

Non-destructive Inspection of Threaded Bolts with Eddy Current

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Astrium Space Transportation

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All the space you need



Outline

- Background/Motivation
- Potential NDI methods
- Eddy Current NDT
- Qualification of the technique
- Gained Experience
- Critical Review of the technique
- Conclusion/Outlook

Background – Why NDI for Fasteners?

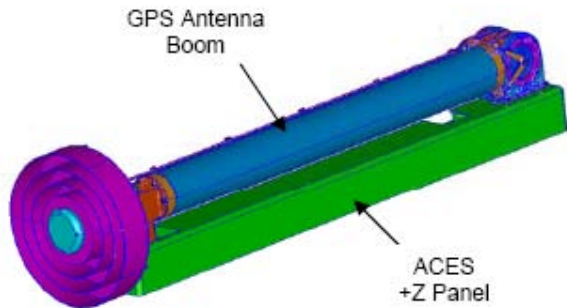
- In special cases a safe life design for bolts cannot be avoided due to:
 - Mission requirements (e.g. for payloads: zero gravity release criterion) or
 - Functional requirements (e.g. ACES: GPS antenna boom)
- Safe life design requires crack growth analysis to ensure damage tolerance capability
 - NDI or Prooftests are used to screen for the initial crack size with 90% probability and 95% confidence level
 - For high toughness bolts a Prooftest is often not feasible, as the determined critical initial defect size is too large for a safe service life



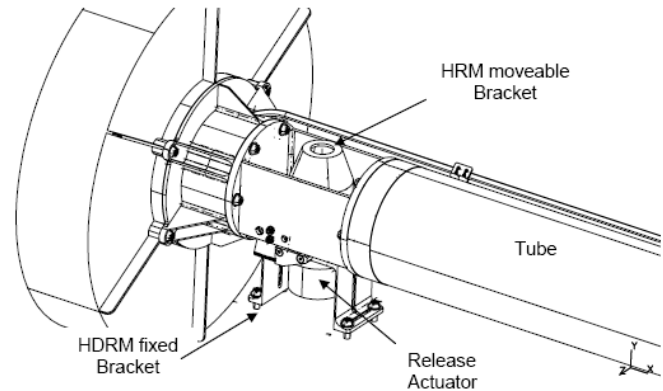
NDI at the beginning of the life to exclude a joint-failure within the service life

Example for Safe Life Unavoidability

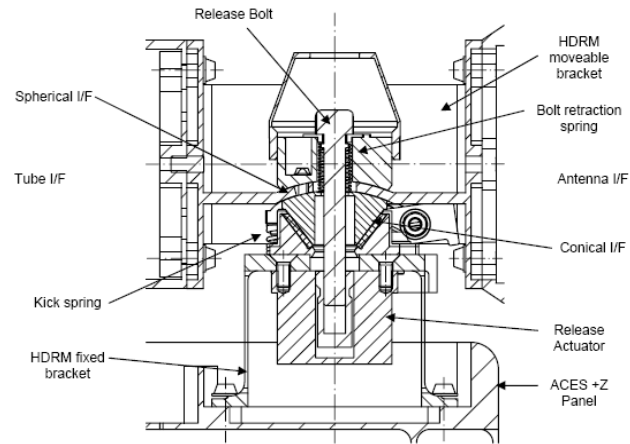
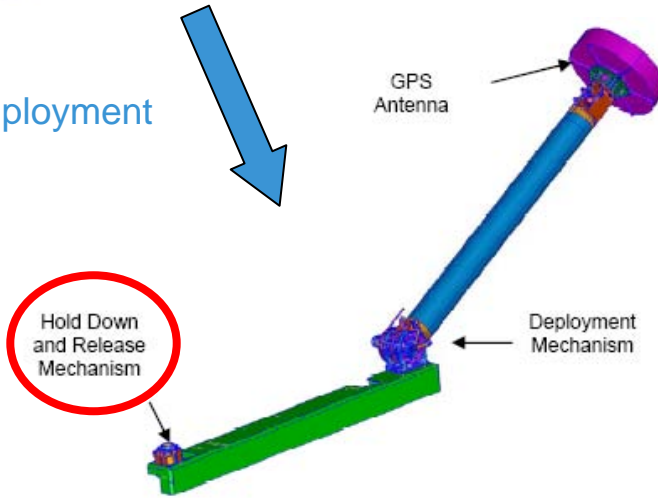
GPS Antenna Boom for ACES



← stowed Position →



Deployment



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Potential NDI methods for fasteners

■ Magnetic Particle

- Requires ferromagnetic material \implies no safe life application known

■ X-Ray

- Not sensitive enough for tight defects

■ Ultrasound

- Coupling problems

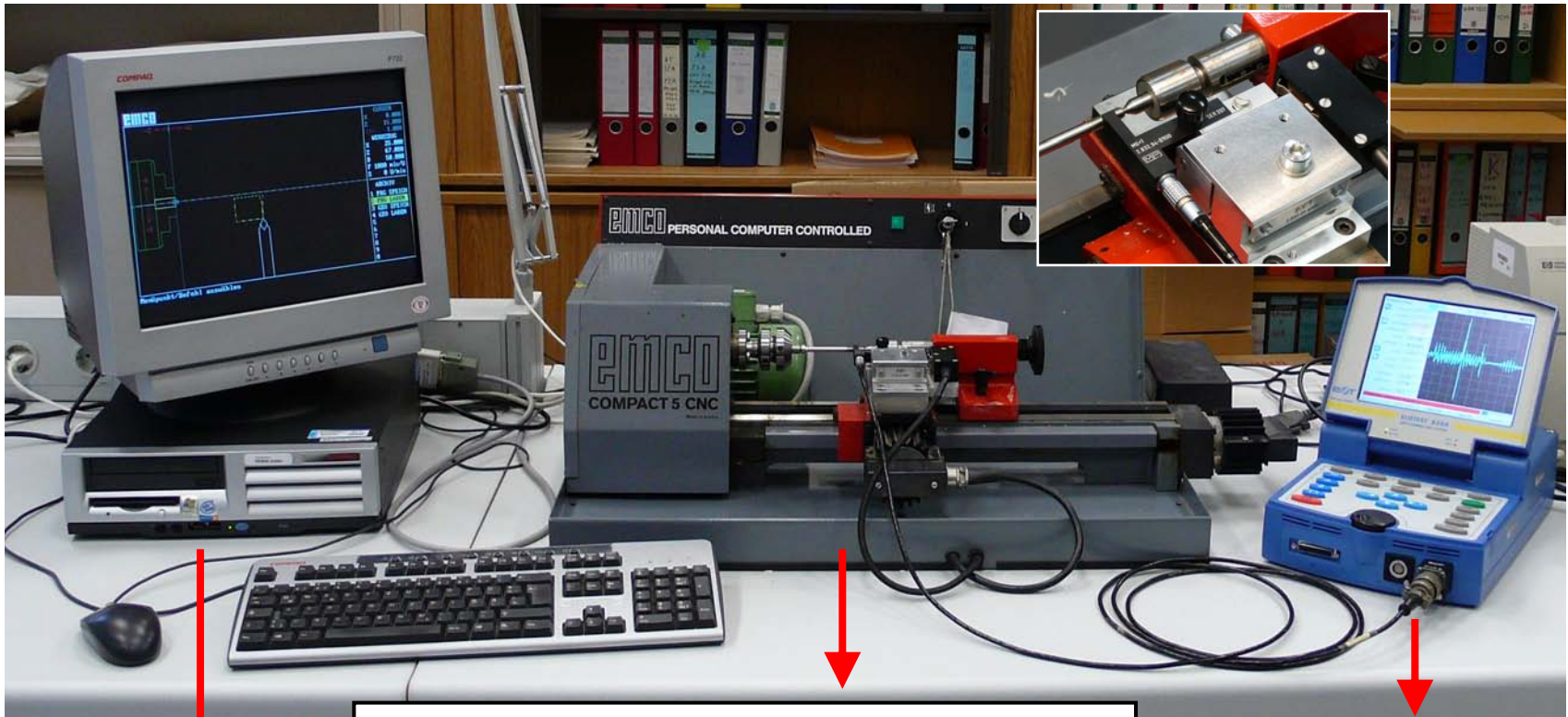
■ Dye Penetrant

- Very difficult to evaluate indications in the thread groove
- Only for surface defects; closed defects, which could occur due to the thread rolling process are not detectable
- For technological reasons etching is not allowed \implies reduction of sensitivity

■ Eddy Current

- Surface, closed and near surface defects can be found
- Requirements w.r.t. fasteners: appropriate device and adapted probes

Eddy Current NDT of Bolts - System



Controlling unit

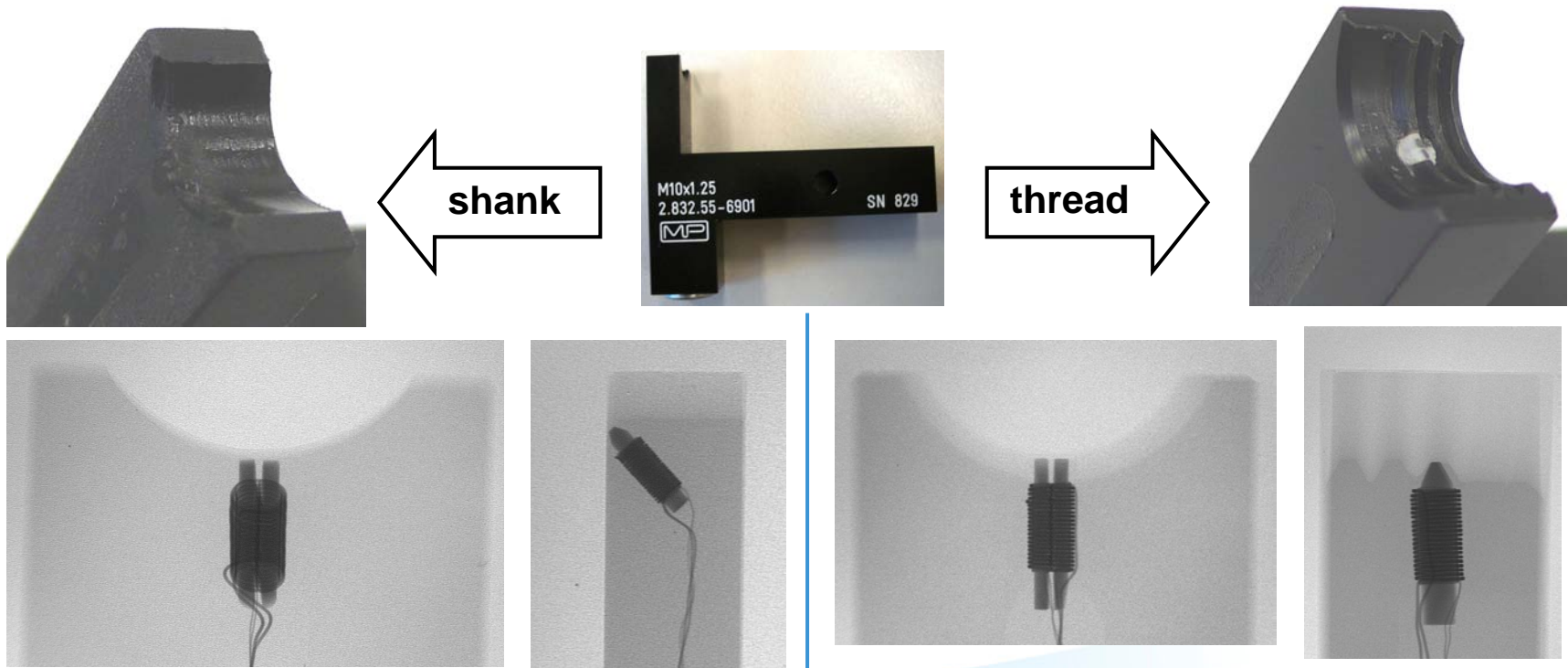
Adapted lathe with low turning speed

Eddy current device

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Eddy Current NDT of Bolts - Probes

- Fasteners from M6 up to M20 are inspectable
- Spring suspension to provide sufficient contact

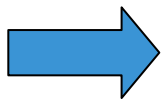
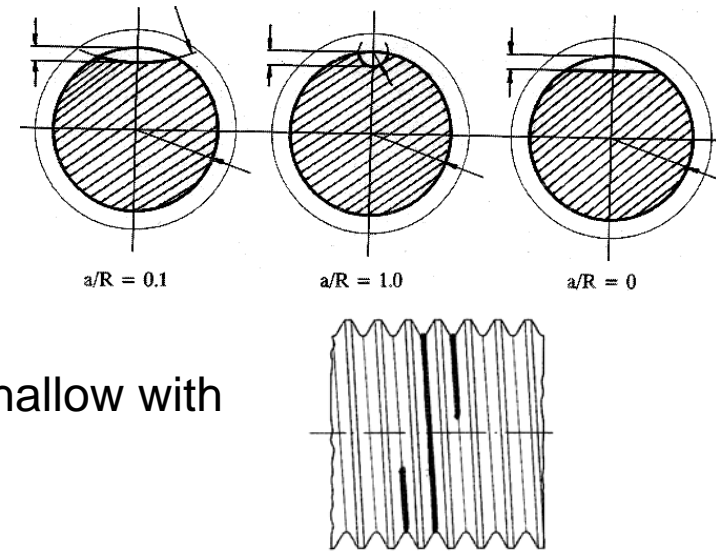


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Qualification of the Method

- Performed in 1994 (ESA contract no. 9935/92/NL/PP/(SC))
- Fasteners of A286 and Ti6Al4V were evaluated
- Investigated crack shapes:

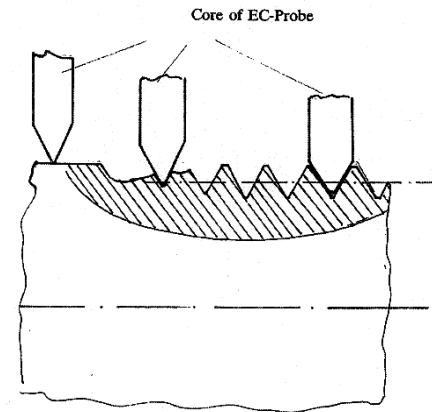
- Eroded shallow and semicircular defects
- Fatigue defects for comparison
- Eroded circumferential defects \Rightarrow very shallow with smooth runout – helix



Study looked promising for a detectable defect depth of 0.6mm

Gained Experience

- Calibration bolts (same batch) are essential for reliability and quality
 - Especially for the difficult inspectable thread-shank-transition
- High toughness/strength fasteners (Inconel 718, MP35N) are much more difficult to inspect
- Impact of the fastener condition
 - Roughness of the shank and especially the thread (noise)
 - Condition of the thread-shank-transition (signal)
 - Concentricity (noise)



Problematic especially for high strength material

Critical review considering experience gained

- What was the impact of the „starter mark“ for fatigue defects w.r.t. the signal amplitude in the qualification?

- What was indicated? The starter mark, the fatigue defect or both?



Perfect fatigue cracks may be investigated

- A lot of fasteners to be inspected are made of high strength material (Inconel 718, MP35N)

- An appropriate quality (roughness, geometry) for high strength fasteners is difficult to achieve \implies high rejection rate



Improvement of the manufacturing process of the fastener or reduction of the system response (signal) regarding geometrical deviations

Conclusion and Outlook

- The procedure ensures that ESA Standard defect sizes are reliably found
- Smaller defects may be found with appropriate calibration
- The initial expectation (qualification) to detect a defect of 0.6mm depth is usually difficult to achieve (high rejection rate)
- Potential future activities:
 - Evaluation and improvement of the inspection of high strength fasteners to reduce the rejection rate
 - Evaluation of perfect fatigue defects (without „starter marks“)