Benefits of plane wave imaging (PWI) for ultrasound NDT industrial applications

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Kurzfassung

Ultrasonic testing is currently one of the main techniques employed in many industries (metallurgy, foundry, aeronautics, etc.). This technique consists in generating ultrasonic waves into parts to be inspected to possibly detect and size defects from the analysis of back-scattered signals. Starting from conventional techniques, new technologies matured through the years: Phased Array some decades ago and FMC/TFM a decade ago. The PWI technique is filling the gap between these two: merging the speed of Phased Array and the accuracy of FMC/TFM. Nowadays, acquisition devices are more and more powerful and customizable. The Plane Wave Imaging (PWI) offers numerous advantages for NDT inspections: high level of energy in emissions, same high number of elements in emitting and receiving, ability to insonify large pieces. In this paper, the principle of the technology is presented. Then, several applications cases taken from industrial cases are detailed, showing the improvement compared to Phased Array and FMC/TFM techniques. We show that PWI is beneficial for large metallurgical pieces and foundry blocks specifically. It also shows improvement for crack detection in such cases.

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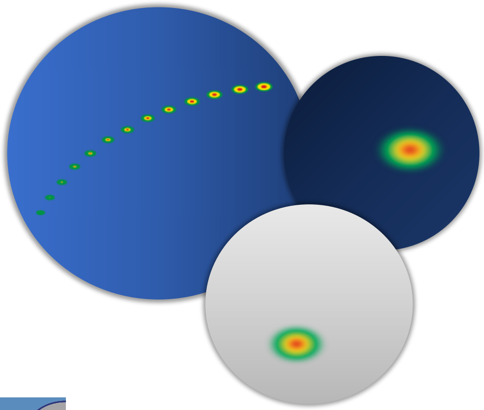

BENEFITS OF PLANE WAVE IMAGING (PWI) FOR UT NDT INDUSTRIAL APPLICATIONS

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DGZfP

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Introduction

- A French aluminum foundry is facing increasing quality expectations from its customers
- During cooling of the blocks, defects are randomly happening
- Present production quality check with mono-channel UT is very partial (no defect sizing, unprecise location) and is creating false calls
- Customer demand was to improve overall reliability of the inspection
- Due to customer low knowledge of defects typology and dimensions of the to be inspected blocks, idea was to get an echography of the blocks
- PWI has been chosen considering above context

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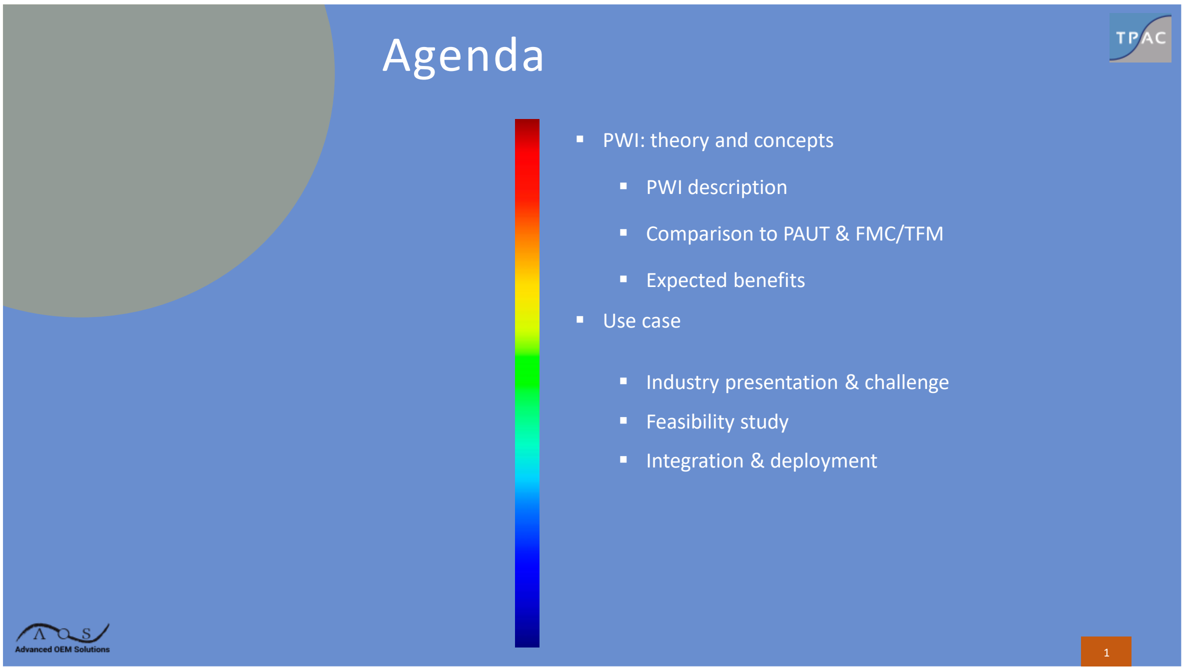
Agenda
TPAC
PWI: theory and concepts
PWI description
Comparison to PAUT & FMC/TFM
Expected benefits
Use case
Industry presentation & challenge
Feasibility study
Integration & deployment
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PWI: theory & concepts
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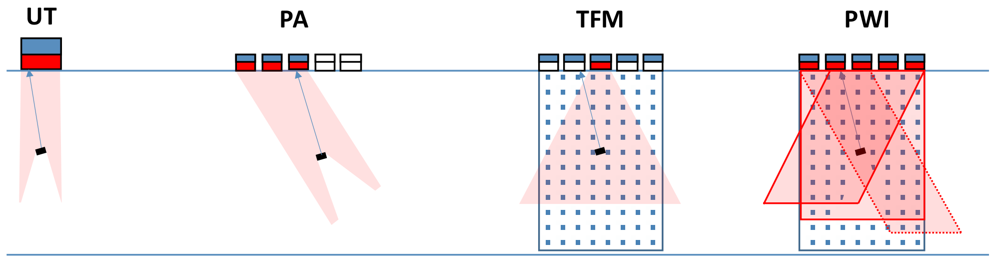
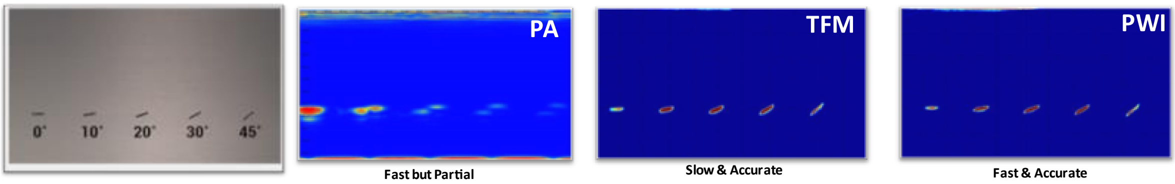
UT Methods Benchmarked

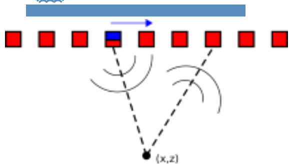




TFM Total Focusing Method

Technology

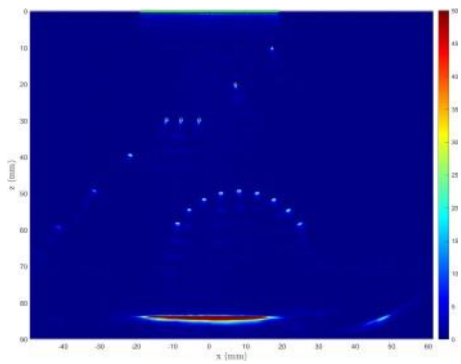
Acquisition



Size of data : **Nt** x **Ne** x **Ne**

Nt : Nb time samples
Ne : Nb elements

Reconstruction



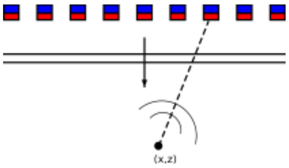
Benefits & Drawbacks

Very good resolution
Very good contrast

Low acquisition speed
Low computation
Low energy

PWI Plan Wave Imaging

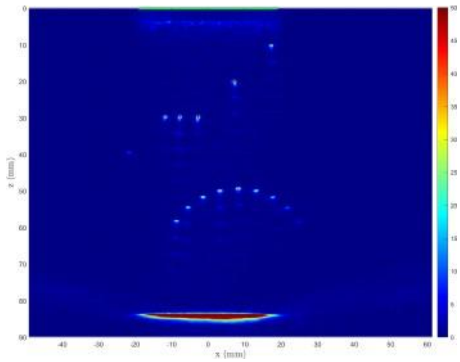
Acquisition



Size of data : **Nt** x **Na** x **Ne**

Nt : Nb time samples
Na : Nb angles
Ne : Nb elements

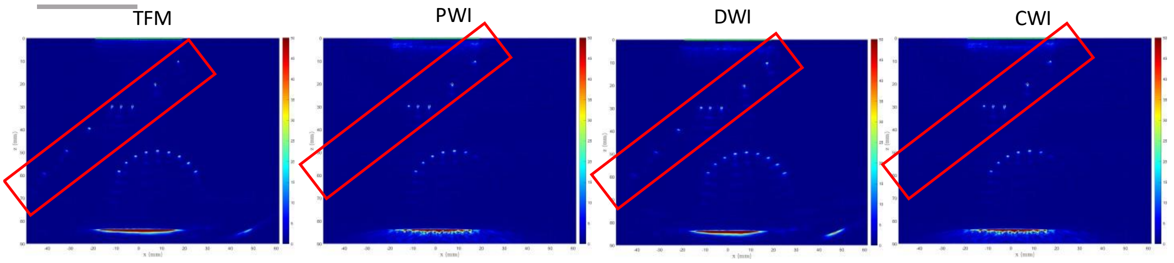
Reconstruction

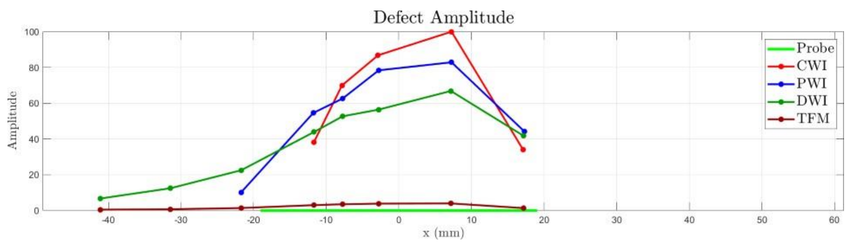


Benefits & Drawbacks

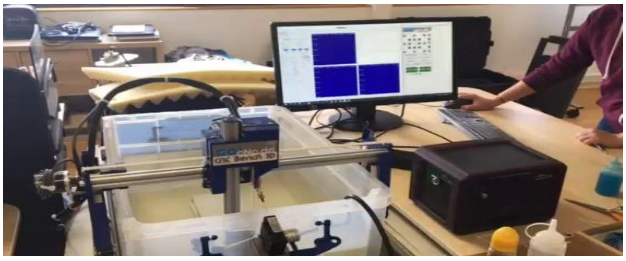
Good resolution
Good contrast
High acquisition speed
Fast computation

TFM vs PWI vs DWI vs CWI





PWI: expected benefits



- Capacity to merge accuracy of FMC/TFM and faster than PAUT
- Ability to insonify large or attenuative pieces
- Robust to be deployed in industrial environment

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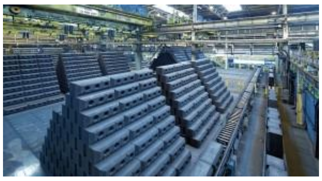
PWI: industrial application

Industrial case: aluminum foundry



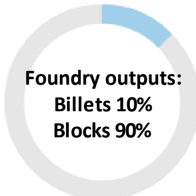
Main final use: packaging

Intermediate steps: machining and lamination

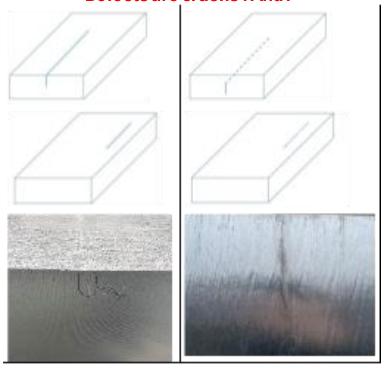
Industrial case: inspection of aluminium blocks

Block dimensions :

- Length : 2 400 mm à 9 200 mm
- Width : 950 mm à 2 500 mm
- Thickness : 370 mm à 630 mm
- Weight: 6 t à 32 t



Defects are cracks ? And?



Challenges:

- Number of dimensions
- Variety of alloys
- Surface conditions
- Depths and sizes of the defects
- 18,000 blocks per year to inspect

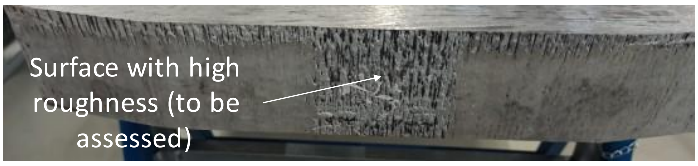
Industrial case: feasibility study as a first step

Challenges:

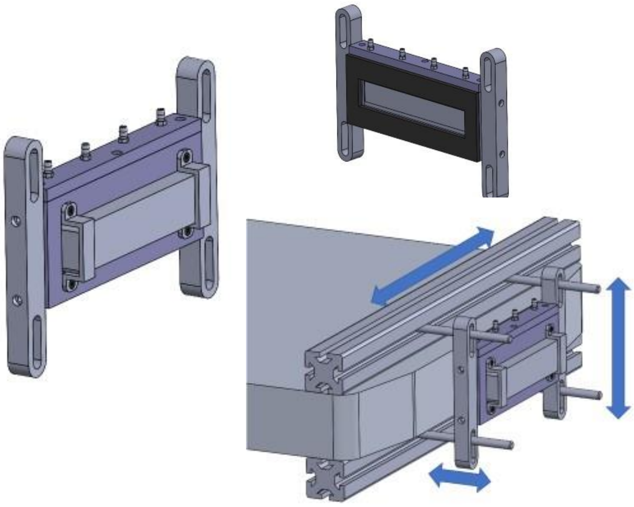
- Number of dimensions
- Variety of alloys
- Surfaces conditions
- Depth and sizes of the defects
- 18,000 blocks per year to inspect

Options for the study:

- On representative blocks slices
- Prototyping of a probe holder
- Test of different UT technics
- Focus on inspection speed

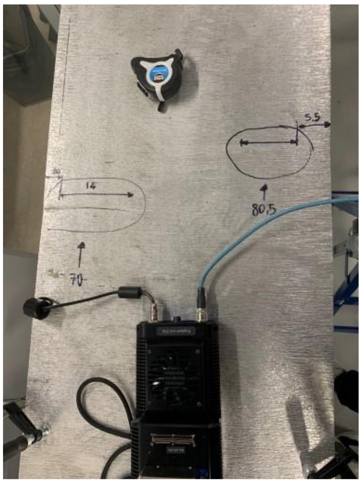


Industrial case: probe holder design



- Key milestone for acquisition quality (coupling, stability, repeatability)
- Choice to go for atrue industrial prototype
- Manufacturing through 3D printing

Industrial case: test set-up



UT Device:
- Explorer 128/128

Probe:
- 1 MHz 128 elts Pitch 1 mm

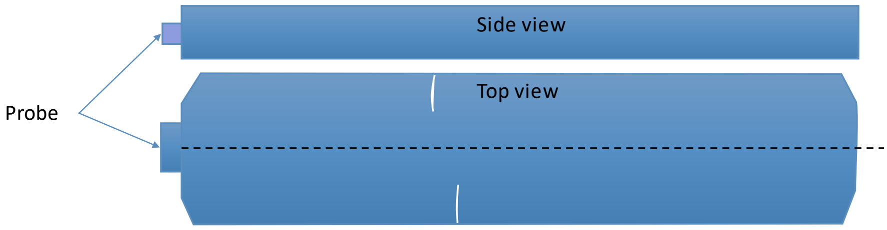
ProbeHolder:
- Water Path ≈ 4 mm

SW:
- Prelude 4.1.9
- ARIA 2.5.6

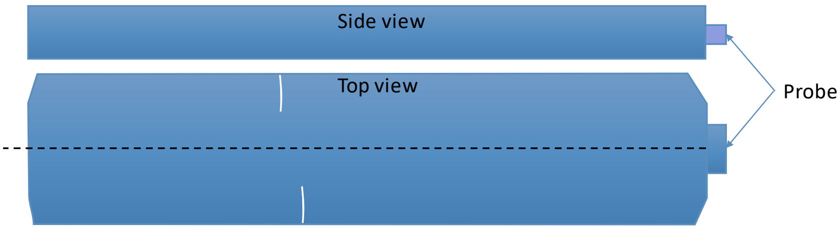
Plate1: 2130 x 500 x 65mm
Plate2: 1820 x 510 x 85mm

Industrial case: test set-up

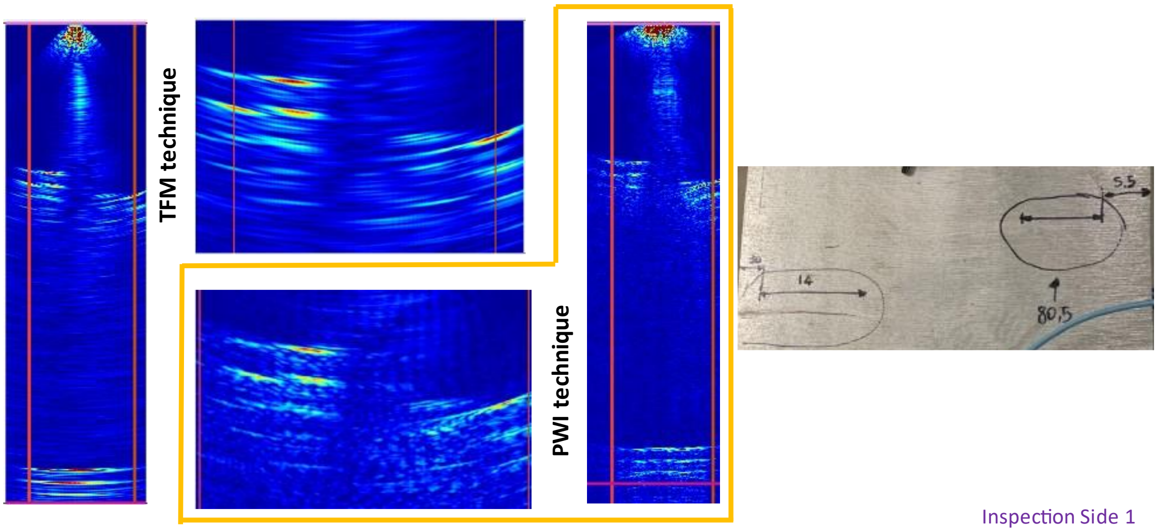
Inspection side1



Inspection side2

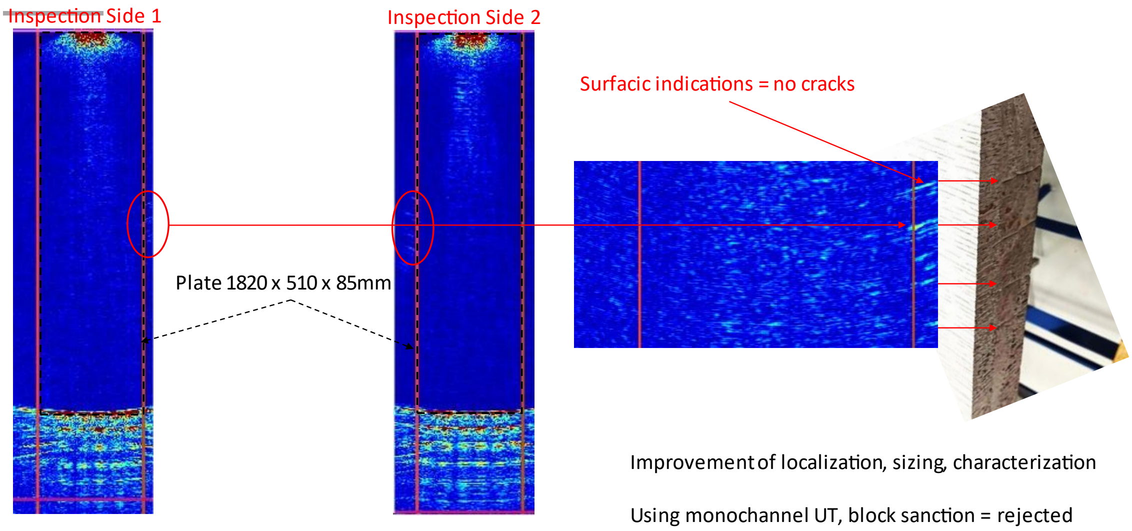


Industrial case: defect detection FMC vs. PWI



Inspection Side 1

Industrial case: defect & non defect detection with PWI



Improvement of localization, sizing, characterization

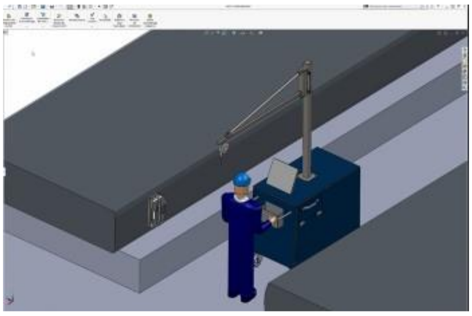
Using monochannel UT, block sanction = rejected

Industrial case: conclusions of feasibility study

- Higher resolution / no deformation of image with PWI among UT technics (conventional & PAUT)
- Lower probability of false calls with PWI versus current inspection
- In this industrial application, PWI will be faster than any other UT technics (linear speed of 50 mm per sec is reachable)

Industrial case: next steps

- Inspection of finished and cooled blocks located on storage area
- Move from the feasibility study to an industrial prototype through an integrator with our support:
  - Design & manufacturing of final probe holder
  - Definition of a process inspection trolley to manage all constraints
    - Coupling
    - Weight
    - Atmospheric conditions
    - Energy supply



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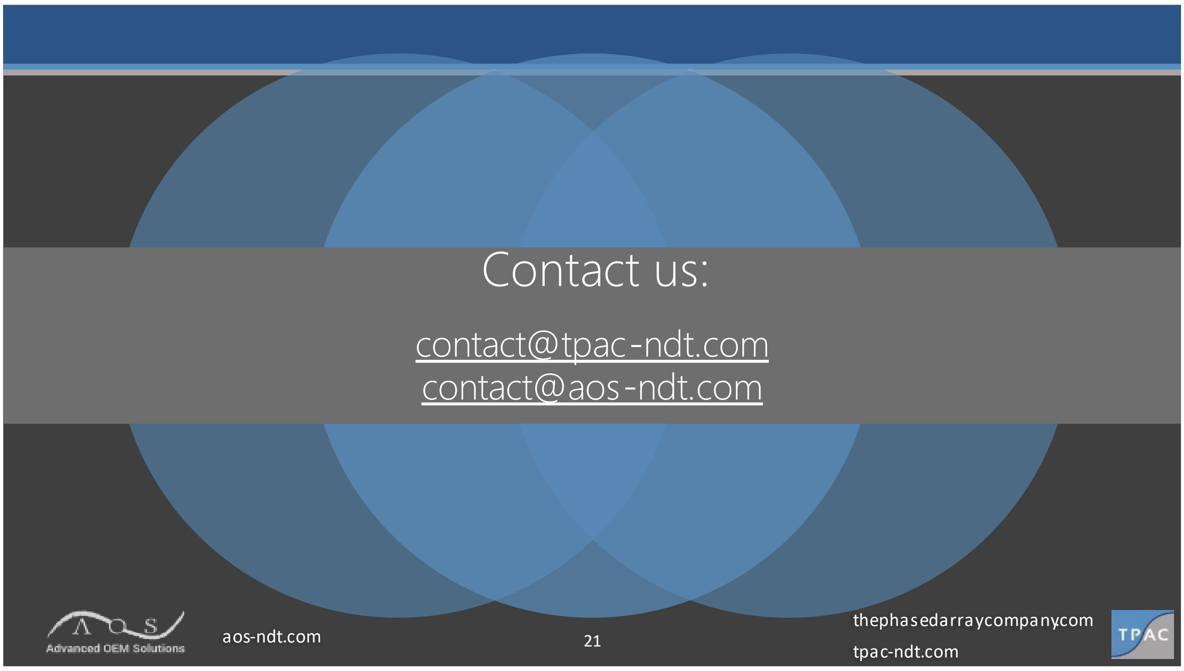
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