identification number is marked adjacent to the weld. **Method of Counting** # of obs = # of joints checked. # of defs = # of joints not properly identified adjacent to the weld.		

Remarks
Incorrect joint numbers. 281,282,297,298. Corrected 4/18/24

Results	Observations	Defects	UOM	Attribute ID	Attribute Description	Defect Code	Defect Description
Sat	0	0	Each	129v3	Check that material, size, grade and type matches the JRC, drawing, and sketch. **Method of Counting** # of obs = # of joints checked. # of defs = # of joints that have pipe pieces or components that are not IAW the material list or JRC.		

Remarks

Results	Observations	Defects	UOM	Attribute ID	Attribute Description	Defect Code	Defect Description
Sat	0	0	Each	132v3	Check that the correct joint design was used and documented on JRC. **Method of Counting** # of obs = # of joints checked. # of defs = # of joints where the incorrect joint design was used or incorrectly documented.		

Remarks

Results	Observations	Defects	UOM	Attribute ID	Attribute Description	Defect Code	Defect Description
Sat	0	0	Each	135v3	Check that the correct weld procedure was utilized and documented on the JRC. **Method of Counting** # of obs = # of joints checked. # of defs = # of joints where the incorrect weld procedure was used or incorrectly documented.		

Remarks

Results	Observations	Defects	UOM	Attribute ID	Attribute Description	Defect Code	Defect Description
Sat	0	0	Each	137v3	Check that the dates and signatures on each JRC are complete and in a non-conflicting sequence. **Method of Counting** # of obs = # of JRC's checked. # of defs = # of JRC's with missing signatures, missing dates, or conflicting dates.		

Remarks

Inspection Form

Project Objective(s)

- The objective of this project is to develop and pilot a robotic system(s) for visual cleanliness inspection of the interior of piping systems.
- This system should have the ability to record and store inspection videos, live streaming capability, and be able to retrieve any debris that is discovered during the inspection.
- The inspection system will enable the inspector to perform the inspection in a faster, less physically challenging manner.

ManTech Metrics

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Goal 1: 50% Reduction in labor across Quality Department for 70% of visual pipe inspection use cases.

Parameter	Baseline Value	Requirement Threshold Value	Requirement Objective Value	How to Measure	Timeframe (i.e. Subtask X.X) to Verify	Achievement Value	Achievement Date	Demonstration Method
Hours required to visually inspect pipe	Current hours required	50% of Current hours required	57% of Current hours required	Time study	Task 7.3	TBD	TBD	Demo during Phase II

Goal 2: 50% reduction in time to document, write, and develop inspection reports

Parameter	Baseline Value	Requirement Threshold Value	Requirement Objective Value	How to Measure	Timeframe (i.e. Subtask X.X) to Verify	Achievement Value	Achievement Date	Demonstration Method
Hours required to make notes, write reports,	Current hours required	50% of Current hours required	30% of Current hours required	Time study	Task 7.3	TBD	TBD	Demo during Phase II

Goal 3: 50% reduction in labor across Quality Department, elimination of Safety Department, and elimination of Rigging for 30% of visual pipe inspection use cases.

Parameter	Baseline Value	Requirement Threshold Value	Requirement Objective Value	How to Measure	Timeframe (i.e. Subtask X.X) to Verify	Achievement Value	Achievement Date	Demonstration Method
Pipe inspection hours, and related rigging installation hours, and Safety hours	Current hours required	80% of Current hours required	88% of Current hours required	Time study	Task 7.3	TBD	TBD	Demo during Phase II

Exit Criteria: End User Approval of Process and/or Tech Insertion

Activity	Requirements	Pass/Fail	How it will be Measured	Achievement Date	How Demonstration is planned
Implementation of the visual inspection system for pipe	Prototype meets the criteria identified during Task 2.	TBD	Assessment based on criteria defined in Task 2 and 3.	Task 7	Implementation inserted in Ingalls Capital Plan for Implementation

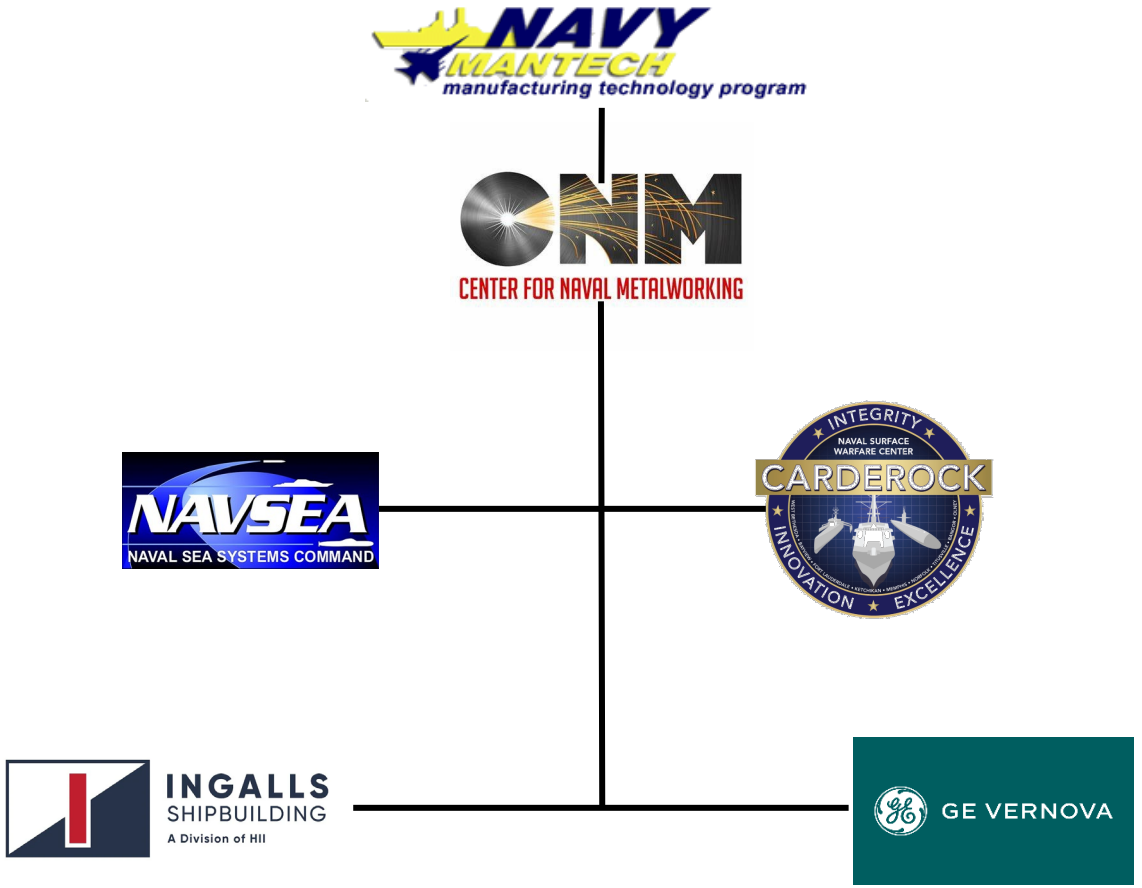
Goal 1: Labor ⬇ | **Goal 2:** Documentation ⬇ | **Goal 3:** Other Departments ⬇

Benefits / Payoff / Business Case Update

- Major Benefit:
  - Decrease labor hours to conduct visual Inspection of Pipes
  - Decrease reliance on other trades required to conduct visual inspections.
  - Decrease time removing foreign debris found during the inspection
  - Increase efficiency of the inspector documenting the inspection report.

COSTS		
MANTECH PROJECT COSTS		
Ingalls	$425,000	
GE Vernova	$1,240,000	
CNM	$49,950	
Total ManTech Project Costs	**$1,714,950**	
IMPLEMENTATION COSTS		
Alternative Technologies/Products 2	$25,000	
Training	$8,000	
Update Policy/Procedures	$2,000	
Total Implementation Cost	**$35,000**	
TOTAL COST =	**$1,749,950**	
SAVINGS		
SAVINGS ASSUMPTIONS		
SAVINGS	**Annual**	**5-Year**
Savings on Platform A	**703,414**	**3,517,070**
Savings on Platform B	214,590	1,072,950
Savings on Platform C	274,000	1,370,000
Total Savings	**1,192,004**	**5,960,020**
RETURN ON INVESTMENT		
ROI =	(Return - Investment) / Investment	
5-year ROI for Platform A Only =	**1.03**	
5-year ROI for Combined Platforms =	**2.43**	

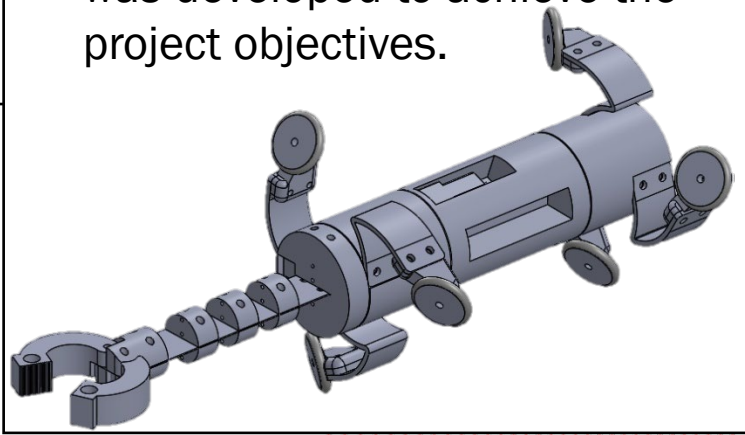
Project Organizational Structure



Technical Approach

	Task	Description
	Phase I – Baseline Requirements and Design	
✓	1	Phase I Program Management *D4: Kick-off Meeting Minutes* *D9: Technology Transition Plan* *D10: Phase I Report*
✓	2	Finalize Process Mapping and Requirements *D14: Baseline process Map Report* *D15: Future State Process Map* *D16: Prototype Requirements* *D17: Mockup Design for Prototype Evaluation* *D18: Project Test Plans*
✓	3	Prototype Design *D19: Prototype Concept Design* *D20: Prototype Design Review* *D21: Design Review Report*

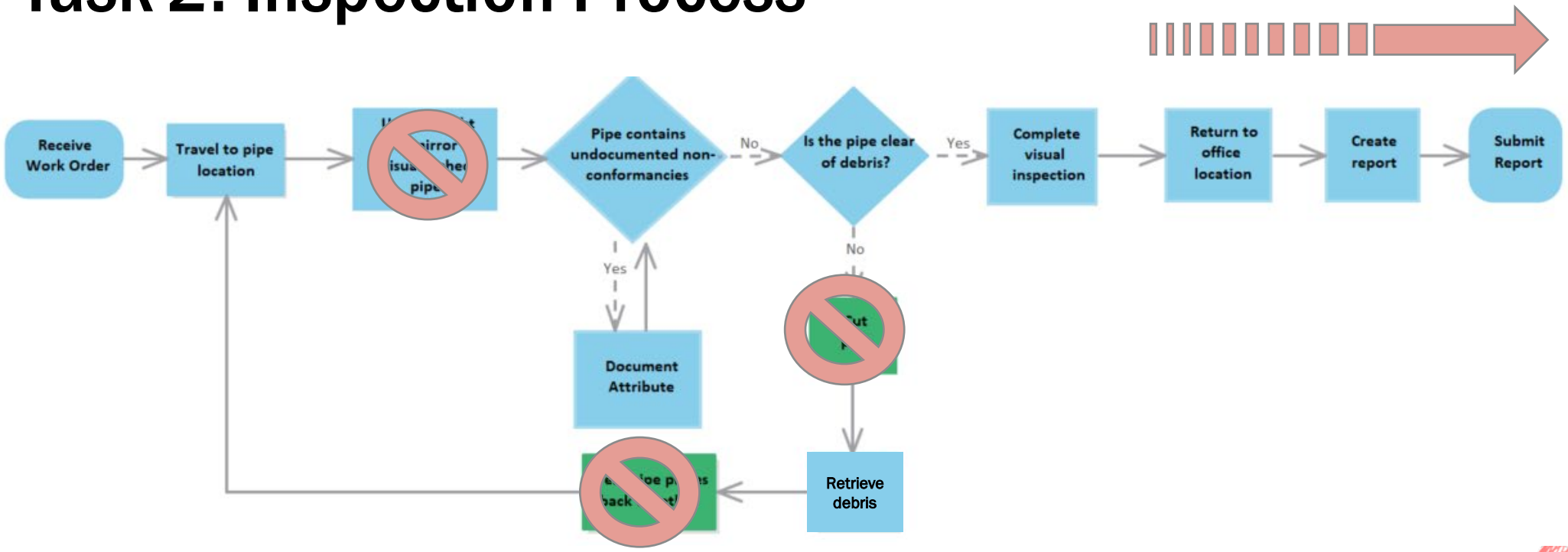
- Three initial prototype designs were presented by GE Vernova
- After feedback from the end user a simpler prototype design was developed to achieve the project objectives.



Technical Approach

	Task	Description
	Phase II – Prototype Development and Functionality Testing	
→	4	Phase II Program Management *D23: Final Technical Report* ***(ECD 2nd Quarter FY 2026)***
→	5	Fabricate Mock-Up Structure *D24: Evaluation Mockup* ***(ECD 3rd Quarter FY2025)***
→	6	Prototype Development *D25: Prototype* ***(ECD 3rd Quarter FY2025)*** *D26: Vendor Prototype Validation Report* ***(ECD 3rd Quarter FY2025)*** *D27: Updated Prototype Design* ***(ECD 3rd Quarter FY2025)***
	7	Prototype Validation Testing *D28: Validation Test Plan* ***(ECD 3rd Quarter FY2025)*** *D29: Shipyard Evaluation Report* ***(ECD 4th Quarter FY2025)*** *D30: Prototype Acceptance Report* ***(ECD 1st Quarter FY2026)***

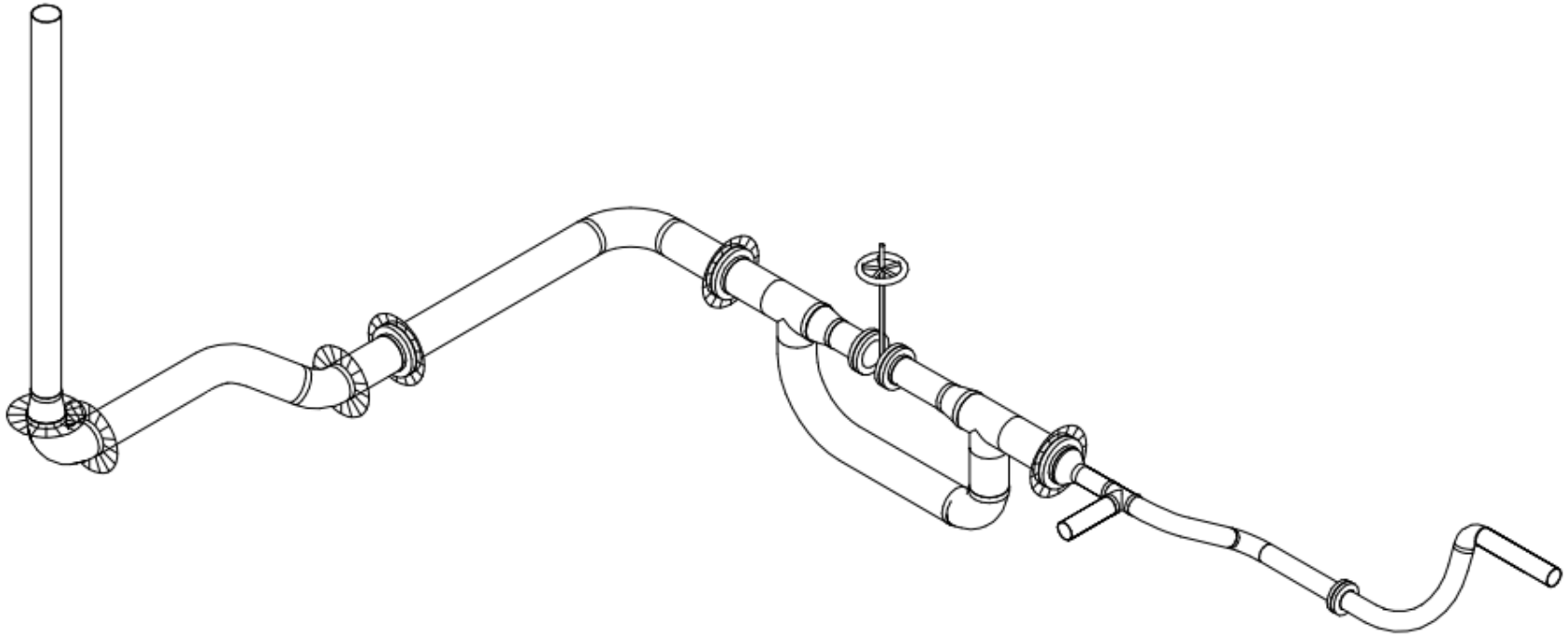
Task 2: Inspection Process



Step Performed By:

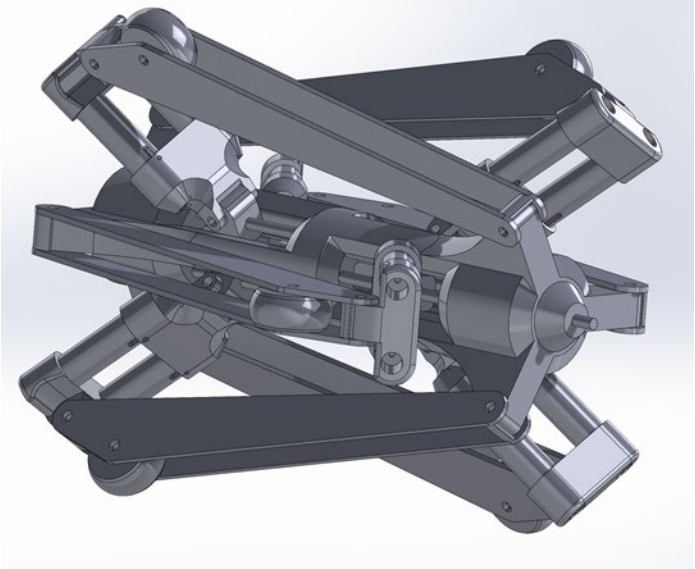
- Inspector
- Inspector & Welding Personnel
- Welding Personnel

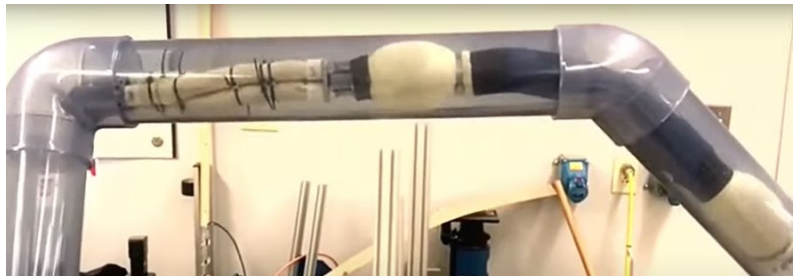
Task 2: Mockup Design

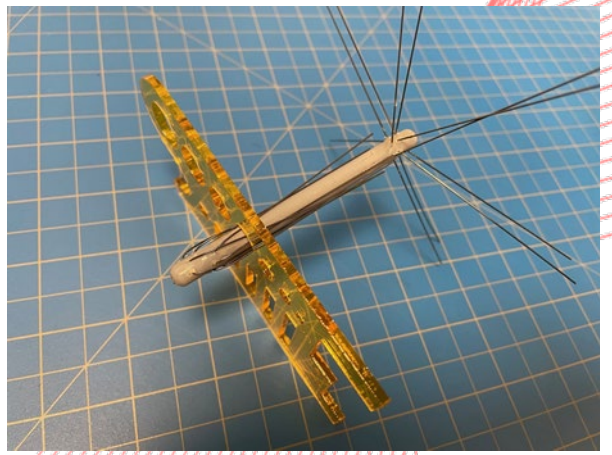


Task 3: Prototype Design

- GE Vernova supplied three concept designs for Ingalls to review.
  - Traditional Pipe Crawler
  - Pneumatic Worm
  - Differential Friction Crawler

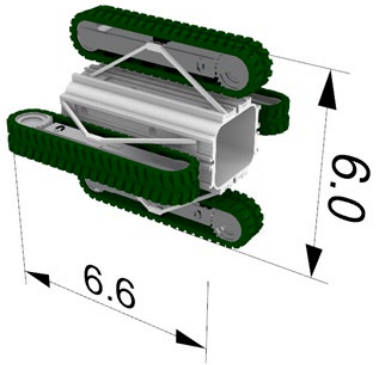




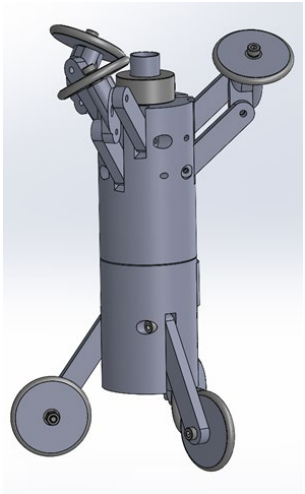


Task 3: Prototype Design

- Ingalls originally down selected
  - Traditional Pipe Crawler for 6”-8” pipe diameters
  - Pneumatic worm for 4” pipe diameters
- Ingalls delivered a preliminary alternative concept
  - Due to concerns from internal stakeholders
- GE Vernova created a 4th concept design
  - Ingalls’ concerns not alleviated with proof of concept from other designs



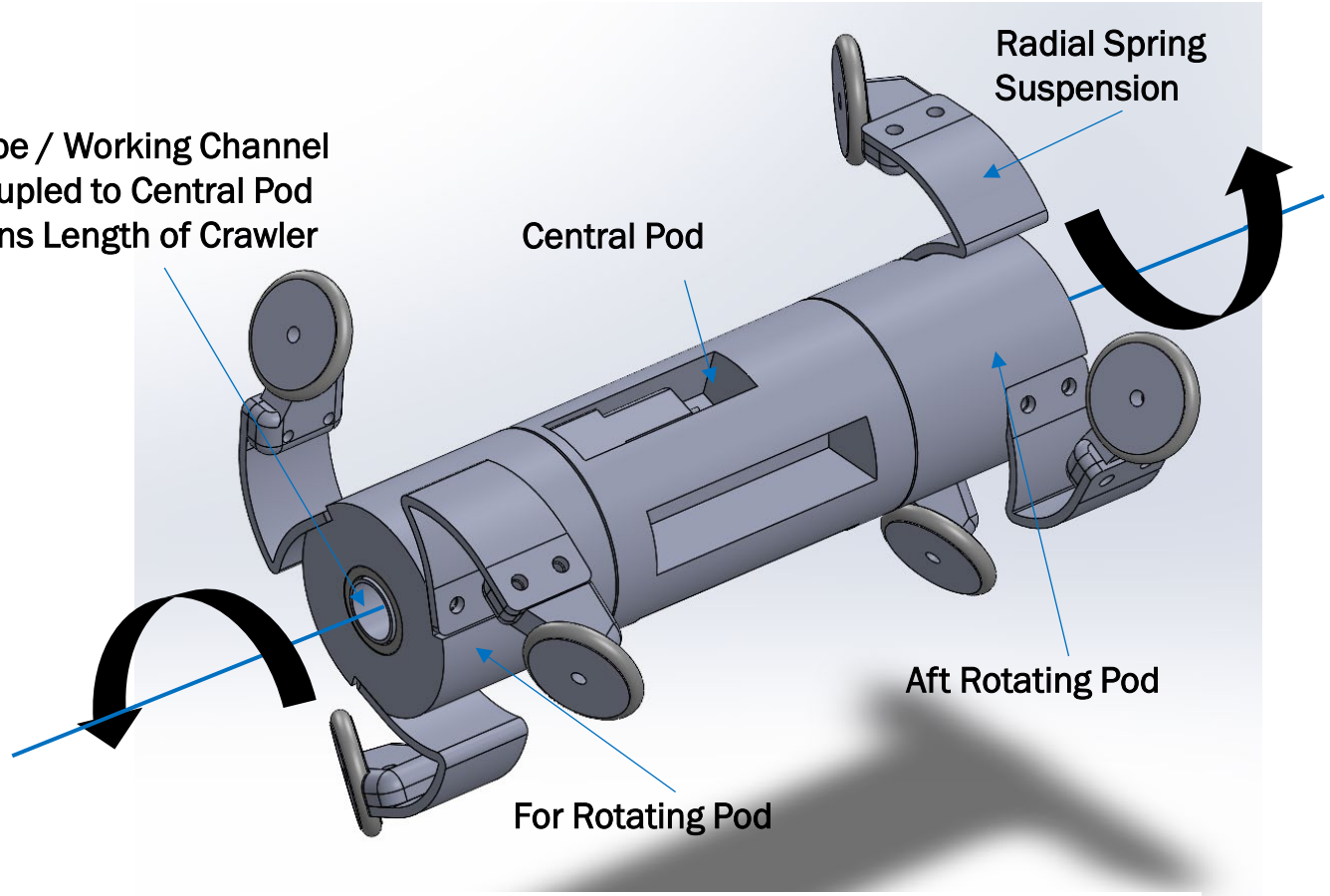
Ingalls’ concept



GE Vernova’s Rotary Crawler

Task 3: Rotary Crawler Preliminary Prototype

Task 3: Rotary Crawler Prototype



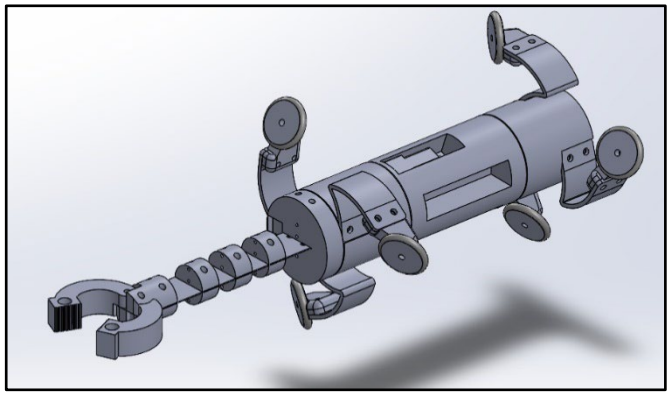
Angled Wheels on Rotating For/Aft Pods Provide:

- Forward / Rearward Thrust (differential rotation)
- Central Pod Rotation (parallel rotation)
- Mixed Thrust and Rotation (blended rotation)

Simple, Versatile Design & Construction:

- 2 COTS motors / Gear Drives + Open bays for more motors and / or electronics for payload support
- Central, non-rotating Pod and Tube is Passthrough and Mount for Camera / Tools (rotationally coupled to Central Pod)
- COTS / Easily Manufactured Parts
  - Printed parts can be re-ordered from a 3D-printing company for COTS-like availability
- Access to 4”-8” Pipes, including Elbows
  - Config A for 4” to <6” Pipes
  - Config B for ≥6” to 8” Pipes
  - Radial Spring Suspension provides pressure for traction and accommodates pipe diameter variations
  - Spring lengths (radial reach) and geometries (forward / aft reach) swapable for access to different pipe sizes
  - Adapters / Spacers with specific radius and for-aft reach can be added to baseline (smaller) system to expand reach and length for large pipe access without swapping springs

Task 3: Rotary Crawler Retrieval Arm Prototype



Concept:

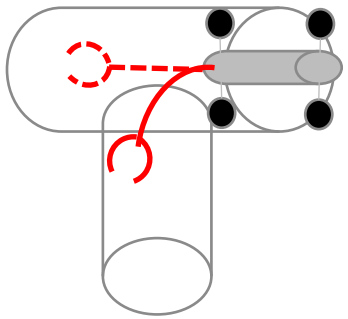
- 1 pass procedure – For inspection and debris removal
- 3 degrees of freedom (1 from arm, 2 from crawler)
- Hybrid tool combines multiple mechanisms to interact with debris in one
  - Magnets for clinging to high iron alloys
  - Barbed hooks for snaring soft materials (rags)
  - Mechanical gripper for interacting with a wide variety of materials
- Coupled to rotary crawler and uses crawler's degrees of freedom for positioning, but also helps crawler navigate "T" features by piloting path for crawler to follow

Pros:

- Multiple functions including path selection and debris removal for multiple material types
- Single pass inspection and debris capture
- Broken attachments can be easily replaced with duplicates to support extended use in the field

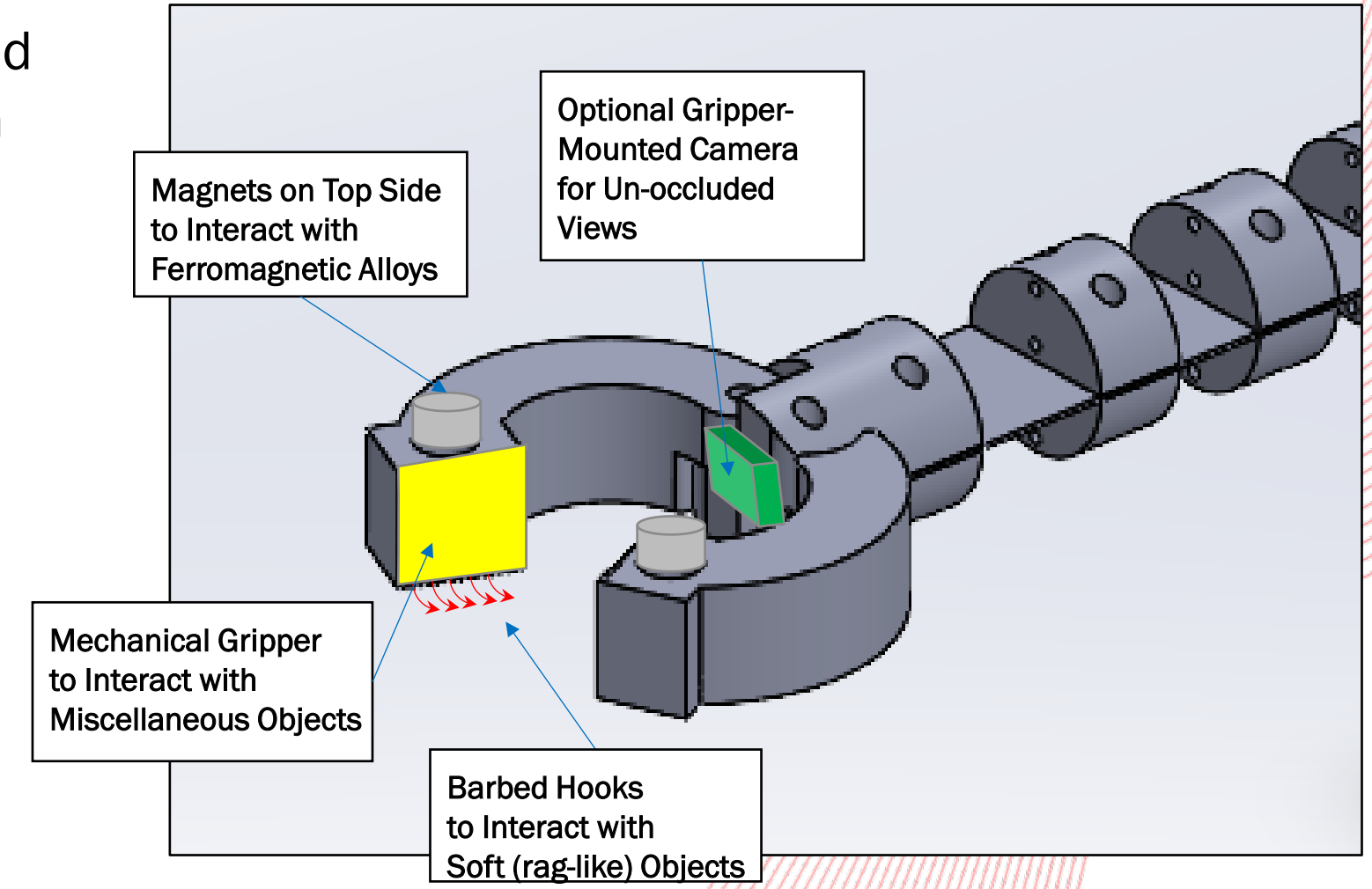
Cons:

- May require custom development to standardize special attachments
- Development depends on manufacturing lead times
- Specifically designed for rotary crawler / uses crawlers degrees of freedom



Task 3: Rotary Crawler Retrieval Arm Prototype

- Controlling the azimuth and deflection (and translation of crawler) lets us select which part of the end-effector (magnet, hook, gripper) interacts with the debris.
- We can touch objects with top or bottom of end-effector regardless of position of debris in pipe.



Task 3: Rotary Crawler Retrieval Arm Prototype

Prototype	Pros	Cons	ROM Cost
Traditional Pipe Crawler (TPC)	• Team experience • Fully independent 6 DOF allows real time adaptation to pipe conditions • Enhanced precision control • More resilient due to maturity • Higher payloads	• Higher maintenance and cost of ownership • Single robot to cover all pipe diameters not impossible but high risk • Alternate to produce 2 robots increases maintenance cost	High ~$25k + (<5k debris removal attachments)
Rotary Crawler (RC)	• High availability due to easily manufactured components for replacement • Lower cost to fabricate and maintain • Versatile	• Payload capacity may be limited	Low ~$10K

The Ingalls team has decided to move forward with the rotary crawler for 4”-6” and 6”-8” diameter piping. (Likely two distinct systems.)

Phase II Next Steps

- In Phase II, Ingalls will fabricate the test article mock-up structure, GE will develop and fabricate the pipe inspector prototype, and the team will work together to complete validation testing. Once testing is complete, Ingalls will update the business case and prepare for full implementation.

- Phase II – Prototype Development and Functionality
  - Task 4 – Program Management
    - Deliverables: Final Review and Presentation, Final Technical Report
  - Task 5 – Fabricate Mock-Up Structure
    - Deliverables: Evaluation Mockup
  - Task 6 – Prototype Development
    - Deliverables: Prototype, Vendor Prototype Validation Report, Updated Prototype Design
  - Task 7 – Prototype Validation Testing
    - Deliverables: Validation Test Plan, Shipyard Evaluation Report, Prototype Acceptance Report

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Questions?

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