# Use of IQI Standard – a tentative way forward in NDI of AM parts?

**WG2 Break-out session: FDT and NDI of AM parts  (EASA FAA Industry-Regulator AM Event)**

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# Experience in certification expectation and key technology blockers …

Experience in certification expectation:

- In-house activities to provide sufficient substantiation taking much longer (and costs) than expected

**key technology blockers:**

- **Process complexity/material variation - dependent on associated AM process parameters/parts geometry**
  - amongst others: *LackOfFusion **defects of concern***, occurrence rate depending on process parameters/machine and difficult to detect by NDI, random occurrence related to inherent process 'disturbances'

- **Parts quality substantiation strategy** – **business case critical**
  - Beneficial HIP impact on defects and µ-structure homogenization to improve quality of AM part
  - ***NDI costs** (depending on parts criticality):* LOF defects: sizes/frequency of occurrence and detectability
    - → *CT – "Gold Standard" – application critical on large Ni-components w.r.t. detectability / cost*
  - Combined NDI, FAI, process control vs. (allowable) defect size used in the analytical substantiation (design lines and/or damage tolerance)
  - **Concern/Q: → 'largest flaw size' which can be missed?**

# Starting Point: Image Quality Indicator (IQI) Standard for Radiography

**ASTM-E1025 - 18:** Standard Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiography
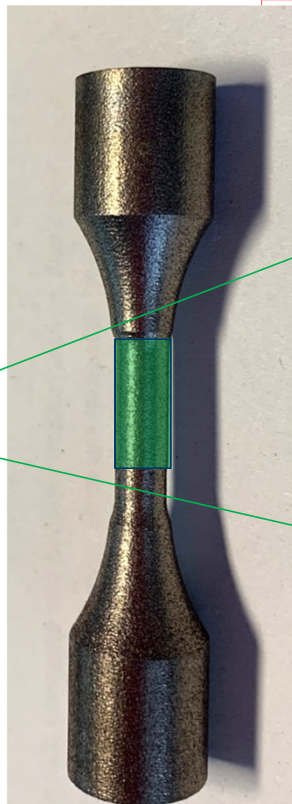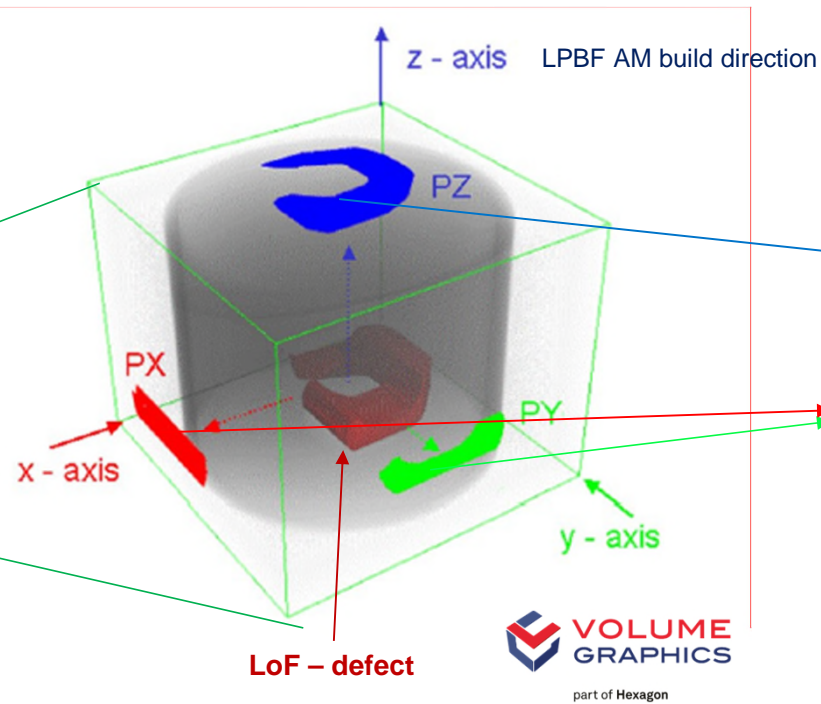
Modified IQI Standard:
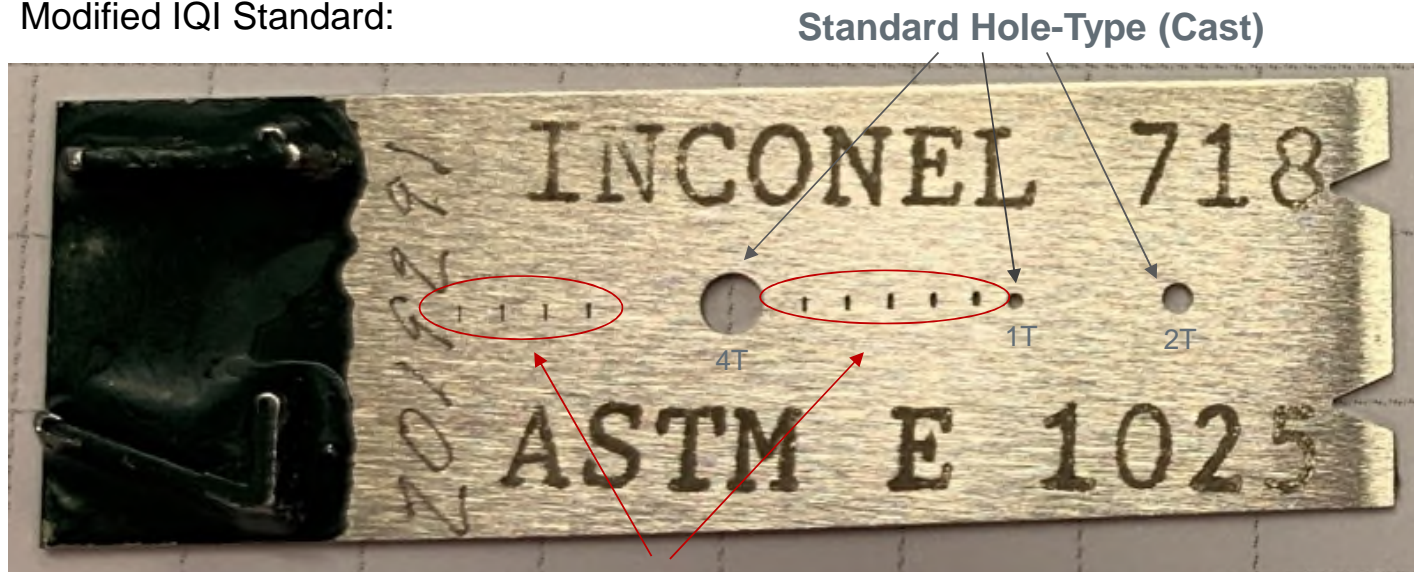
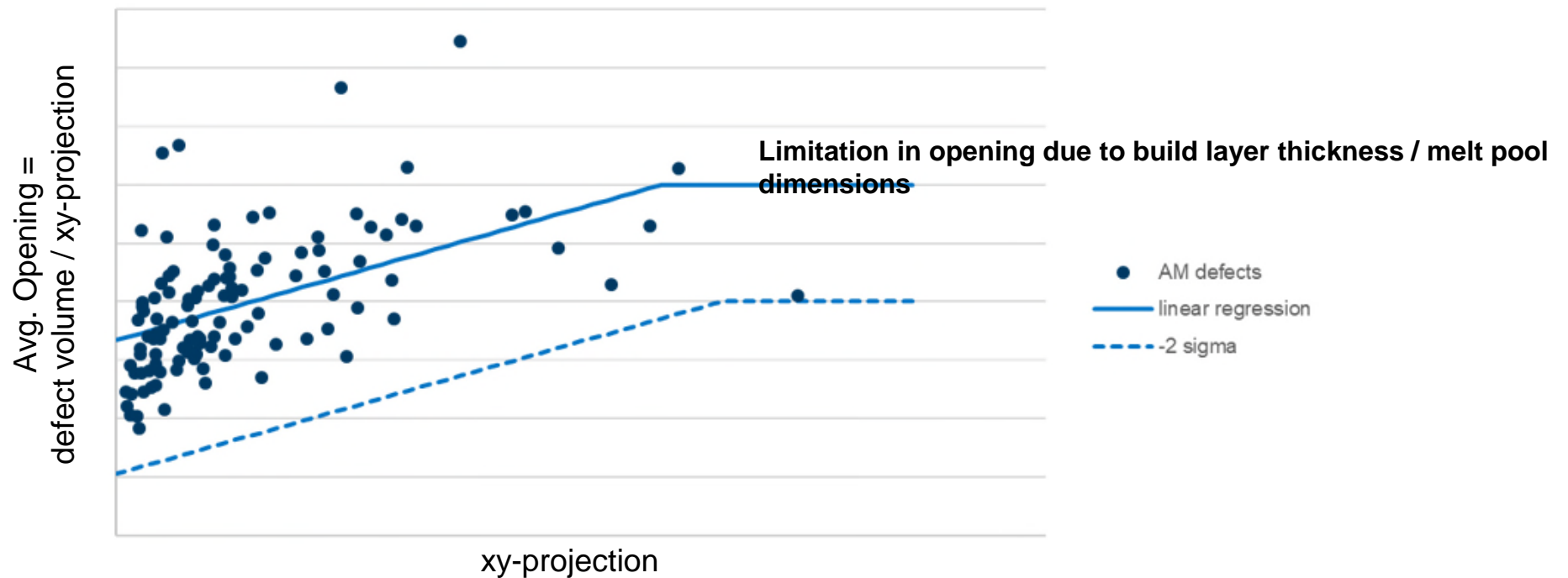# Dimensional characterization of AM LOF defects using CT…



V|tome|xs 240

specimen with low energy process parameter
(intentionally induced AM defects → LOF)

**xy-projection**

**Avg. Opening =**
defect volume / xy-projection

z - axis  LPBF AM build direction

PZ

PX

PY

x - axis

y - axis

LoF – defect

VOLUME GRAPHICS
part of **Hexagon**

# Dimensional characterization of AM LOF defects …



**Limitation in opening due to build layer thickness / melt pool dimensions**

Avg. Opening = defect volume / xy-projection

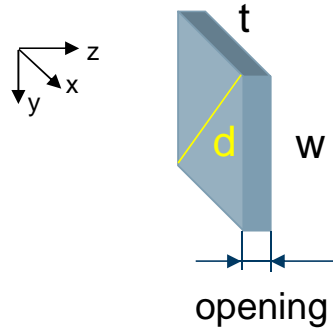xy-projection

- AM defects
- linear regression
- -2 sigma

Linear Regression of avg. opening AM defects vs. area projection and limitation due to layer thickness

# Cuboid-Type → Modified IQI

**Definition cuboid-type:**
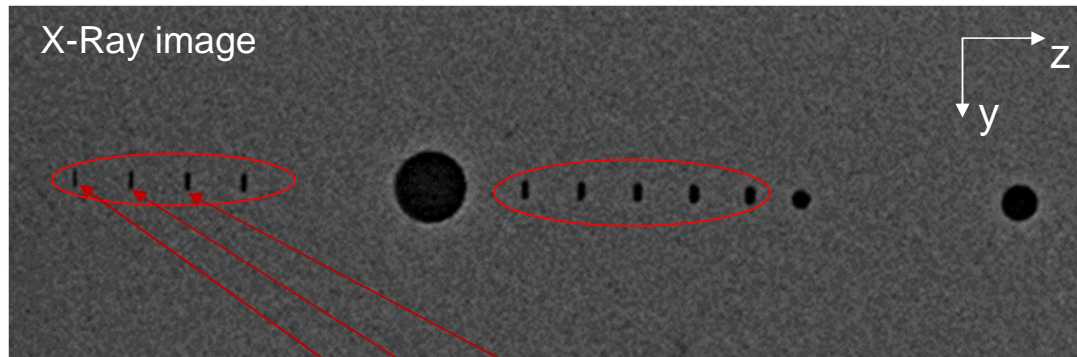
IQI wall thickness t = width w

➡️



opening

➡️ Laser cutting → Modified IQI (ASTM-E-1025)
Various IQIs dependent on different wall thickness

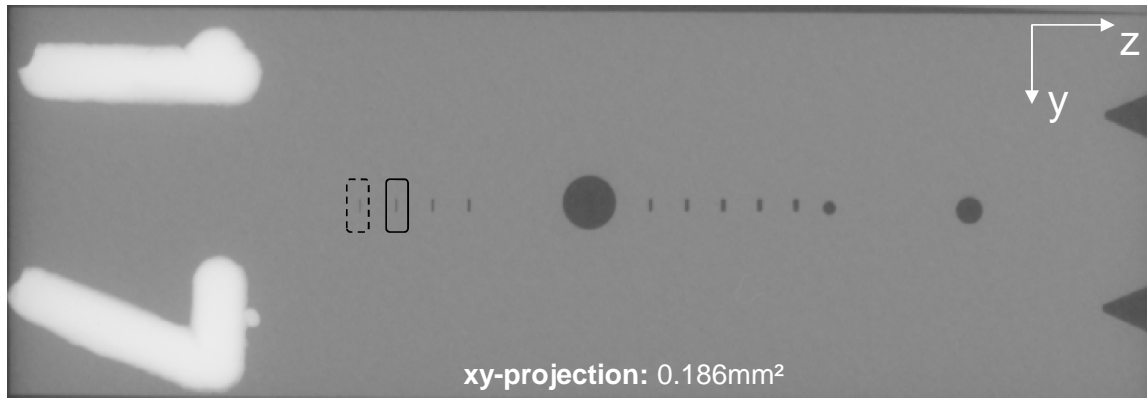IQI used on AM step plate with step thickness representative for part thickness



X-Ray image

Cuboid slot (opening) → 40µm, 60µm, 80µm, +20µm…

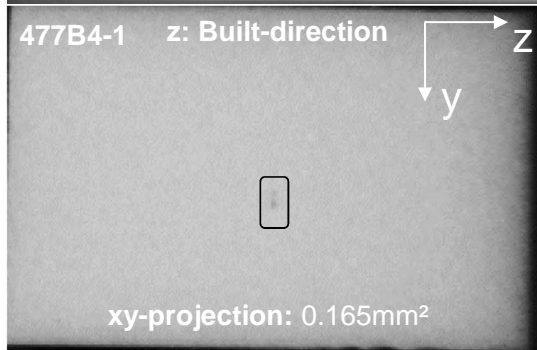**Cuboid-Type derived from linear regression (avg. opening vs. xy-projection)**

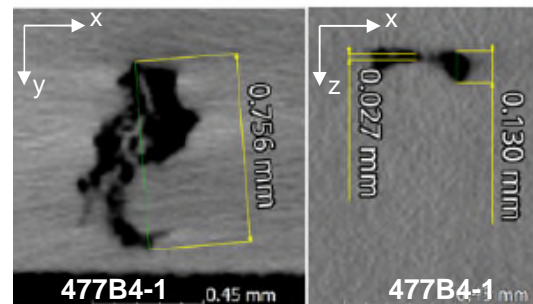# Cuboid - Type vs "real" AM defect

**2D film X-Ray:**

**opening:** 0.060mm (confirmation with 0.040mm)
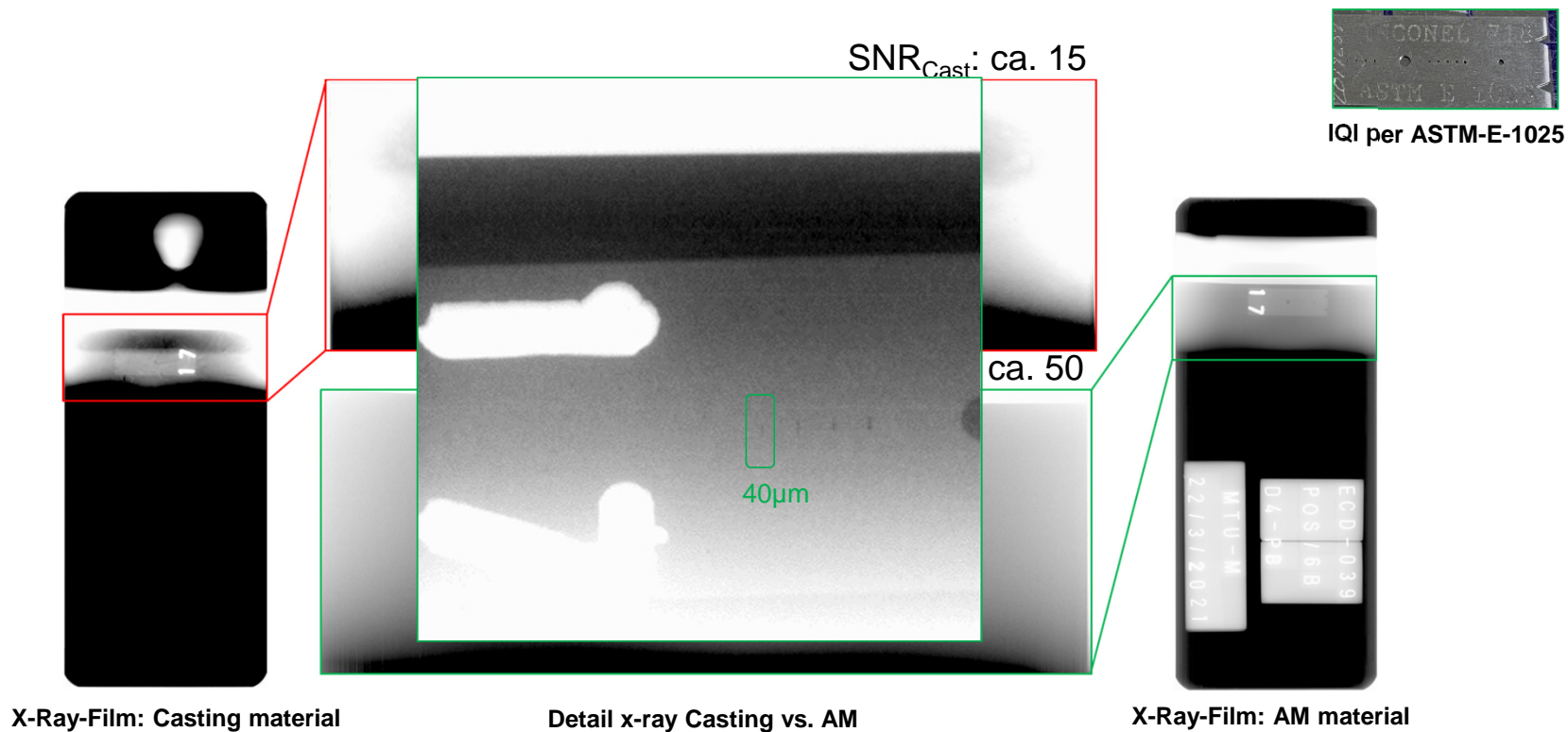
**xy-projection:** 0.186mm²

**avg. opening:** 0.058mm

**xy-projection:** 0.165mm²

Detectability of IQI vs. "real" AM defect are comparable. Any correction / knock down factor needed?

# Manufacturing Method @ MTU – NDI capability (Comparison casting and AM material)

IQI per ASTM-E-1025

$SNR_{Cast}$: ca. 15

ca. 50

40µm

X-Ray-Film: Casting material

Detail x-ray Casting vs. AM

X-Ray-Film: AM material

**Compared to typical casting microstructure, the additively produced bulk material enables significantly improved detectability of defects using conventional 2D film X-ray technology**

# Is this a way forward for a future 'Standard'?
# - Comments welcome!

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