Waygate Technologies

Industrial X-Ray Inspection Futures

Swedish NDT Society (FOP) Webinar

Daniel Emmons & Peter Deschepper

November 23, 2023

Baker Hughes

Agenda

Industrial X-Ray Inspection Futures

We will discuss 3 aspects for X-ray advances in field and bunker environments:

- NDT Challenges and Trends
- Usability advances in Flexible DDA, other next gen panel technology and industry standards implications
- Inspection speed brought about through automation and generative, robotic, and vision AI.
- Continuously improve NDT effectiveness
- Conclusion

Industry Situation

Waygate Technologies
a Baker Hughes business

NDT Industry Challenges

- New Technology Features & Modalities

Acoustic Emission	X-ray/ CT image	Visual Inspection
Multiple sensors	Spectroscopy	Strain Sensor
Ultrasonic	Laser Excitation	Resistivity
Optical Sensing	Piezoelectric	

- New Materials & Applications
- People – skilled workers
- Processes – techniques, systems, reporting, standards
- Software – more and better

Baker Hughes

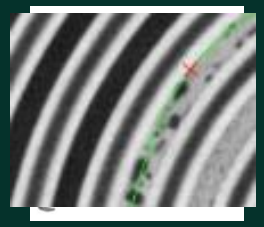
Materials/Applications X-ray and beyond NDT

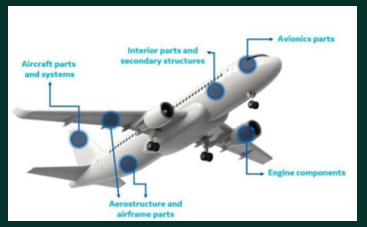
Traditional X-ray/CT NDT Topics

- Oil and Gas – pipes, etc.
- Chemical
- Vessels
- Castings / Parts
- Road, Bridges
- Automotive
- Aviation
- Aerospace
- Art
- Electronics / BGAs

Emerging NDT Applications

- **Additive Parts**





- Body – hips, elbow, etc.
- Aviation - turbine blades
- Pressure vessels
- Vehicles – body, etc.

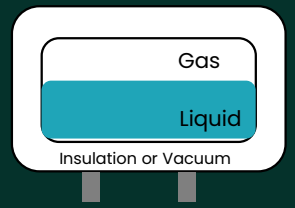
- **Vehicle and other Batteries**

Automotive News Europe

- Prismatic, Cylinder, etc.
- Liquid and Solid State
- Cars, Trucks, etc.
- Mobile, watch, etc.

- **Hydrogen**

Liquid Hydrogen Cooled Storage Tank



Reuse of gas infrastructure

- Storage/Transport Tanks
- H2 Pipelines
- H2 Power Stations
- Refinery, Chemical plant ..

Waygate Technologies
a Baker Hughes business

Flexibility / Usability

Waygate Technologies
a Baker Hughes business

Usability & Advances in Software & Hardware

User Interface of SW	Form Factor/Casing of HW	Technical Specs of HW

File Scanners	CR	Portable DDA	Flexible DDA
Stationary DDA	Large CT	UT/Piezoelectric	Infrared
Visual / Cam	Ground Radar	Optical & Lazer	Misc.

Flexible Use

- Multiple HW devices with a given category
- Simultaneous views of different studies, series
- Simultaneous views of multi-modality images

Flexible DR

Sector

- New Product Introduction planning for several industries

Requirements

- Fast, reliable, and good data sharing – xray or gamma sources
- 10 x 25 cm active area (up to 12 inch pipes)

Solution

- Flexible DR panel with wireless and wired connectivity to acquire SW
- Applications
  - Pipe – weld, erosion/corrosion (pitting), deposit in pipes
  - Other – boilers, vessels, or tanks, etc. [back exposure]

System	Flexible DDA
Pixel pitch:	99 µm
Energy Range	50-450 KeV / gamma (SE/IR)
Integration time:	up to 180 seconds;multiframe

Indicate	Indication Classify	Classification	Location	Dimension
1	Accept	Weld defect	1.2 meter, 17^0	Small
2	Reject	Erosion	3.5 meter, 182^0	Large
3	Reject	Pitting	4.7 meter, 232^0	large
4	Accept	Deposits	5.2 meter, 47^0	Small

ASTM DICONDE NDE Indication module planned
Zero degree is marked with lead markers

Baker Hughes

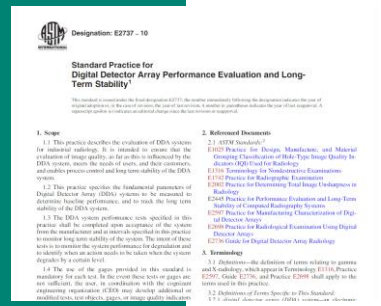
X-ray Standards: ISO and ASTM Flexible and other DDA advances

Problem statement:

- ISO 17636-2 and ASTM standards are crucial for new technology adaption
- Standards have not set different norms for Flexible and some other emerging tech

Resolution :

- ISO 17636-s overview
- ASTM overview
  - SRB
  - SNR
  - Bad Pixels
  - Other signal standards
- Pixel pitch and angles not an issue



Designation: E2737 – 10

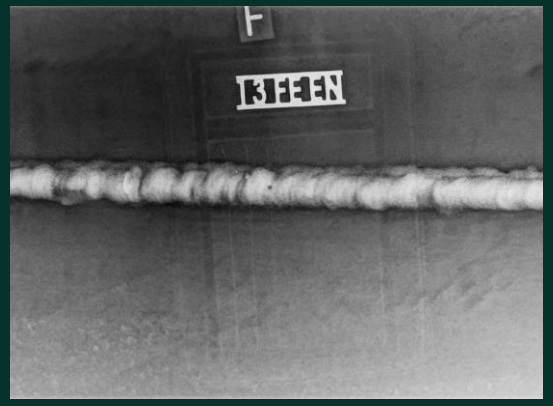
Standard Practice for
Digital Detector Array Performance Evaluation and Long-Term Stability[1]

ISO 17636-2 Class A	
Penetrated thickness w (a) in mm	Maximum BSR
$w \leq 1.0$	50
$1.0 < w \leq 1.5$	63
$1,5 < w \leq 2$	80
$2 < w \leq 5$	100
$5 < w \leq 10$	130
$10 < w \leq 25$	160
$25 < w \leq 55$	200
$55 < w \leq 150$	250
$150 < w \leq 250$	320
$w > 250$	400
(a) For double wall technique, single image, the nominal thickness shall be used instead of the penetrated thickness	
CRx Vision 35µm pixel & IPU imaging plate	

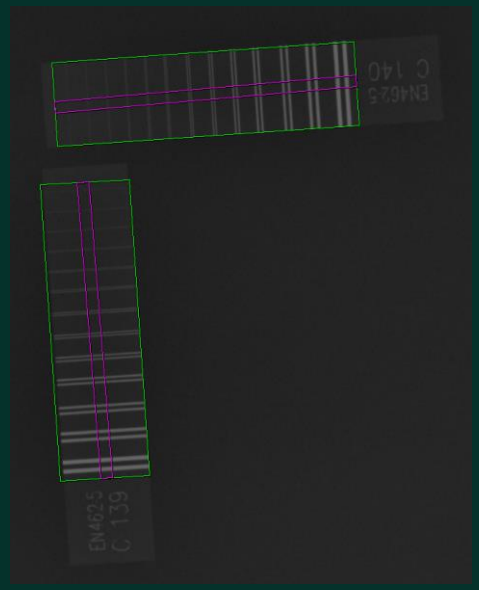
Example

Class B

6 inch SCH40 Se75 – DWSI – OD 168mm – wt 7.1mm



- Se75
- FS 3 mm
- Source filter: no
- SDD 174 mm
- 50Ci
- 4s int. time
- 10 frames
- Tot. exp. time 40s



- ISO 17636-2 requirements Class B:
  SRb Detector: 63 micron
  IQI detector side: w14
  SNRn: 140

- Class B achieved with CPII
  SRb Detector: 100 micron
  IQI visible: w16
  SNRn: > 300

Waygate Technologies
a Baker Hughes business

Speed

Waygate Technologies
a Baker Hughes business

One Click Automation

Sector

- Major aerospace and aviation inspection house

Requirements

- No more than one swipe (for techniques) and one click

Solution

- Supporting High Energy Linac in bunker
- Automatically turn on, warm-up, and take images, shutting down
- Lower dose required because of automation
- Can leverage QR codes, one click automation

One Swipe

One Click

System	Linac, High Energy DDA
Pixel Pitch:	various µm
Energy Range:	2-3 MeV / various filters
Integration time:	.5 to 150 seconds
Defects:	Cracks, Porosity, etc.

Defect	Indication Classify	Classification	Location	Dimension
1	Conforming	Porosity /Void	2.45 x 9.92 cm	Small
2	Non-conform	Crack	8.57 x 17.33	Large
3	Non-conform	Porosity /Void	13.87 x 37.88	Large
4	Conforming	Lack of Penetration	18.33 x 45.22	Medium
5	Info only	Lack of Fusion	23.77 x 66.81	Small

Baker Hughes

Artificial Intelligence

Generative AI

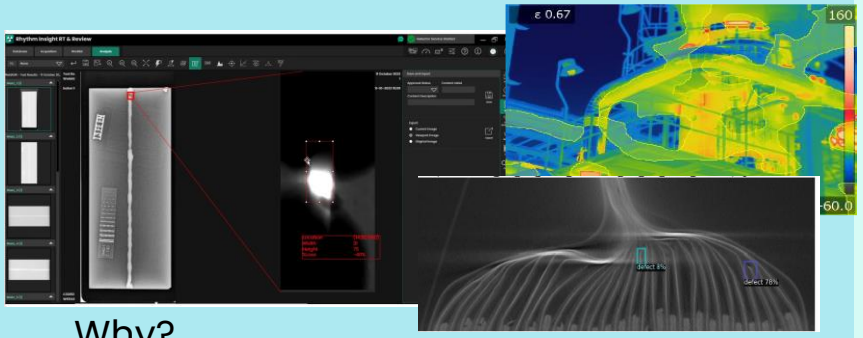
What?
NDT aware large language models built into software.

> What is technique should I use to shoot this 7 inch pipe?
> .. Use ...
>
> Explain to me Contrast in X-rays?
> .. CNR and CR are 2 means of ..

Why?
- Batter remote support
- Faster learning of NDT concepts
- Faster learning of software
- Better NDT results: quality, safety, efficiency

ADR AI

What?
- ADR for FRAD – weld, corrosion, parts
- ADR for CT – batteries, BGA
- ADR for other domains



Why?
- Assisted or automated finding defects for faster analysis
- Results is accepted if no large defects automatically

Robotic/Sensor AI

What?
- Gantry and bots in fixed systems
- In field robots
- Sensors adding data for conditions and reliabilty

Why?
- Handle strenuous or dangerous inspections
- Reduce inspection time and costs
- Add data for analytics

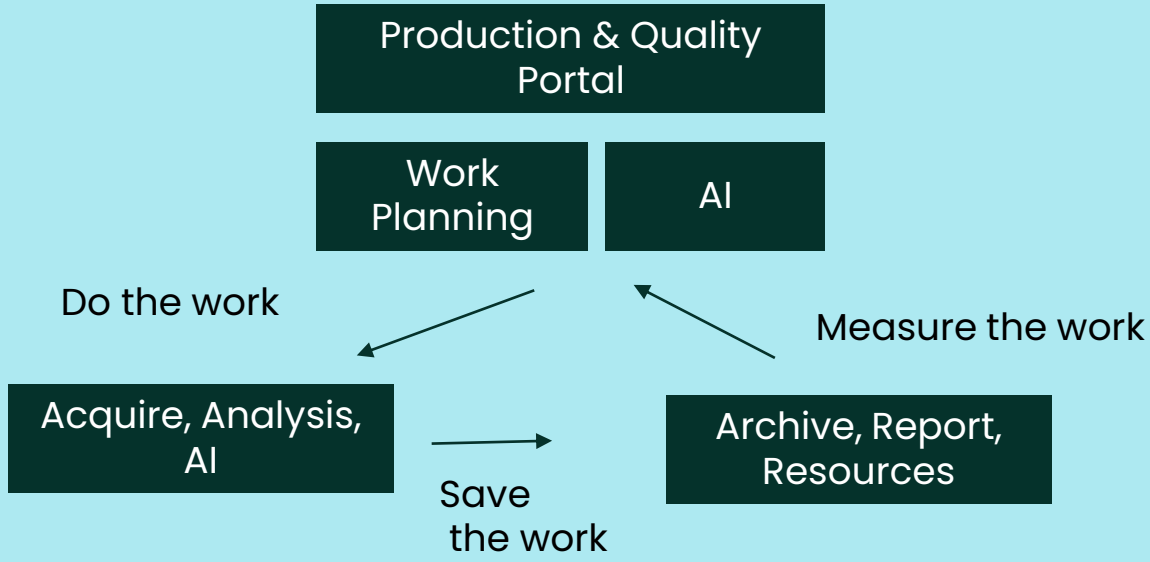
Continuous Improvement

Get Better

Mindset

From Six Sigma

Future Systems View - Day to Day Operations



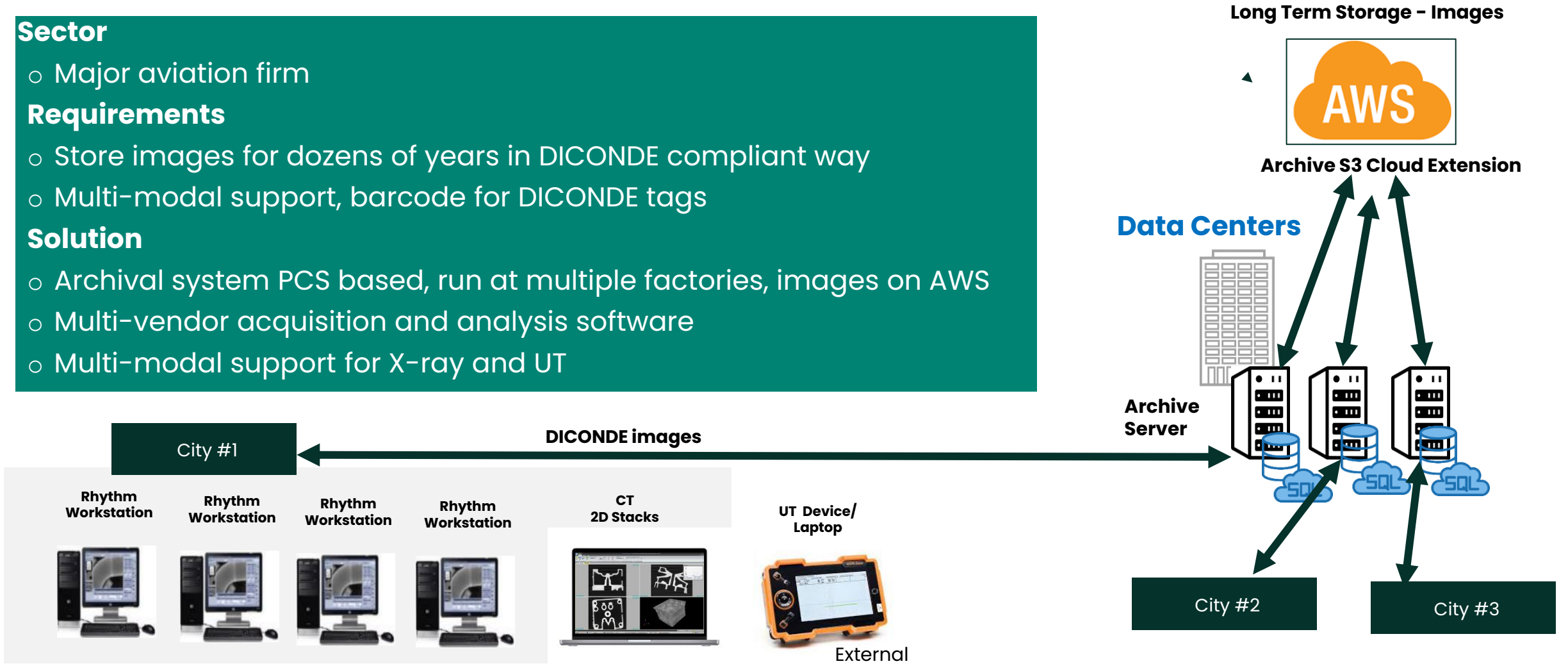
Multi-modality

Archiving

Sector
- Major aviation firm

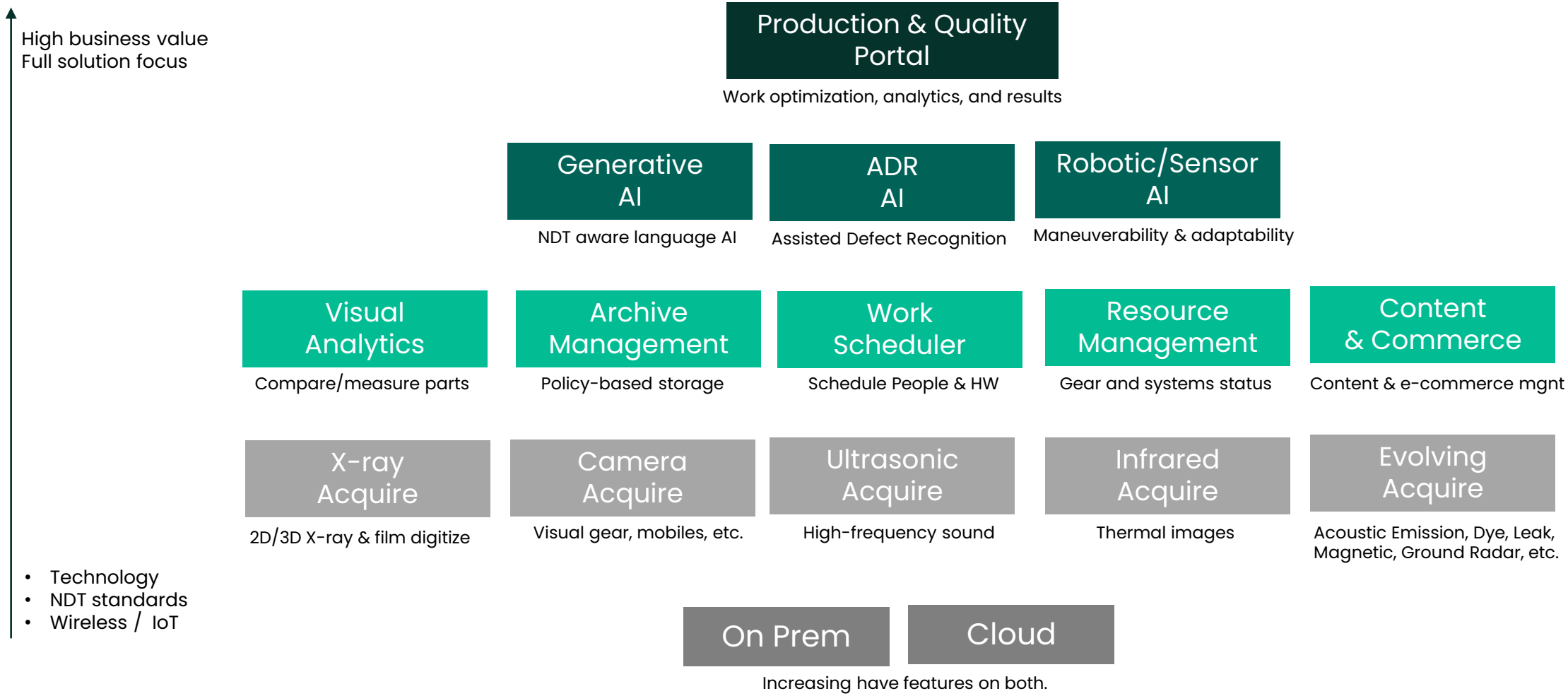
Requirements
- Store images for dozens of years in DICONDE compliant way
- Multi-modal support, barcode for DICONDE tags

Solution
- Archival system PCS based, run at multiple factories, images on AWS
- Multi-vendor acquisition and analysis software
- Multi-modal support for X-ray and UT



Baker Hughes

The Future Software Stack



Baker Hughes

Conclusion

Waygate Technologies
a Baker Hughes business

Conclusion

We discussed 3 aspects for X-ray advances in field and bunker environments:

- NDT Challenges and Trends
- Usability advances in Flexible DDA, other next gen panel technology and industry standards implications
- Inspection speed brought about through automation and generative, robotic, and vision AI.
- Continuously improve NDT effectiveness

Daniel Emmons
Senior Product Manager
daniel.emmons@bakerhughes.com
Phone: +32 479 64 00 66

Peter Deschepper
Senior Sales Representative
Peter.deschepper@bakerhughes.com
Phone: +32 479 64 00 75

Swedish Channel Partner
Mathias Sandberg
Teknisk Säljare
Örebro | Sweden
Phone: +46 21 15 51 03
mathias.sandberg@novatic.se