

# Welcome!

The program will begin soon.  
You will not hear audio until we begin.

# Robotics: In-Service Inspection Capabilities and Future Trends

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# Tank Inspection – The Traditional Approach

- ❑ PROJECT LASTS WEEKS OR MONTHS
- ❑ DRAIN, VENT, CLEAN, WASTE DISPOSAL
- ❑ INSPECT WITH MAGNETIC FLUX LEAKAGE (MFL)
- ❑ VALIDATE WITH ULTRASONIC (UT) Prove-ups
- ❑ REPAIR *"SINCE IT IS OUT OF SERVICE"*



# Robotics Enable Safe, Informed Efficiency



## Environmental, Social, Governance

- Zero confined space entry
- Reduced work at heights
- \*Carbon Equivalent releases contained per average tank:
  - Diesel > 5 Tons
  - Gasoline > 20 Tons

\*Source - Third Party Verified for 100' diameter tank

## Capital Efficiency

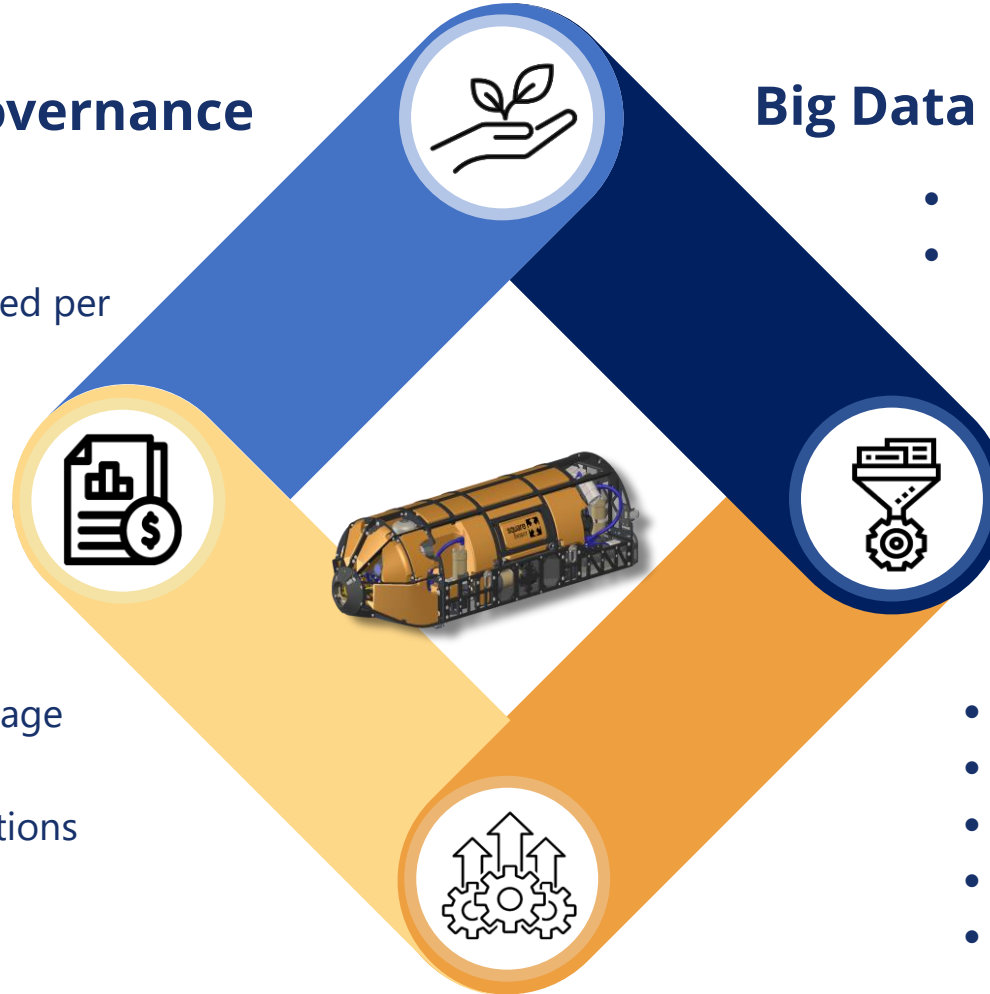
- \*\$300,000 - +\$2M savings per average out-of-service tank operation
- Proactive risk vs time based inspections

## Big Data Solutions kBytes to tBytes

- High confidence / high resolution data
- Big data feed / advanced processing
  - API 653 / EEMUA 159
  - RBI / EVA / Digital Platforms

## Operational Efficiency

- In-Service Inspection
- Tank utilization
- Extended out-of-service dates
- Extended tank life
- Predictive repair & maintenance



\*Source - Solomon Associates 2018 Fuels Study

# Is Robotic Inspections Allowed?



## EMMUA 159

- Paragraph 6.4.2.2.2.1 - It is the responsibility of the tank owners' Tank Integrity Assessor (TIA) to decide whether or not the robotic inspection results can be applied in lieu of conventional out-of-service inspection or can be considered as a basis for next condition or risk-based inspection date.

## API 653

- Section 6.4.1.2 - If the internal inspection is required solely for the purpose of determining the condition and integrity of the tank bottom, the internal inspection may be accomplished with the tank in-service utilizing various ultrasonic robotic thickness measurement and other on-stream inspection methods capable of assessing the thickness of the tank bottom, in combination with methods capable of assessing tank bottom integrity as described in 4.4.1.

## API 575

- Section 5.1.3 - In-service inspections performed while the equipment is in operation using nondestructive techniques, including techniques such as robotic magnetic flux leakage (MFL) or acoustic emission examination, may reveal important information without requiring entry into the tank. With such data and information, FFS or RBI evaluations can be performed, which can aid in maximizing the period of operation without taking the tank out of service.
- Section 8.4.5.3 - Statistical methods are also available for assessing the probable minimum remaining metal thickness of the tank bottom, and the methods are based on a sampling of thickness scanning data. The number of measurements taken for a statistical sampling will depend on the size of the tank and the degree of soil-side corrosion found. Typically, 0.2 % to 10 % of the bottom should be scanned randomly. The collection of thickness data is required to assess the remaining bottom thickness.

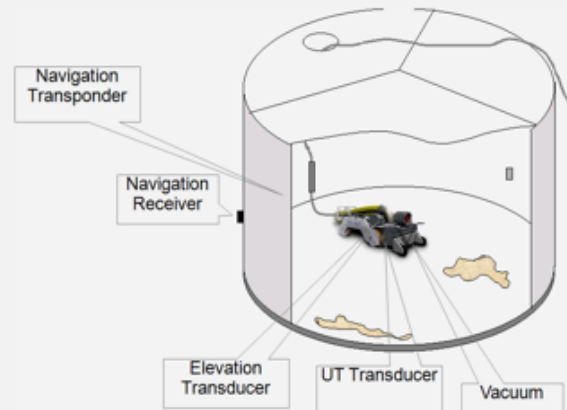


# In-Service Robotic Inspection Technology



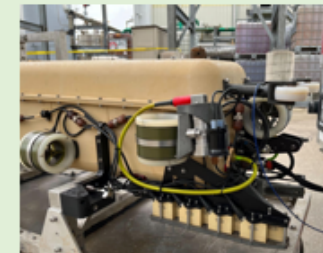
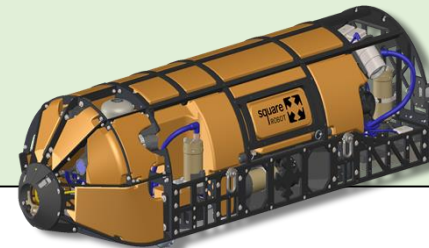
## Generation I Robot Crawling

- FM Class 1 Division 1 (C1D1) compliance through process/nitrogen blanketing
- 3"- 4" umbilical support power and communications
- Power/navigation from outside of tank
- Positioned using external acoustic transponders
- Payloads include Magnetic Flux Leakage (MFL), Spot Ultrasonic, Camera (outward)



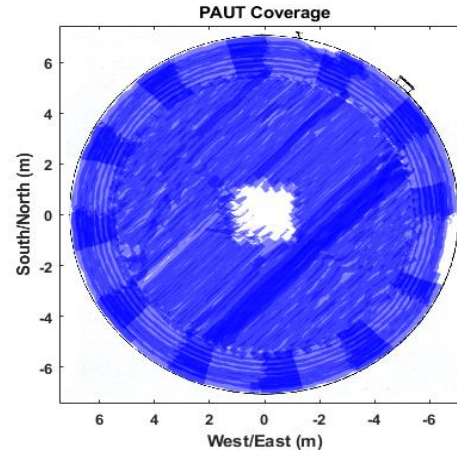
## Generation II Robot Autonomous, Submersible, Swimming

- FM Class 1 Division 2 (C1D2) certified robot
  - Process can also be certified C1D1
- ¼" fiber optic communications cable
- Onboard power/autonomous navigation
- Onboard positioning sensor package
- Payloads include Phased Array Ultrasonic (PAUT) and two Cameras (outward/floor)
  - Plate thickness over entire coverage area
  - Product/Soil Side corrosion and defect mapping
  - Sediment/sludge mapping
  - Tank Bottom Settlement

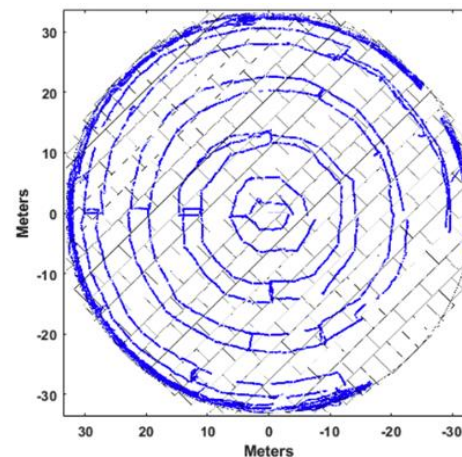


# Robotic Inspection Considerations

- Quantitative/Qualitative Data
  - Supports informed decisions
  - Extends out-of-service dates
  - Recommend repairs
- Coverage Dependencies
  - Available Inspection time
  - Sludge level and consistency
  - Physical appurtenances
  - Robot access



High Coverage  
= Higher Confidence



Low Coverage +  
Extreme Value Analysis (EVA)  
= Improved Confidence

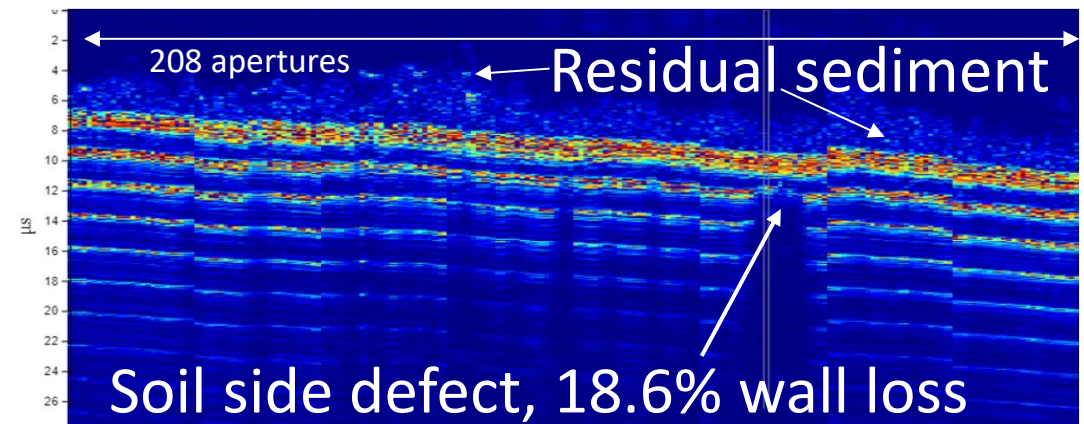


# Internal Tank Inspection

## PHASED ARRAY ULTRASONIC TESTING

- 256-element PAUT transducers (12-inch Array)
- Soil vs product side corrosion indications
- Thin and Thick Film Liners
- Up to 60mil Fiberglass Liner
- 18,000 data points per square foot
- Critical zone scanning within 0.5" of the shell
- Compliance with regulatory requirements:  
API 653, NFPA, EPA

**PAUT replaces the need for  
traditional MFL & single point UT**

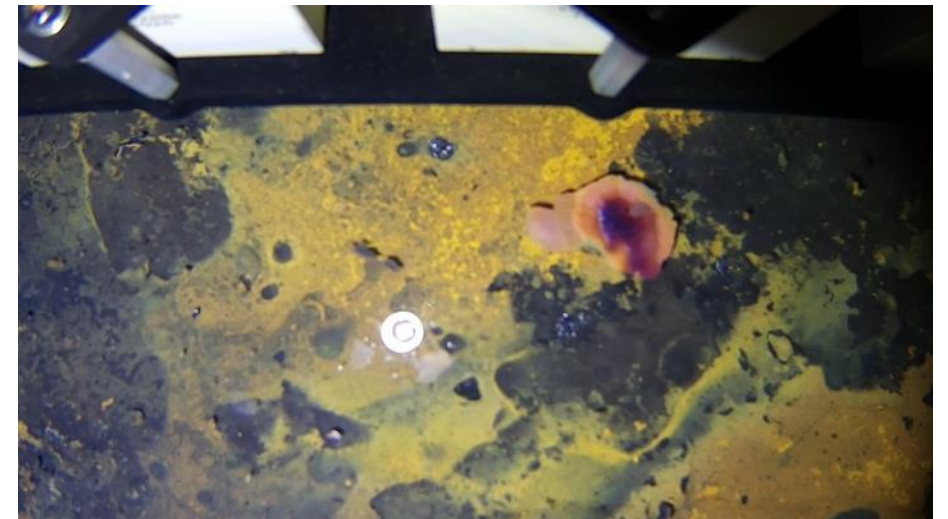
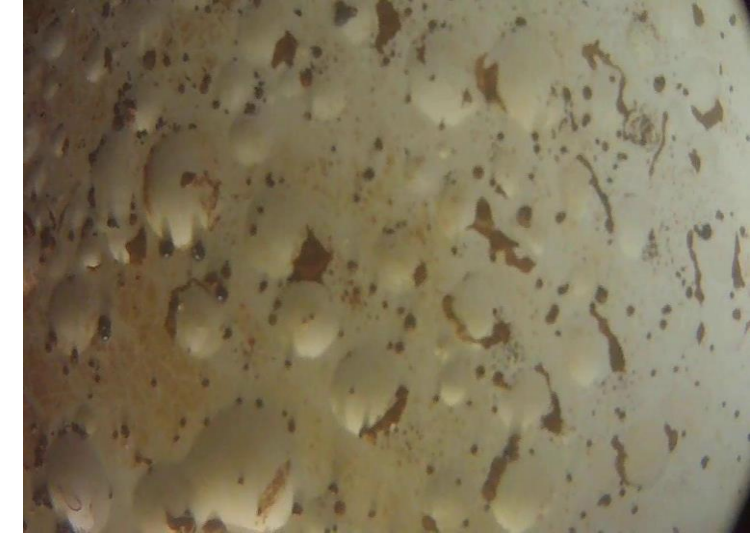




# Internal Tank Inspection

## VISUAL INSPECTION

- Two high-resolution (1080p) cameras with LED lighting
- Downward focused
  - Coating
  - Tank Bottom
  - Water Puddling and Sediment
- Outward focused
  - Columns
  - Sumps
  - Shell
  - Roof/Seals
- Internal floating roof seal inspection (SR3 only)

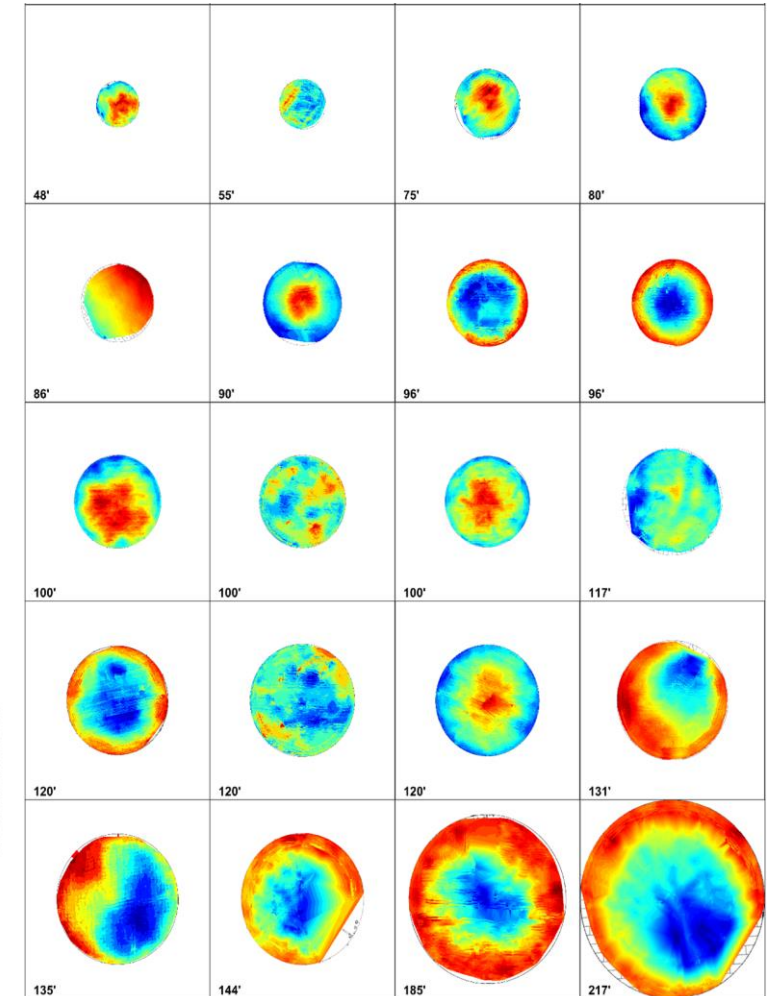
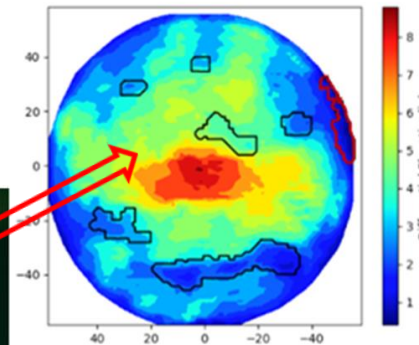
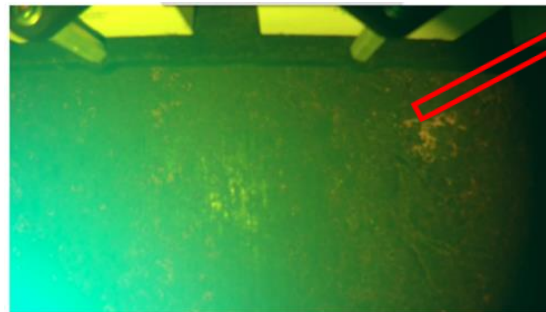


# Internal Tank Inspection

## TANK BOTTOM SETTLEMENT SURVEY

- Simultaneously completed with PAUT Inspection or as a standalone survey
- Survey uniquely under fully loaded tank conditions
- Heat map illustrates relative tank bottom elevation
- Identifies low areas where puddling may occur

Surveying under loaded conditions provides the most accurate data



# The Future of Robotics?

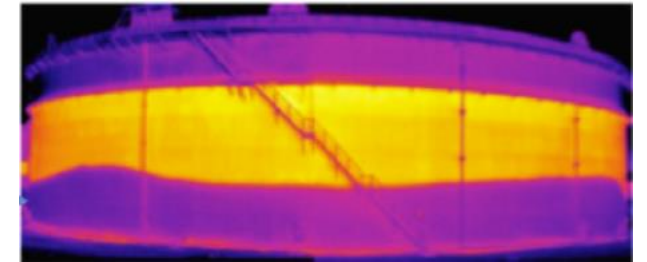
## Capabilities

- Seal Inspections
- Insulated Tanks (CUI)
- Sediment Mapping



## Near Future to Future

- Crude Tanks
- Cleaning
- Coatings
- Repair
- Sumps
- Welds
- Resident Robots



# ANY QUESTIONS?

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