Mechanizing Industrial Asset Inspections and Integrity Assessments

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Managing outcomes with multi-sensor source data integration and inspection capabilities

THE FUTURE OF INSPECTION: CROSS-INDUSTRY ANALYTICS PLATFORM

WHAT IS NEEDED?

- Domain expertise
- Technical expertise
  - Sensors
  - Analytics
  - Robotics and automation
  - Software development and systems design
- Delivery and process expertise
- Customer and market focus
Mechanized inspections can drive value across industries

- Decrease facility inspection costs up to 25% annually
- Increased equipment uptime up to 10-15% with optimized Capex replacement schedules
- Increased human safety
Automating and augmenting manual inspection processes

**AUTONOMY & ROBOTICS**

- UAVs for remote vision, IR, and fugitive methane detection
- Robotic crawlers for UT
- Autonomous underwater vehicles

**HANDHELD & INSTALLED SENSORS**

- GE’s connected advanced inspection tools
- Persistent corrosion monitoring via installed sensors

Avitas Systems, a GE Venture
Remote visual and infrared aerial inspection

A SAFER, MORE EFFICIENT APPROACH TO ASSET INSPECTION

Current inspection approach
> Camera/video mounted on helicopter
> Rope access
> Scaffold
> Crane and man baskets

TECHNOLOGY
> Safer operation; eliminates dull, dirty, dangerous tasks
> Controlled flight and inspection plan
> Better visibility, more thorough asset inspection
> Higher quality data with the ability to mount RGB and IR cameras
> Faster, more reliable process

SOFTWARE
> Real-time data analysis
> Repeatable process for longitudinal and autonomous data collection
> Risk-based strategy (vs time-based)
> Cloud-based storage and reporting

BENEFITS
> Increase inspection safety
> More efficient, higher quality inspections with more comprehensive data collection
> Reduce manual inspection labor
> Decrease in inspection costs
Fugitive emissions inspection

COST-EFFICIENT SOLUTION FOR IDENTIFYING LARGE AND SMALL FUGITIVE EMISSIONS

Current inspection approach

> Intermittent, labor intensive, and time consuming inspection without leak rate or volume
> Today’s detection technologies are either sensitive or cheap, but not both

Technology

> Reduced inspection time (when compared with currently used OGI practices)
> Enhanced data quality; provides both qualitative and quantitative analysis of leakage
> Increased sensitivity for identification of small-scale leakage

Software

> Autonomous inspections
> Automated, customizable reporting and uploading to cloud-connected database

Benefits

> Reduced cost per inspection/site
> Reduced time per inspection/site
> Reactive leak mitigation strategy
Robotic crawlers

A SAFER, MORE EFFICIENT AND COMPREHENSIVE APPROACH TO INSPECTION

**Current inspection approach**

> Manual inspection with ropes teams and scaffolding

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<tr>
<th>TECHNOLOGY</th>
<th>SOFTWARE</th>
<th>BENEFITS</th>
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| > Safer operation  
> Controlled, precise, repeatable inspection plan  
> Better visibility, more consistent and thorough asset inspection  
> Higher quality data with the ability to mount RGB and IR cameras, stereo, structured light, PEC and UT  
> Faster, more reliable process | > Real-time data analysis  
> Repeatable process for longitudinal and autonomous data collection  
> Risk-based strategy (vs time-based)  
> Cloud-based storage and reporting | > Increase inspection safety  
> More efficient, higher quality inspections with more comprehensive data collection  
> Reduction in manual inspection labor  
> Decrease in inspection costs |
Subsea inspection

INCREASING DATA QUALITY WHILE REDUCING COSTS

Current inspection approach

> Work class ROVs with high cost 10 man crew and support vessel
> Inspections are slow with manual navigation and tether restrictions
> Data quantity is low (e.g., annually) and quality can be limited

Technologies

- Autonomous underwater vehicles
- Precision navigation to points of interest
- 3D field models and topographical mapping
- Laser and high definition imaging
- Host of NDE instruments
- Localization, collision avoidance and auto defect recognition

Software

- 3D and topological data fusion with direct and indirect associated signatures
- Object perception and classification for significance
- Probability map and statistics for identifying areas to explore based on supporting sensor info

Benefits

- Increase the quality and quantity of actionable inspection data to enable better operational decisions
- Reduce the operational costs for performing subsea inspections
- Reduce the non-productive time of subsea operations
- Extend the life of subsea assets
Sensor mesh networks for continuous VOC monitoring

COST EFFECTIVE CONTINUOUS QUANTITATIVE MONITORING VS. INTERMITTENT QUALITATIVE INSPECTION

**Current inspection approach**
- Man + pickup + OGI device
- Qualitative output
- Manual review and reporting
- Intermittent

**TECHNOLOGY**
- 24/7 self contained and self powering
- Ruggedized and intrinsically safe
- PPM sensitivity
- Multispecies sensing… C1 – C4
- Multi-nodal distributed network
- Cost competitive to semiannual inspection

**SOFTWARE**
- Cloud-based leak source localization
- Mobile-enabled leak notification and analysis
- Leak rate calculation
- Cloud-based storage and automated reporting
- Advanced sampling automation

**BENEFITS**
- Scalable to large dispersed operations
- Simple upkeep and maintenance
- Risk-based strategy (vs time-based)
- Safer operation; less miles driven by personnel to remote locations

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# Predictive corrosion management

**REAL-TIME, CONTINUOUS VISIBILITY OF THERMAL AND THICKNESS INSPECTIONS**

## Current inspection approach
- Expensive operation
- Scaffolding required on semi-permanent basis
- Insulation removal is a MOC
- Impact on population in vicinity

## TECHNOLOGY
- RightTrax installed UT sensors; collect corrosion and temperature data
- Repeatable, accurate corrosion measurement
- Reduce manual corrosion-based inspection labor
- Designed for safety; ATEX certified

## SOFTWARE
- Repeatable, accurate corrosion measurement
- Continuous data across multiple inspection points
- Trend and predict failures and schedule maintenance

## BENEFITS
- Conduct inspections in-service vs. shut down
- Eliminate or reduce manual inspection labor
- Eliminate costly scaffolding, rigging, and insulation removal
The Avitas Systems solution

WORKFLOW MANAGEMENT
> Risk-based inspection and maintenance workflow optimization

DATA FUSION
Store and structure
Normalization
Integration with APM

RISK-BASED ANALYTICS
Predictive analytics
Automated defect recognition

INTERACTIVE DASHBOARDS
> Synthesized operations, maintenance, and inspection data
> Alerts and live, interpreted results

AUTONOMY AND ROBOTICS
- Aerial
- Subsea

AUTOMATED INSPECTION AND SENSOR ANALYTICS
- Ultrasonic
- Fugitive emissions
- Persistent corrosion monitors

NATIVE SYSTEMS
- Operational systems

EXISTING DATA SOURCES
- Environmental data

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Inspection planning maturity curve

**Time-based**
- Base maturity
- Common current method of operations
- Limited to no digitization
- Reactive with no analytics

**Usage-based**
- Maturity level I
- Common current method of operations
- Digitization of business data
- Reactive with simple analytics

**Condition-based**
- Maturity level II
- Desired method of operation
- Digitization of business and operations data
- Pro-active with advanced analytics

**Risk-based**
- Maturity level III
- Target method of operation
- Complete digitization, including risk strategy
- Strategic, with advanced analytics

**INDUSTRIAL IOT KILLER USE CASE:**
Automating inspections data collection and embedding intelligent decision support systems for managing risk and optimizing inspection resources
Avitas Systems Industrial Image Analytics at Scale

**Generic algorithms**

*A library of common methods that can be used as part of a workbench to fine-tune a customer-specific deployment*

- Parameterized solutions
- Horizontal capabilities such as intelligent change analysis, subcomponent/region identification, and intelligent searches

**Customer workbench**

*Toolkit to be used by a group of Image Analysts/Setup Engineers to perfect algorithms*

- Rapid training using tools and documented methodology
- Test, evaluation, and deployment of new models

**Image repository**

*Create repository of tagged images*

- Image Net for industrial images
- Meta-data standards
- Predix-based

Best-of-breed deep learning algorithms and utilities for intelligent analysis of industrial images

Ability to scale for multiple assets/sites/vertical using site-devoted field image analysts

Image database creates metadata-searchable archival record for visual records
Image analytics for automated defect recognition

Families of deep learning algorithms, such as fully convolutional networks

- **Training phase**: Image with ground truth used to set the right weights (W) by a process called back-propagation that used the difference between the result and ground truth to change the W
- **Run time**: trained network now is able to ingest an image and return the desired result

**DEEP LEARNED DEFECTS**

- Paint breakdown
- Insulation breakdown
- Loose, cracked, broken, or missing bolts
- Cracking
- Corrosion
- Concrete spalling
- Heat distortion
- Numerous other that are asset and part specific (blocked drain, blocked nozzle, kinking, loose ignitor tubing, damaged support/guides, water logging)
Detect and classify

- Deep model that detects corrosion
- Deep models that determine level of severity
- Transfer learning from existing pretrained deep models
Detect and classify

- Object detection and tracking on the edge
- Volumetric analytics on the edge
- Cloud analytics for change and integrity assessment
Analytics lifecycle

**DIGITIZE**
*On completion of initial inspection (On-site & in the Cloud)*

**ANALYZE**
*Online (On-site & in the Cloud)*

**OPTIMIZE**
*On demand (In the Cloud)*

- Baseline
- Current

**ANOMALY AND DEFECT DETECTION**
- Deep learning

**RISK-BASED INSPECTION PLANNING AND RECOMMENDATIONS**
- Asset risk maps
- Anomaly and defects
- Process history
- Advanced data analytics
- Rules-based reasoning