Gecko Robotics: Advanced UT Inspections

"Applying New Technologies to Your Project"

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Problem Statement

Predominant inspection methods are largely manual and produce insufficient information. The lack of information and inability to harness large physical data sets for optimal decision making costs facilities millions of dollars annually due to over or under-repair, and unscheduled maintenance.

Current Methods

•**Slow:** Traditional inspection methods are time consuming and prone to operator error / repeatability issues

Costly: Traditional inspection methods are costly in terms of direct labor cost, cost of over repair, cost of under repair, unplanned maintenance, and access costs.

•**Little Actionable Data:** Inspection data cannot be analyzed over time in one consolidated platform to identify damage evolution, determine targeted repairs, and define predictive maintenance intervals

Gecko's Methods

- **Automated and efficient:** Coverage over surface areas previously thought to be time and cost prohibitive
  (ex UT Corrosion Mapping Robot can cover 5,000 ft^2 per 12-hour shift)
- **Cost effective:** reduce access requirements, direct labor, and unscheduled maintenance
- **Actionable data:** millions of data points visualized through 2D or 3D tools to target repairs, monitor damage over time, and better guide materials orders
- **Digital twin:** identify damage progression, target repairs, and define optimal maintenance intervals

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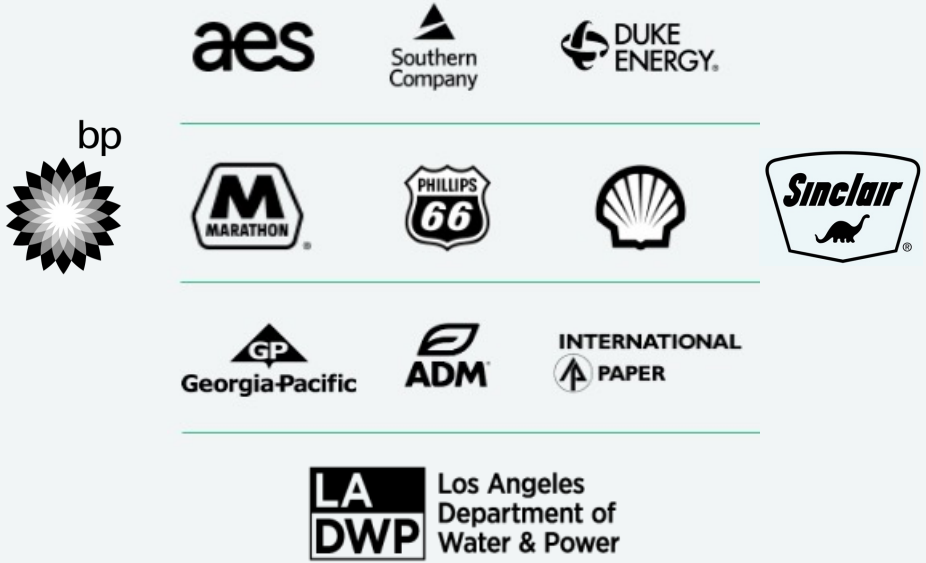
Mission

To protect today's critical infrastructure (and inform tomorrow's projects).

Gecko Robotics is a service-based contractor offering comprehensive inspections of critical assets using **advanced robotics, data visualization and analysis tools.**

Gecko's examinations produce high-volume and high-quality data for predictive insights, preventative maintenance, and **savings in costs and time**.

Gecko Robotics can provide **faster, safer and high quality** inspections that can sometimes lead to more cost effective project outcomes.



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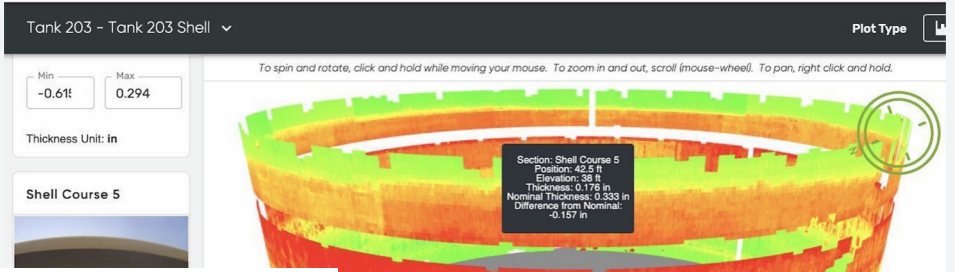
Gecko Robotics: Tank Shell Inspection via Rapid Ultrasonic Gridding

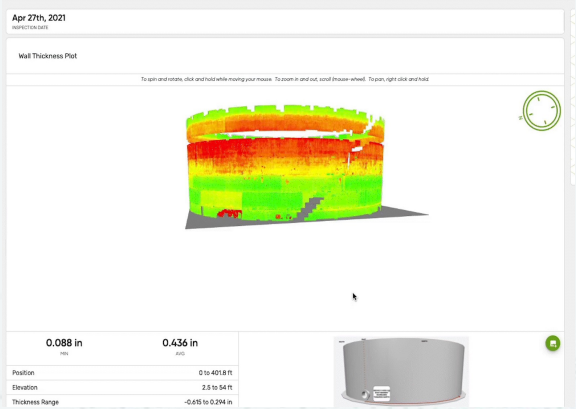


Background:

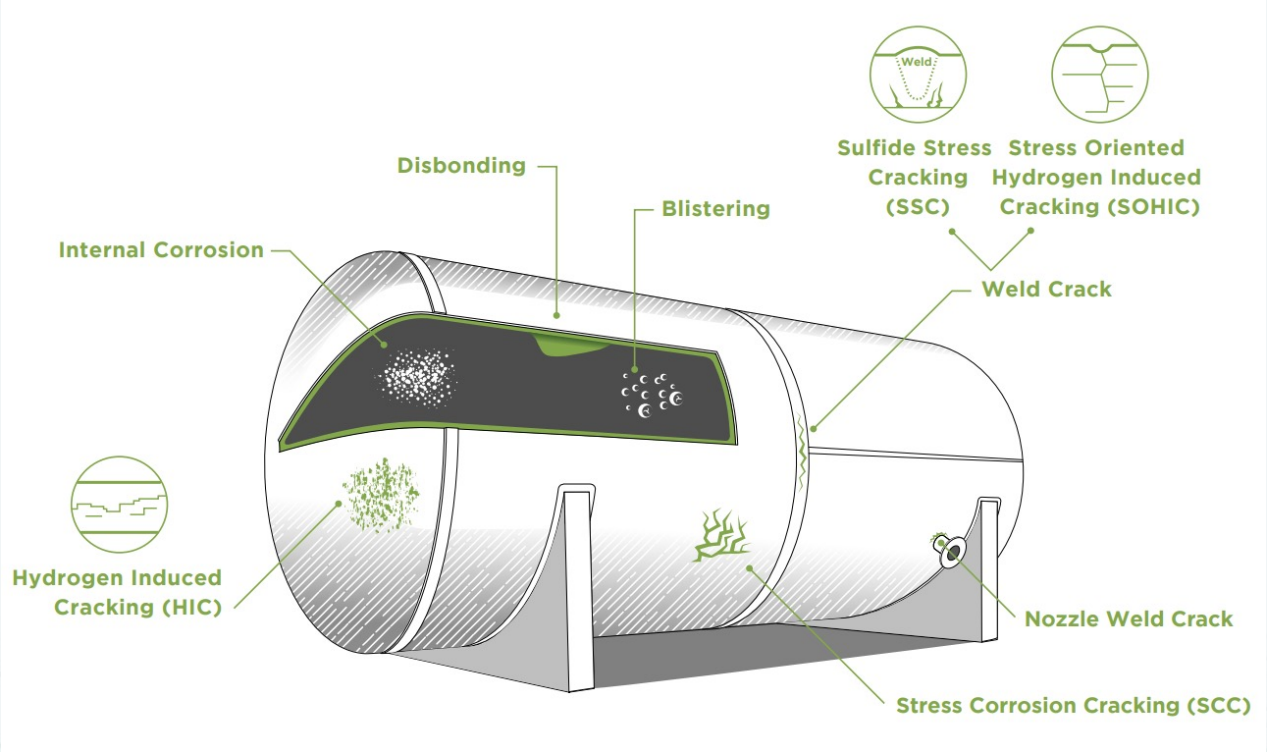
- Tank 203: 56' tall / 128' diameter.
- Tank 204: 53' tall / 96' diameter.
- Scope of work was 100% external UT scan on both tanks to determine internal coating condition and corrosion identification.

Benefits:

- Opportunity
  - Reduced Tk203 repair scope from full replacement ($1.2M) to replacing 1 course w/minor patching ($270K)
  - Performing the inspection online reduced tank outage timeframe for initial discovery insp.
  - Scope completed in 3 days @ 24K
    - Traditional AUT proposal was 5.2 weeks @ $48K
- Execution
  - No scaffolding required – ground access with JLG for repositioning above wind girder
  - Fast scanning of 30ft./min.
  - Gecko utilizes chicago style hose fittings
- Data
  - 39M readings between both tanks obtained
  - Follow up UT performed to confirm lamination calls & validate data
  - Gecko Portal allows ease of viewing 3D rendering with thickness overlaid using color schemes



Advanced Inspections for:



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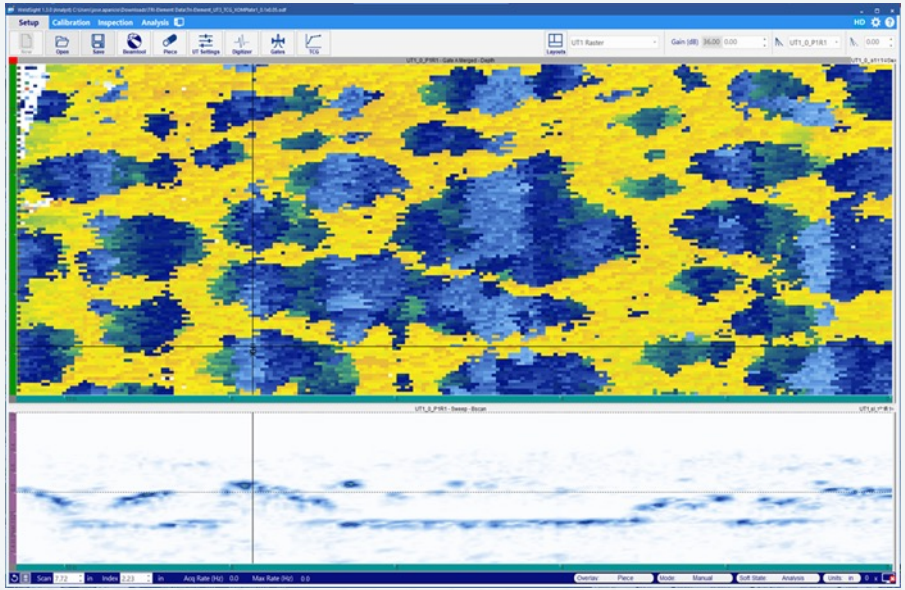
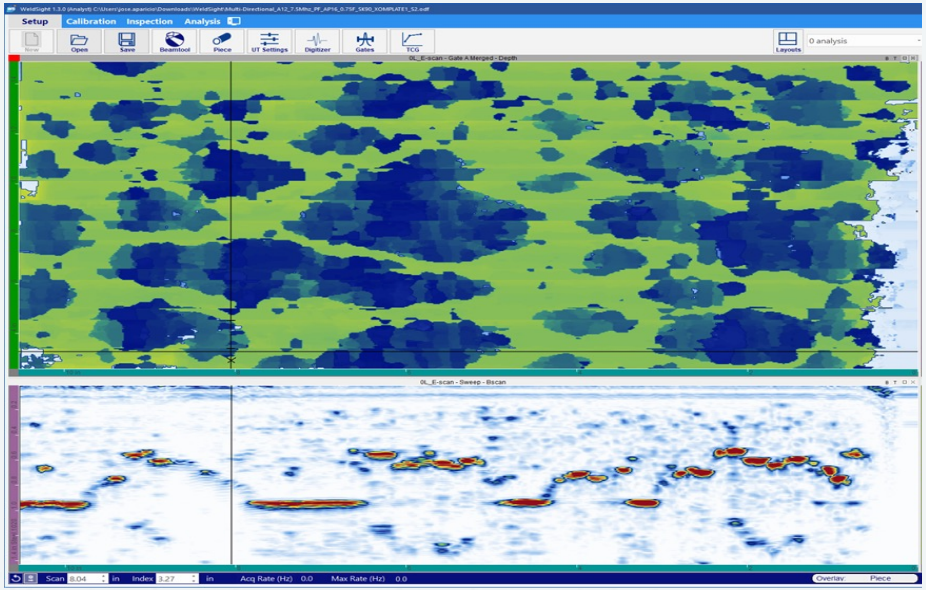
Automated Tools for Speed + Quality

Higher Resolution Data to Pinpoint Damage

Tri-element AUT



Tri-Lateral Phased Array



A, B, C, and D scans to visualize the depth and severity level of subsurface damage.

Positively identify laminations, inclusions, blisters, periphery cracking, and stepwise cracking.

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Hydrogen Damage Case Study: Butane Sphere

Goal

Inspection to support repair/replacement project.

Gecko Approach

- Option A) External Tri-Lateral Shell + External Automated PAUT Weld inspection
- 12 shifts, ~$120,000k (60% cost savings, 60% time savings)
- No scaffolding or vessel entry required for inspection

Status Quo

- Option B) Traditional External AUT inspection: considered cost prohibitive because of time for inspection: 30 shifts at $300k for inspection
- Option C) Internal Inspection via engineered scaffold: $500k+

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Case Study #1: Dry Dock Caisson

Current Process:

- 240 man hours, 104 hour cycle time
- Majority of work at unsafe heights
- Manual sampling creates 70 readings
- Uncertainty over asset condition
- No digital information for analysis

Gecko Solution:

- 10 man hours (25x reduction), 13 hour cycle time (8x reduction)
- Full comprehensive digital data set for assessment and remediation
- Corrosion map displays millions of UT readings with images
- Online portal provides rapid insight and fuel AI/ML models for condition based maintenance transition

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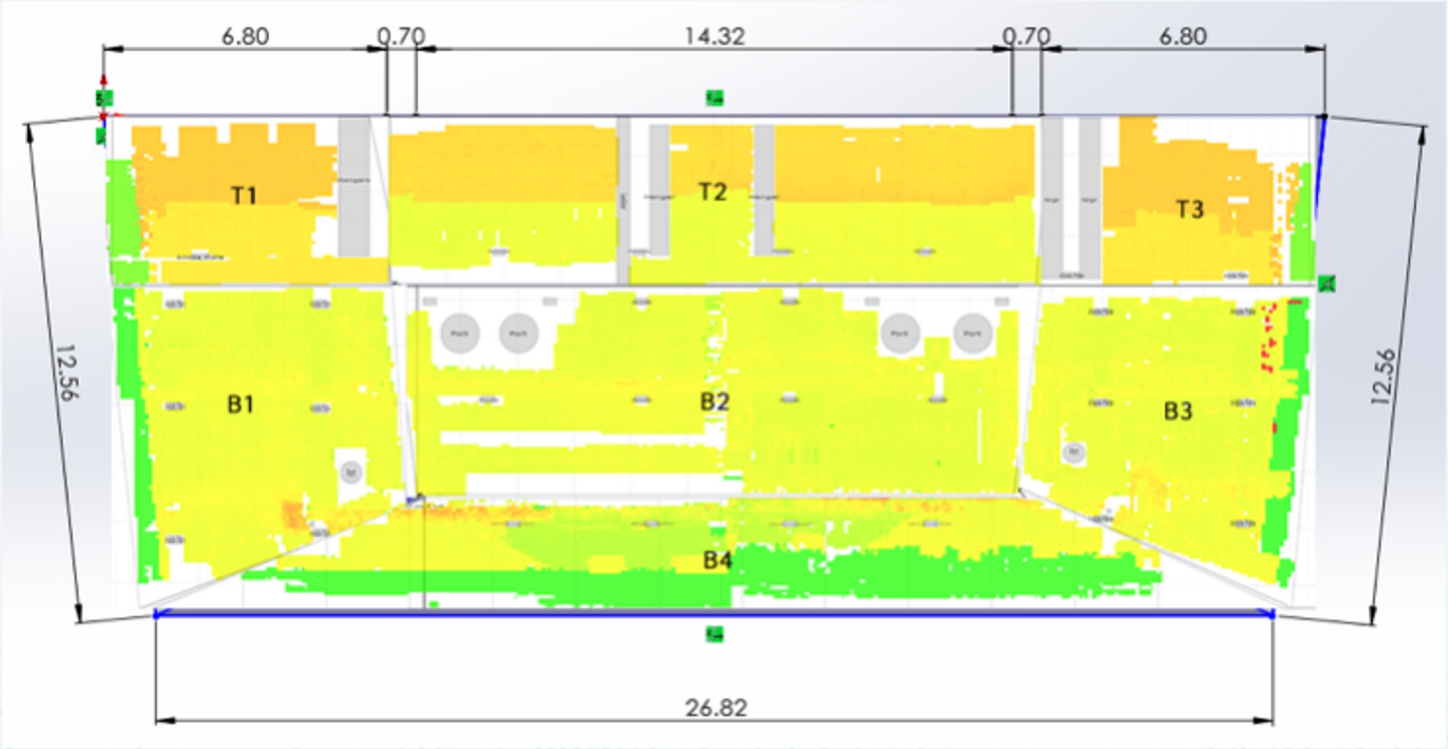
Caisson Scan Data



Case Study #2: Ship Hull Structure

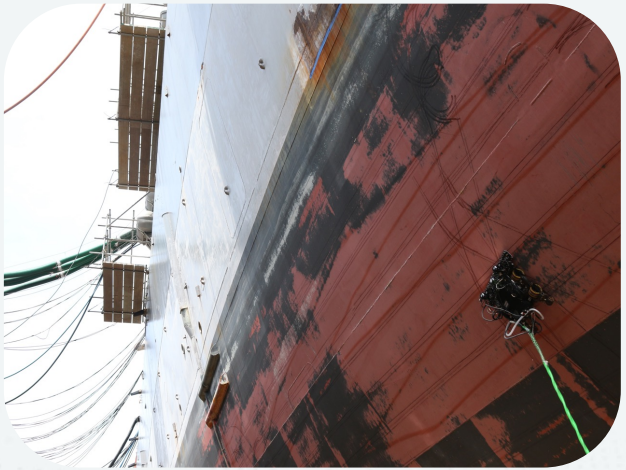
Challenge: The degradation of surface ship undersea hull structure is often unknown and siloed into inefficient and disparate workflows. This problem can be mitigated with a comprehensive view of the right data distributed throughout multiple channels.

Current Process:

- 728 man hours, 237 hour cycle time
- Repetitive process, multiple inspections and analysis before remediation
- No digital information for analysis

Gecko Solution:

- 29 man hours (25x reduction), 29 hour cycle time (8x reduction)
- Full comprehensive digital data set for assessment and remediation
- Corrosion map displays millions of UT readings with images
- Online portal provides rapid insight and fuel AI/ML models for condition based maintenance transition



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Piping Case Study (Overhead Crude Line)

Goal

Inspect as much surface area as possible for overhead crude and fractionator lines. Lines are active and 300°F.

Status Quo

- GUL Guided wave with ultrasonic follow-up
- Scaffold and ropes required

Gecko Approach

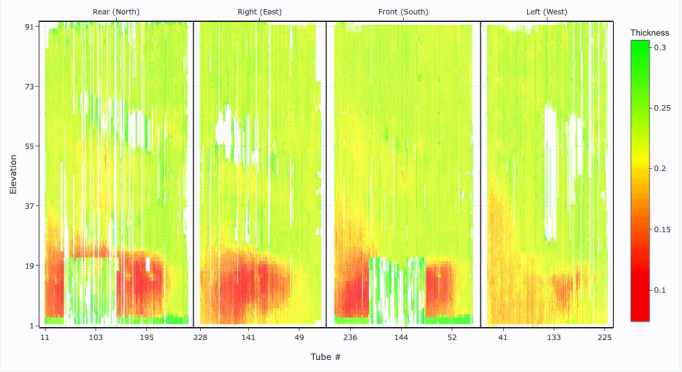
- Scan piping with TOKA Flex platform
- 400 A-scans per square foot of surface
- No scaffolding or ropes
- 2 shifts per inspection
- Continuous monitoring every 3 months

Client used this inspection to prove Gecko capabilities for Delta mapping. They wanted to evaluate the accuracy and usability of Gecko for repeat inspections.

Proven Track Record

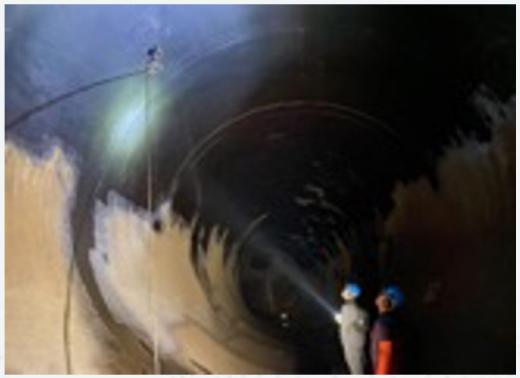
3500 MW Power Plant (1.75M Households)

- Power plant incurring 12 forced outages annually
- Gecko Robotics inspection and data analysis provided a comprehensive understanding of current and future asset condition
- Zero forced outages after Gecko Robotics condition based maintenance program



Dam Penstock

- 1,000x data density than standard inspections
- Access to areas not possible using manual NDT



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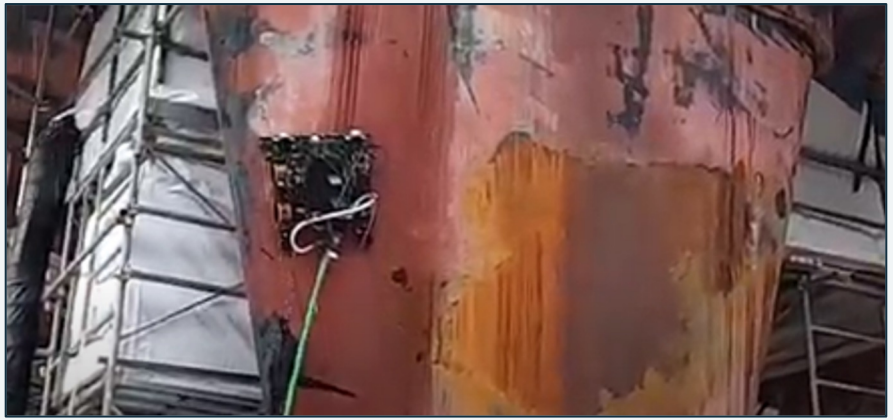
Primary Transition Opportunity – Propulsion Equipment

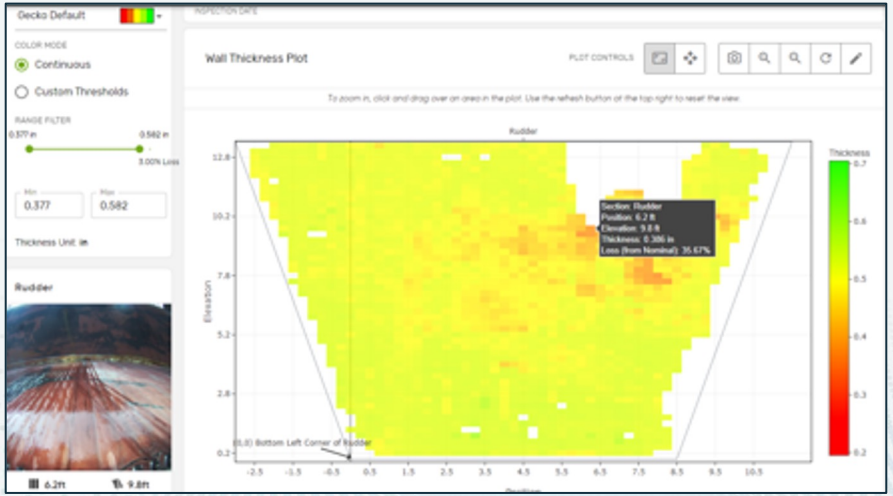
Current Process:

- 184 man hours, 88 hour cycle time
- Limited data produced for critical asset
- Utilizes sampling and extrapolation methods which does not provide certainty over asset condition
- No digital information for analysis

Gecko Solution:

- 8 man hours (23x reduction), 8 hour cycle time (11x reduction)
- 1M readings per rudder
- All work complete from ground level
- Millions of UT readings with associated images paired to UT heatmap





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Current State vs Future State Using Gecko Robotics

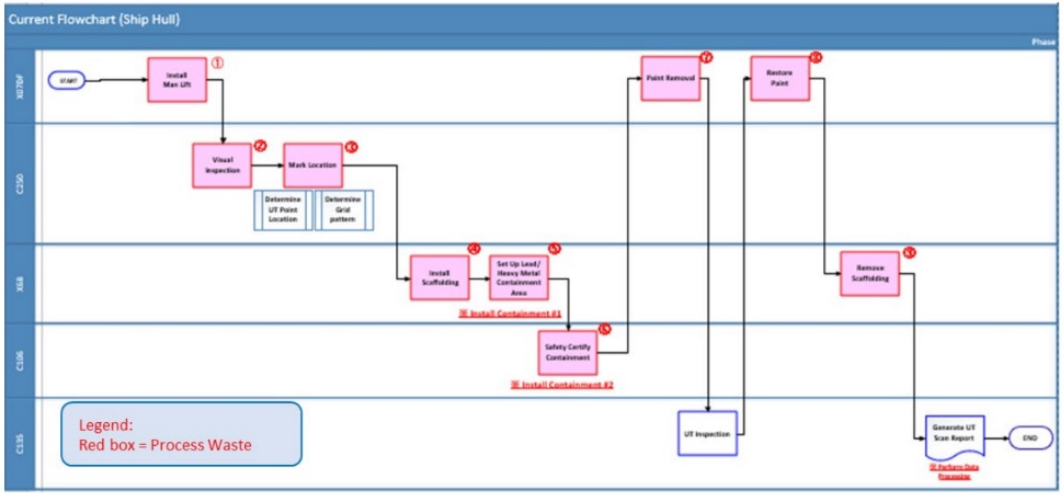

Figure 5. Current Process for Ship Hull and Rudder Inspection

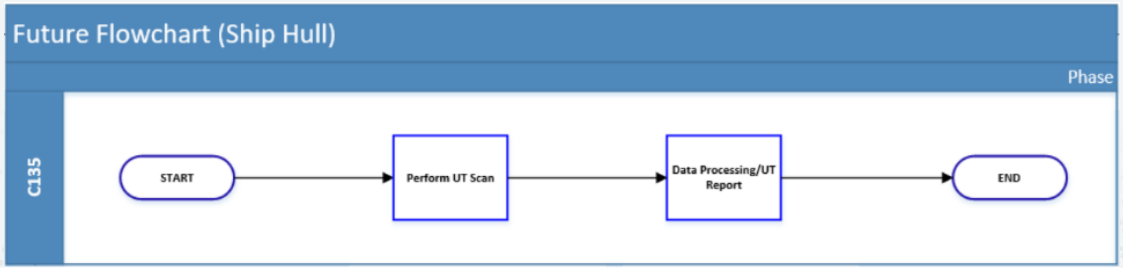

Figure 6. Modernized Process Utilizing Gecko Robotics for Ship Hull and Rudder Inspection

Process Breakdown – Rudder Inspection Report Out

Ship Rudder (one side) Inspection Steps	Man-Hours [Before]	Man-Hours [After]	Man-Hours Reduction	Lead Time (days) [Before]	Lead Time (days) [After]	Lead Time Reduction (days)
Install Scaffolding and Setup	24	1	-23	8	1	-7
Perform Visual Inspection	8	0	-8	8	0	-8
Mark Locations	16	0	-16	8	0	-8
Paint Removal	8	0	-8	8	0	-8
Perform UT Inspection	16	1	-15	8	1	-7
Restore Paint	16	0	-16	16	0	-16
Remove Scaffolding	24	0	-24	8	0	-8
Perform Data Processing	72	6	-66	24	6	-18
Total	**184**	**8**	**-176**	**88**	**8**	**-80**

Surface Fleet Wide Transformation Implications

Current Outcome:

- 88 hours, 11 drydock days per rudder
- Approx 9% of total planned drydock time
- Less than 40% of surface ships get out of drydock on schedule

Gecko Outcome:

- 8 hours, 1 day cycle time
- 10 day cycle time reduction
- 176 hours of manpower reduction that can be reallocated to critical path work
- **194 drydock days saved annually** (9 year availability schedule)

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Value

- If drydock days are the bottleneck to your problem, what does *194 days of drydock saved per year mean to your budget and capacity for drydock projects?*
- *What if you could save $1 million on multiple of your tank* shell maintenance projects per year?
- *How much savings can you find if you can use pre-turnaround inspections to scope maintenance and purchase materials ahead of time?*
- *What if you could decrease the duration of your turnarounds because inspection windows can be narrowed, or assets can be removed from turnaround scope entirely?*
- *Can higher quality inspections reduce the probability of unplanned maintenance and outages?*

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Questions?

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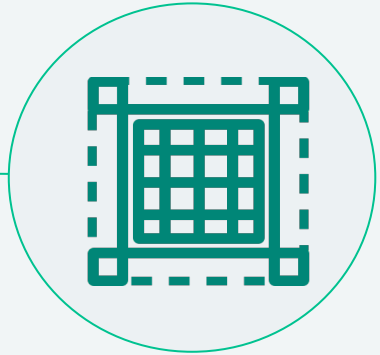
Robotic Inspection Toolbox

Rapid Ultrasonic Gridding (RUG)

General corrosion
5,000 ft^2 / 12-hour shift
Wall thickness < 0.70”
Surface temp up to 275°F

Rapid AUT (R-AUT)

Localized corrosion + pitting
500 ft^2 / 12-hour shift
Wall thickness 0.125-8.00”
Surface temp up to 400°F



Tri-Lateral Phased Array (TriLat)

Wet H_2S & hydrogen damage
500-1,000 ft^2 / 12-hour shift
Wall thickness 0.375-4.00”
Surface temp up to 400°F

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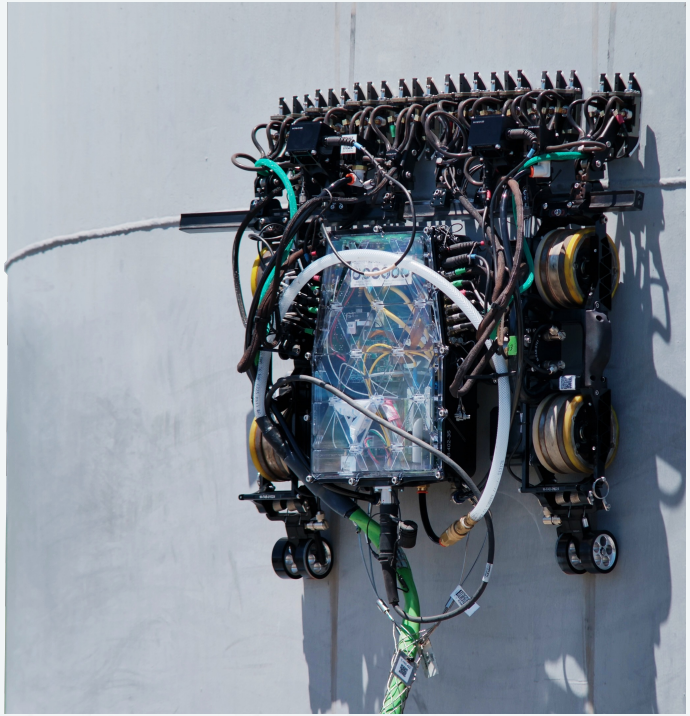
Rapid Ultrasonic Gridding

- Identifies and quantifies **corrosion, erosion, and pitting**
- Up to 24 ultrasonic testing (UT) transducers
    - **700 readings/second**
    - Ultrasonic frequency 5-10MHz
- High speed corrosion mapping
    - **Travels 3-6 inches/second**
    - 2D and 3D C-scan corrosion maps
- Onboard camera and stored HD imagery for visual inspection
    - **Scanning outside line of sight**
- Climbable and steerable, limited access requirements



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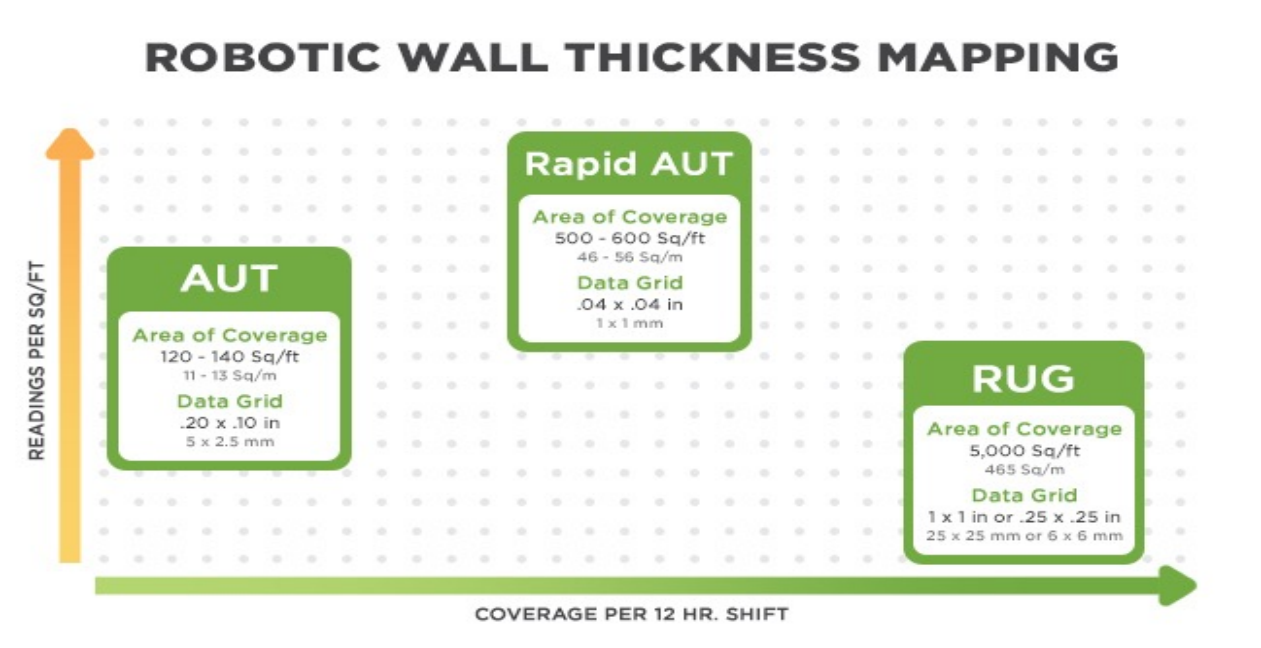
Speed, Quality, & Access Advantages



Tri-Lateral Phased Array

- Identifies and quantifies **wet H_2S damage, including HIC, SOHIC, blistering, and environmental cracking**
- Proprietary phased array probe unit with two probes and three angle beam sets for multi-directional scanning
    - Passive and active focalization
- Unprecedented speed and resolution
    - **2.4 linear feet/minute**
    - **Over 150,000 readings/foot^2**
    - Identifies damage at a depth of 4 inches

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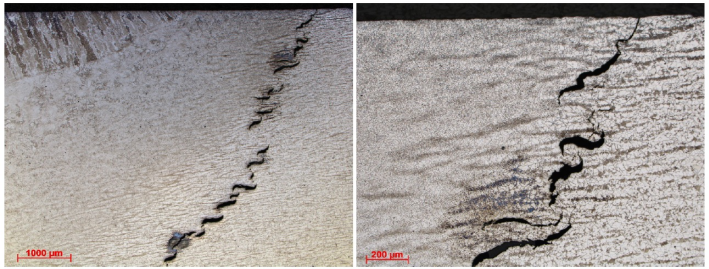
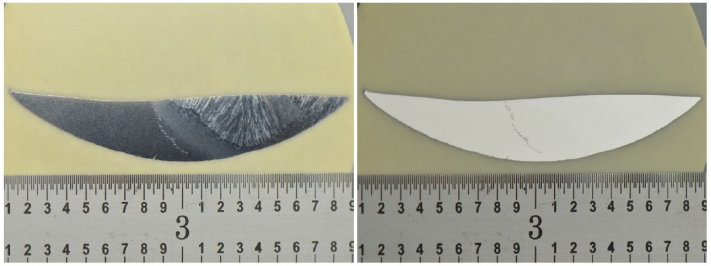
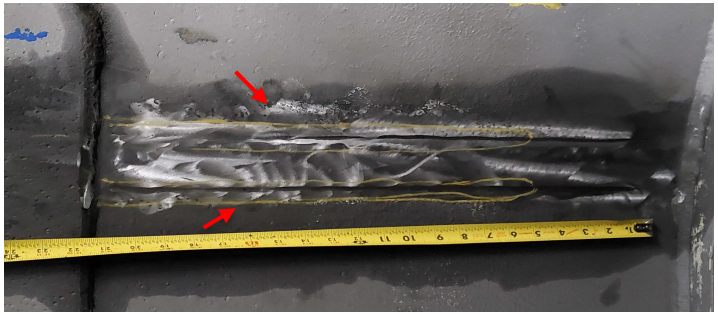
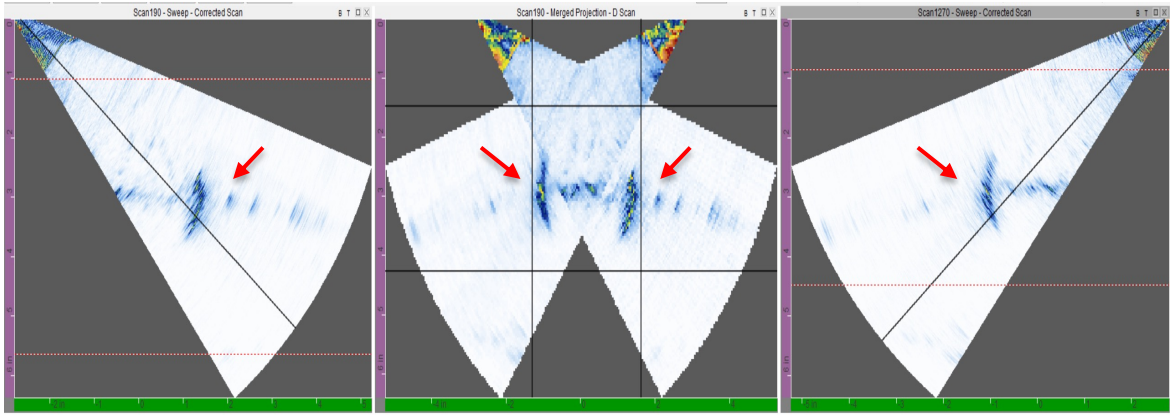
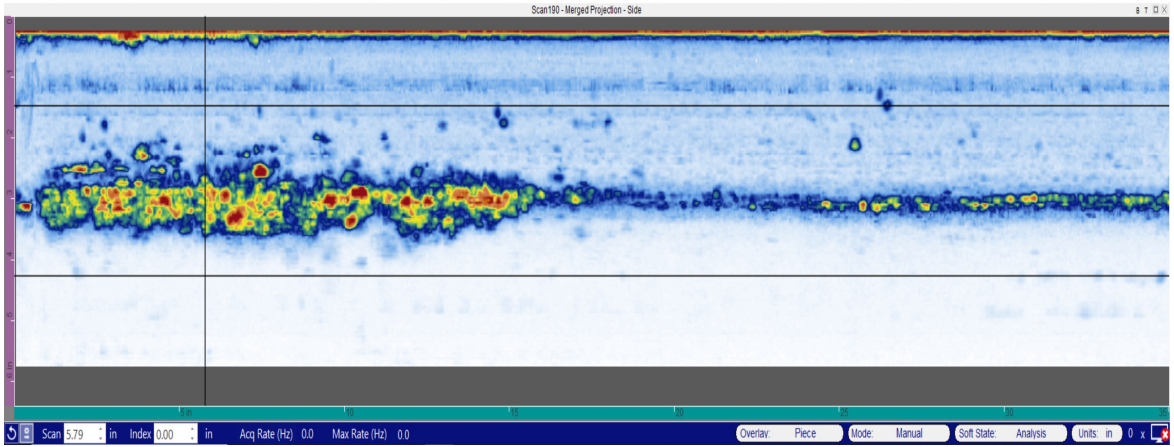
Case Study: Amine Recycle Gas Scrubber











Manual PAUT vs Phased Array UT

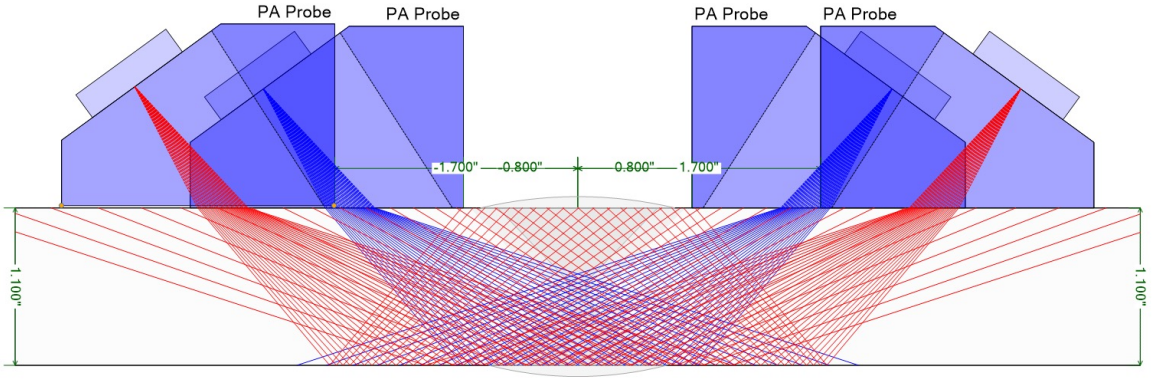
Weld Inspection

Robotic Phased Array

- High productivity
- 2-4 zone coverage in single pass
- High quality data
- Scanning can be done autonomously
- 500-2,500 linear ft / shift

Manual/Semi Automated Phased Array

- Hand driven
- Less accessibility; needs hands on access
- User dependent on data quality
- Poor repeatability
- 100 linear ft / shift



Cracking Detection and Sizing

Time of Flight Diffraction (TOFD) and **Phased Array (PAUT)** are two common tools that can be remotely deployed for the detection of discontinuities.

Remotely scan for discontinuities such as **cracks, corrosion, and flaws** with a high level of production and detection.

These technologies, deployed individually or together, can make a great alternative to dye penetrant or mag particle testing on assets such as pressure equipment.