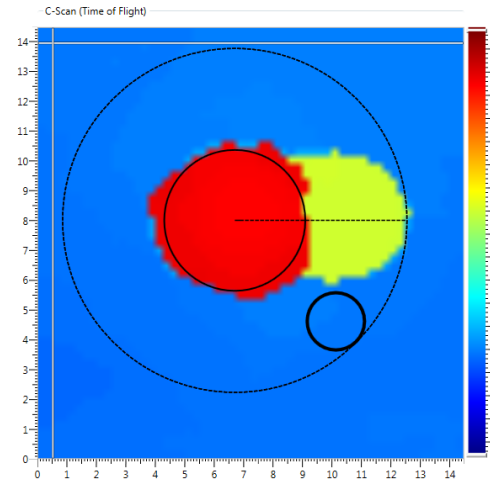


Ultrasound NDT of Drilled Holes using 2D Array System



58th Annual A4A NDT Forum - 2015 Fort Lauderdale

Eskil Skoglund - Head of Development

DolphiTech

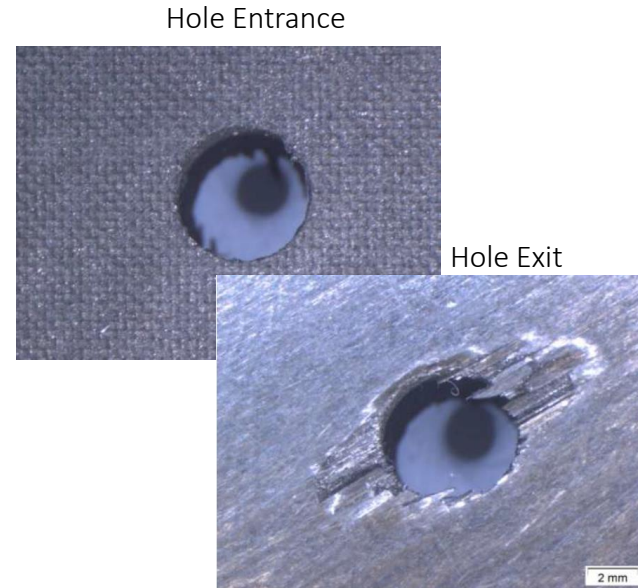
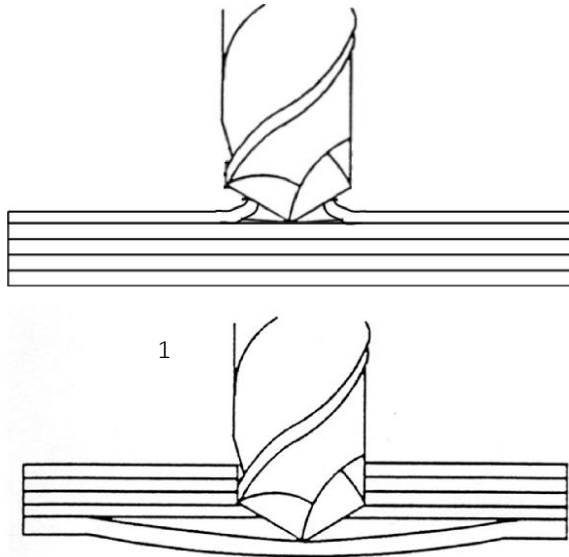
Drilled Holes in Aircrafts



© AIRBUS S.A.S. 2010 - COMPUTER RENDERING BY FIXION - GWLNSD

Tens of thousands drilled holes in a large aircrafts!

Challenges & Effects - Drilling Holes in CFRP

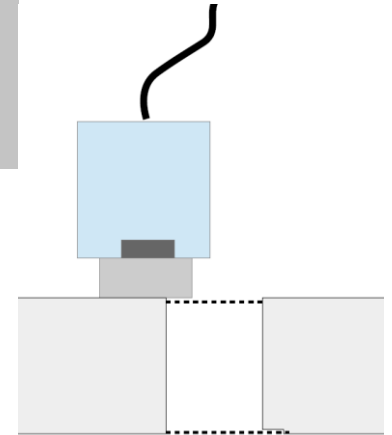
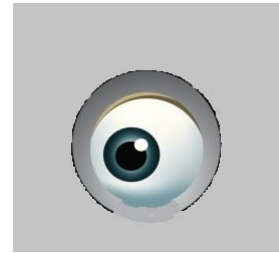


- Peel-Up & Push-Out Delamination
- Intralaminar Cracking (Vertical)
- Fiber Debonding (Horizontal)
- Thermal Damage

1: Image: L. M. P. Durão, A. G. Magalhães, João Manuel R. S. Tavares, A. Torres Marques, Delamination analysis after carbon/epoxy plate drilling

Drilled Hole Inspection Methods

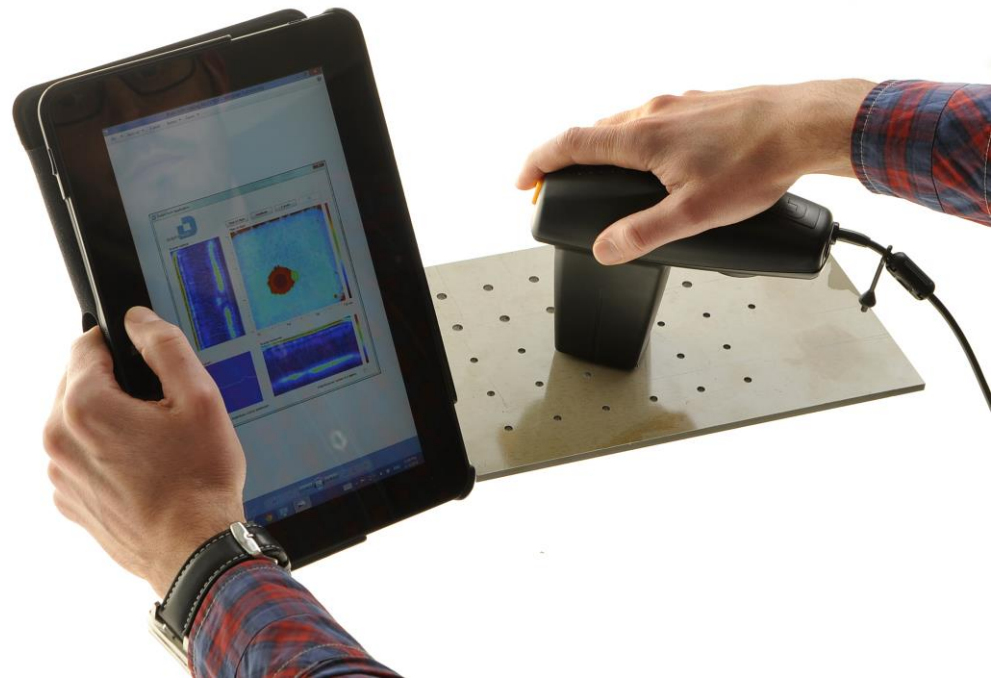
- Visual Inspection & Borescope
- Single Probe Ultrasound (A-scan)
- Daisy Array UT - Circular Array (A-,B-scan)
- PAUT - Linear Array w/ encoder (A-, B-, C-scan)
- PAUT– Linear Array Rolling Probe (A-, B-, C-scan)



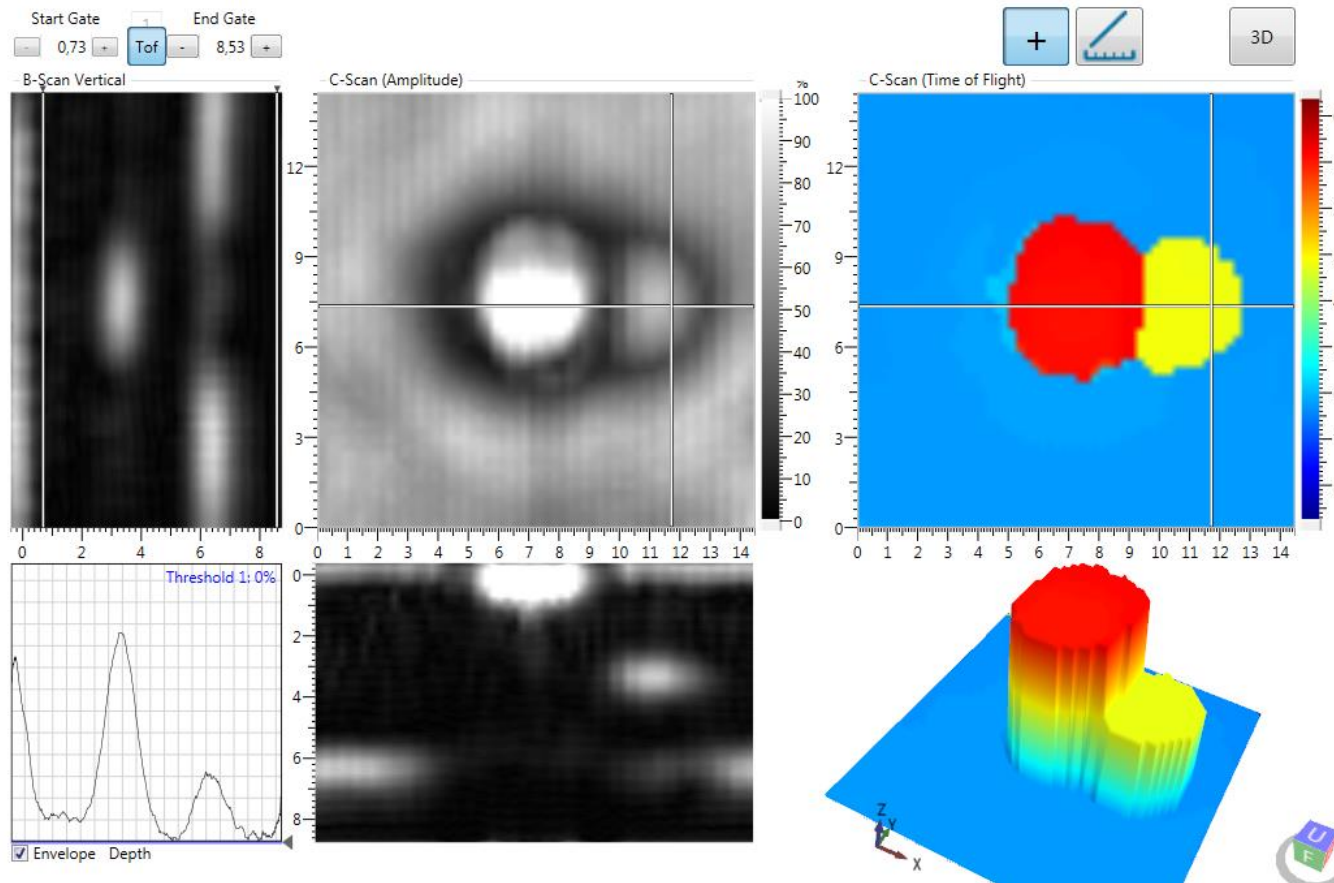
Matrix / 2D-Array System

DolphiCam

- Ultrasound Camera for NDT of CFRP
- Matrix/2D Array – 15.376 elements
- Dry Coupling
- A-, B-, C-Scan & 3D
- Easily operated by non-experts

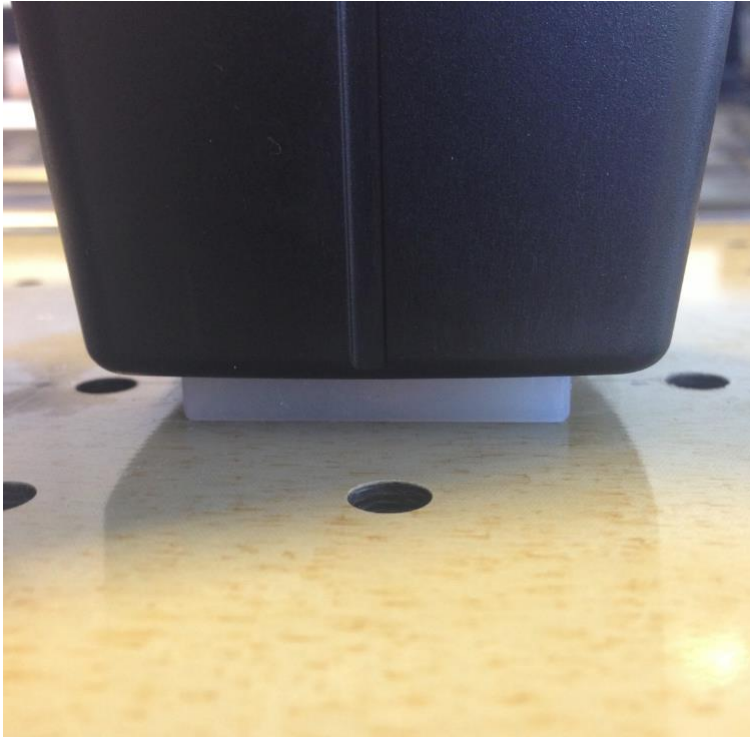


Drilled Hole Image



- Invisible vision

Dry Coupling

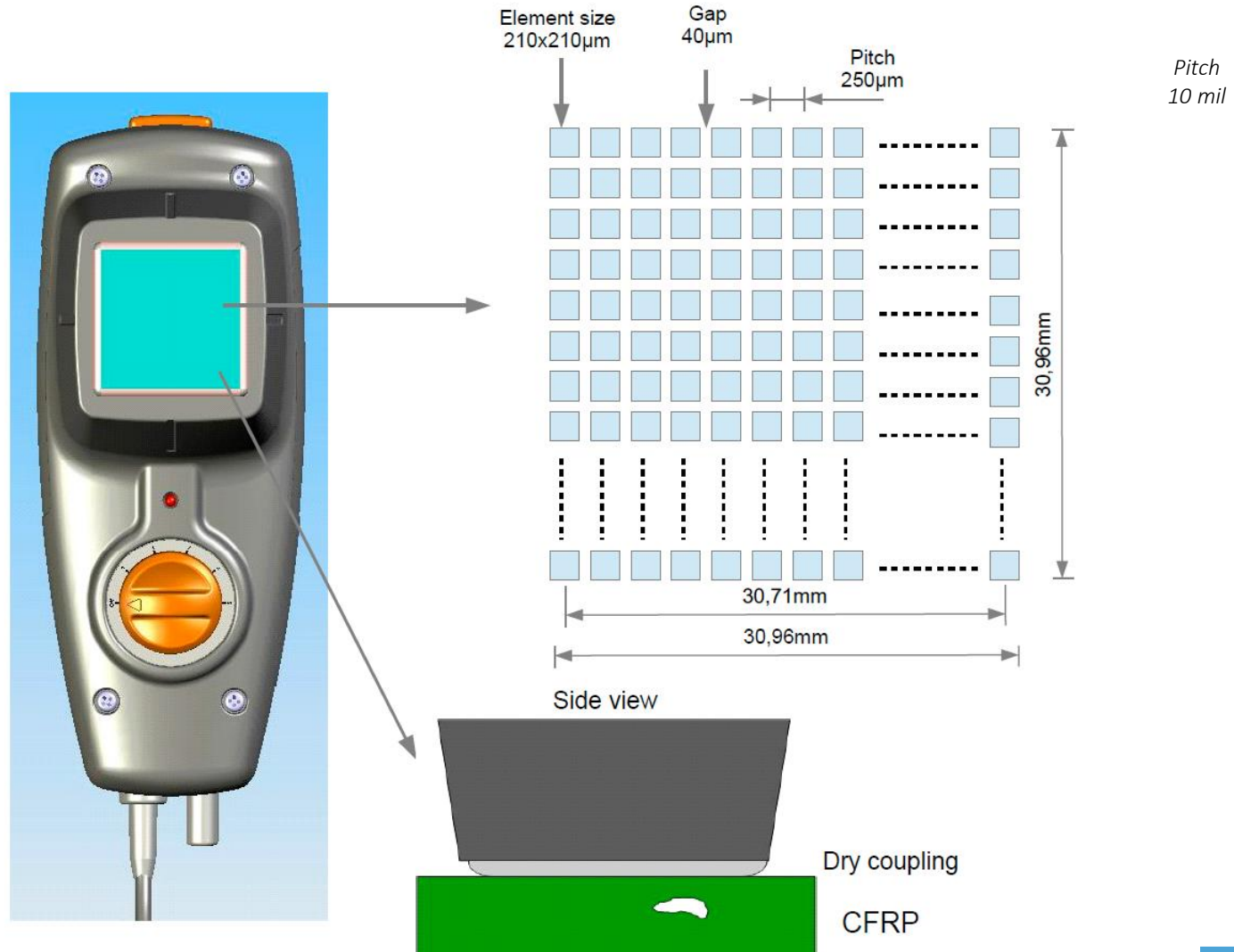


Benefits:

- Easy & fast coupling!
- Nothing to clean up!

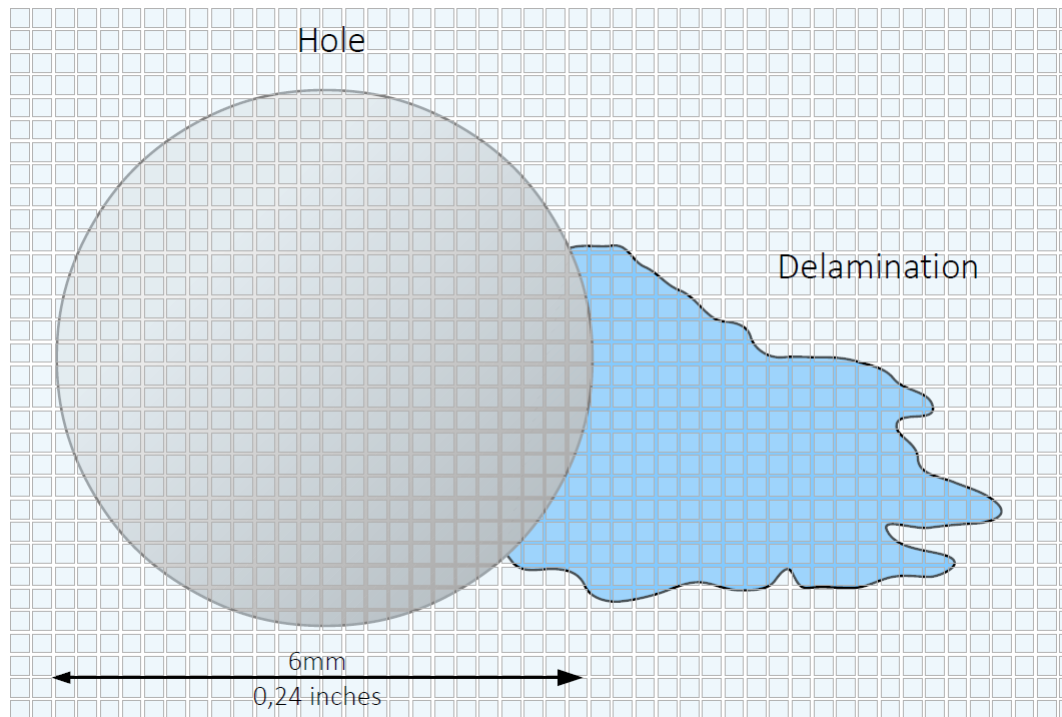
- *Invisible vision*

Matrix / 2D-Array System

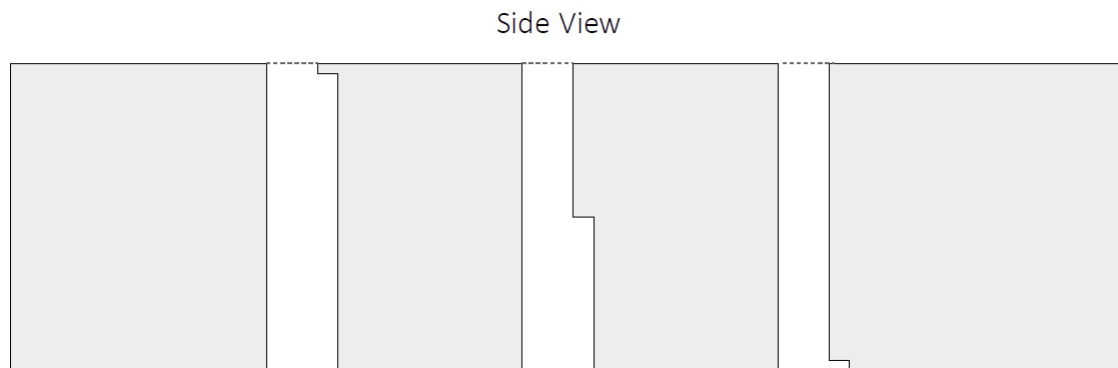
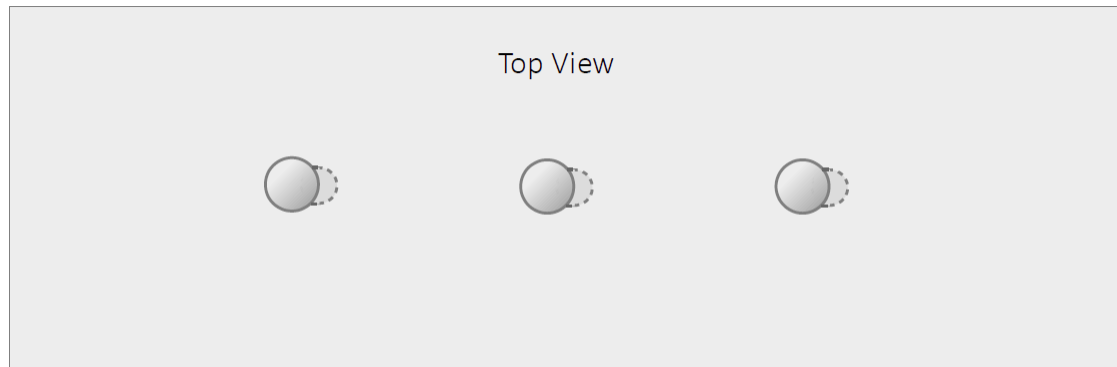
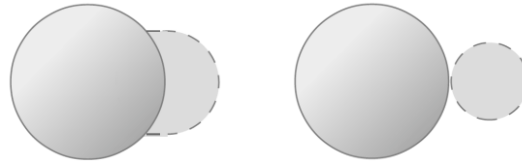


- Invisible vision

Matrix / 2D Array

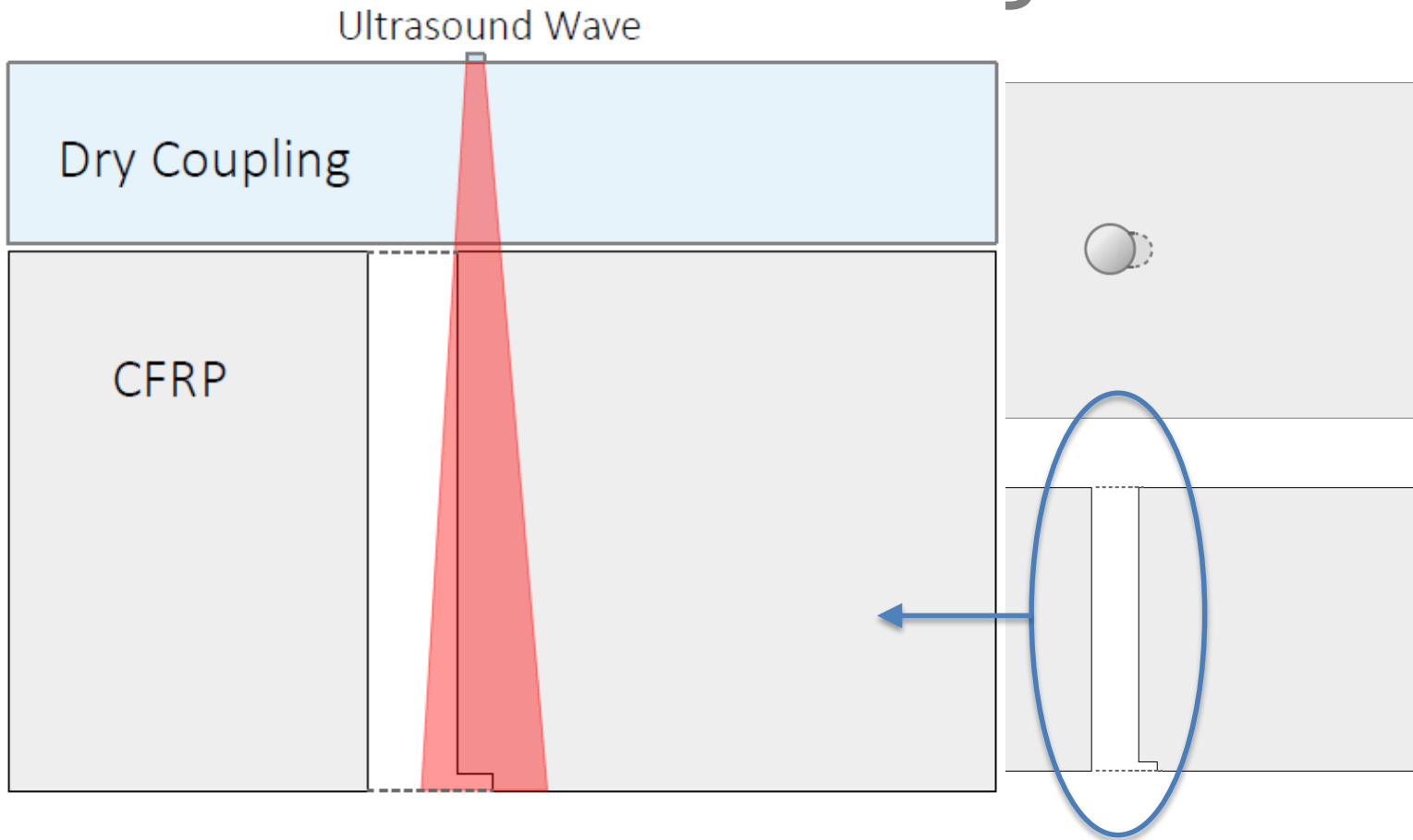


Qualification of NDT on Drilled Hole



- Invisible vision

NDT Challenges



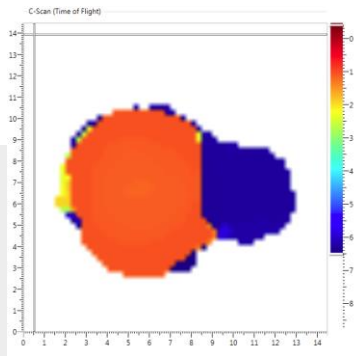
- Small size - 2x4mm / 80x160 mils
- Near surface & near back wall – 2 plies: 0,25mm / 10 mils

- Invisible vision

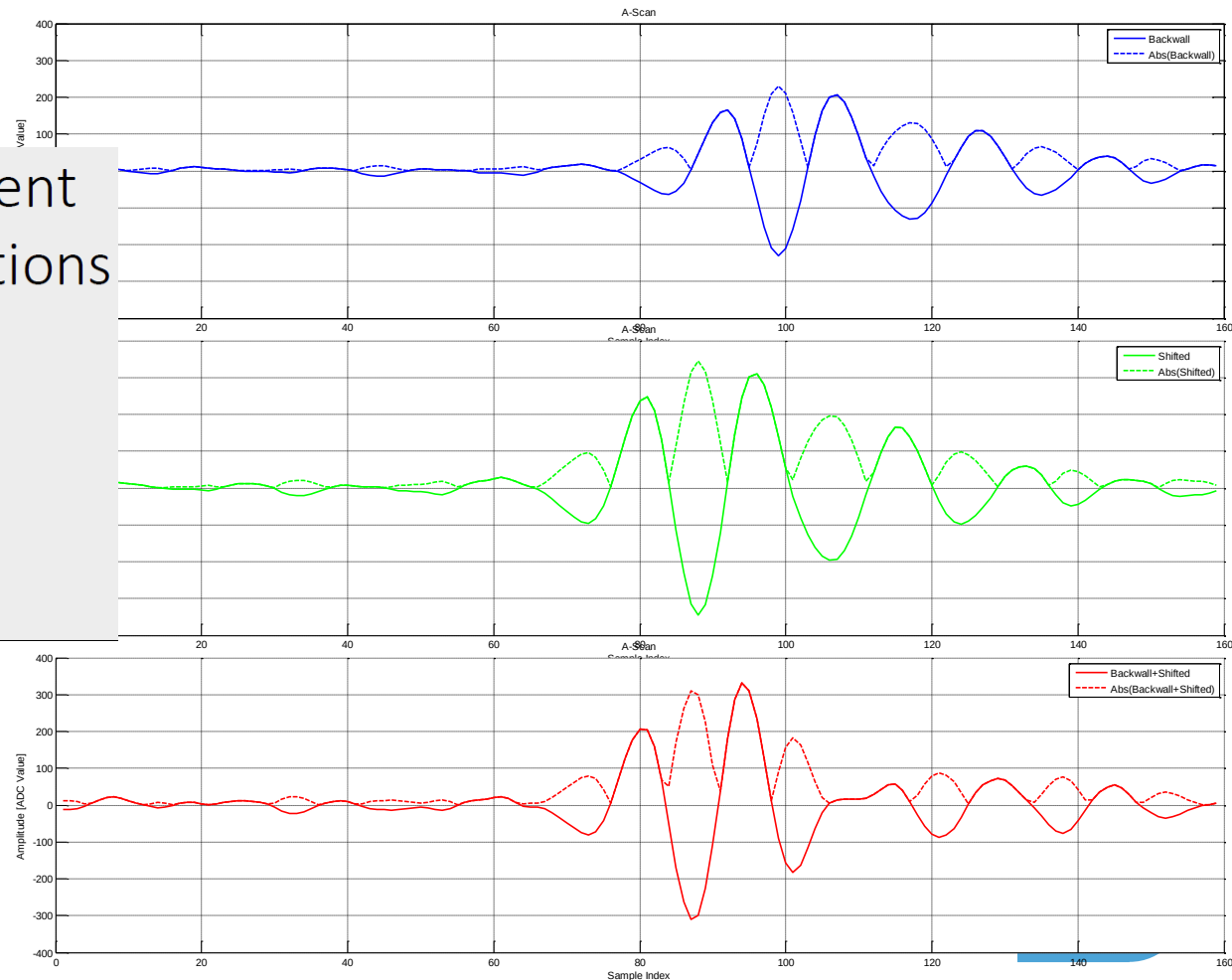
Complex Reflections

Wave length in CFRP: $\lambda = \frac{3000m/s}{4\text{ MHz}} = \mathbf{0,75\text{ mm (30 mils)}}$

Typically 2 plies = $\mathbf{0,25mm - 0,5mm}$ (10-20 mils)



Different Reflections



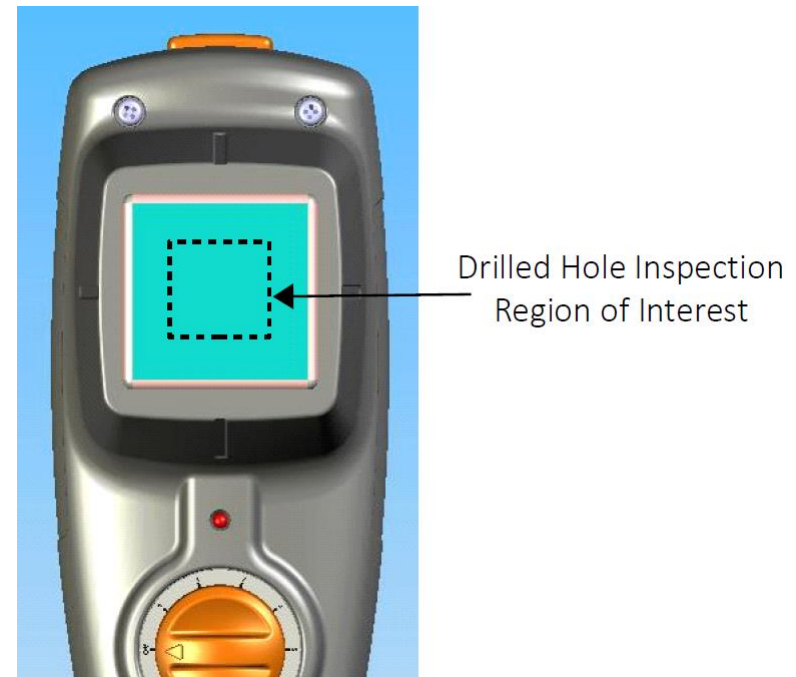
C-Scan Capture Method

Max Negative

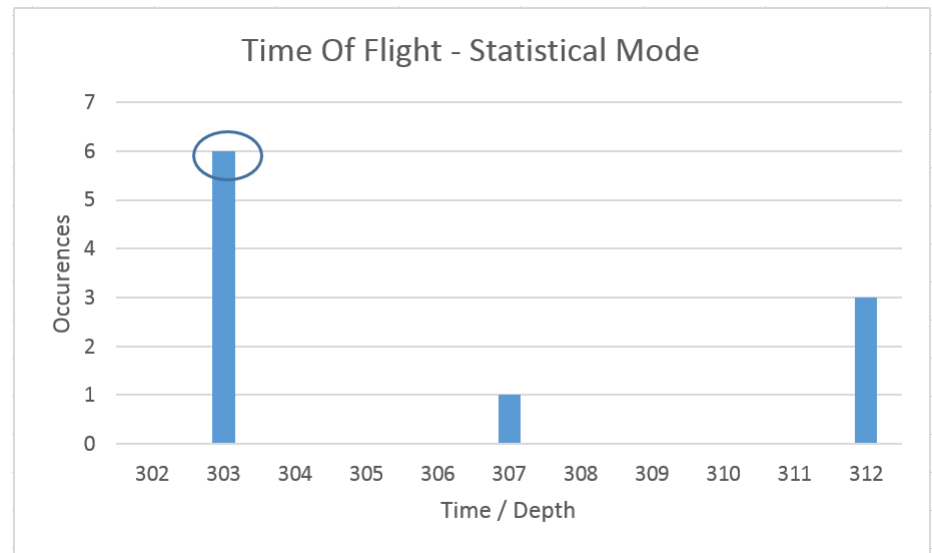
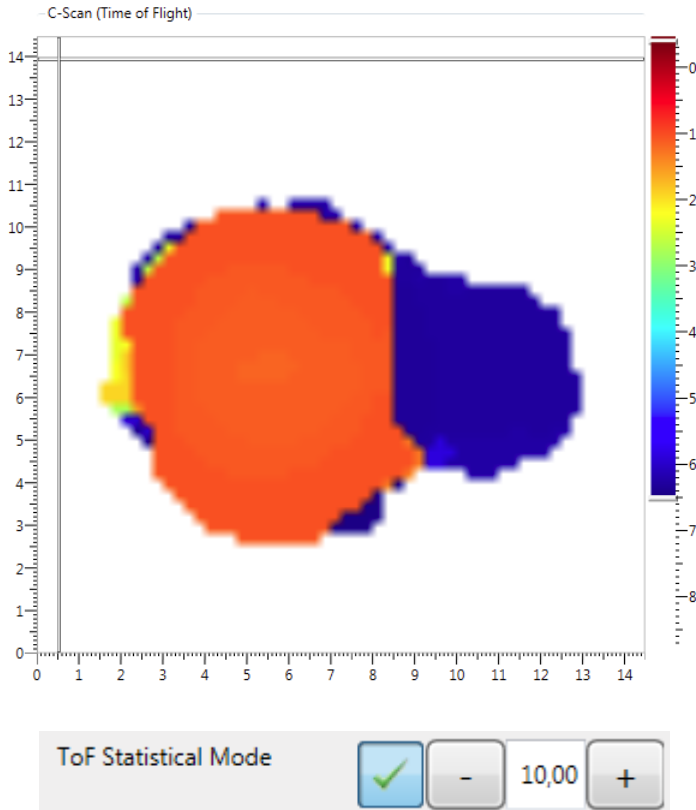
- Invisible vision

Drilled Hole Inspection Region of Interest

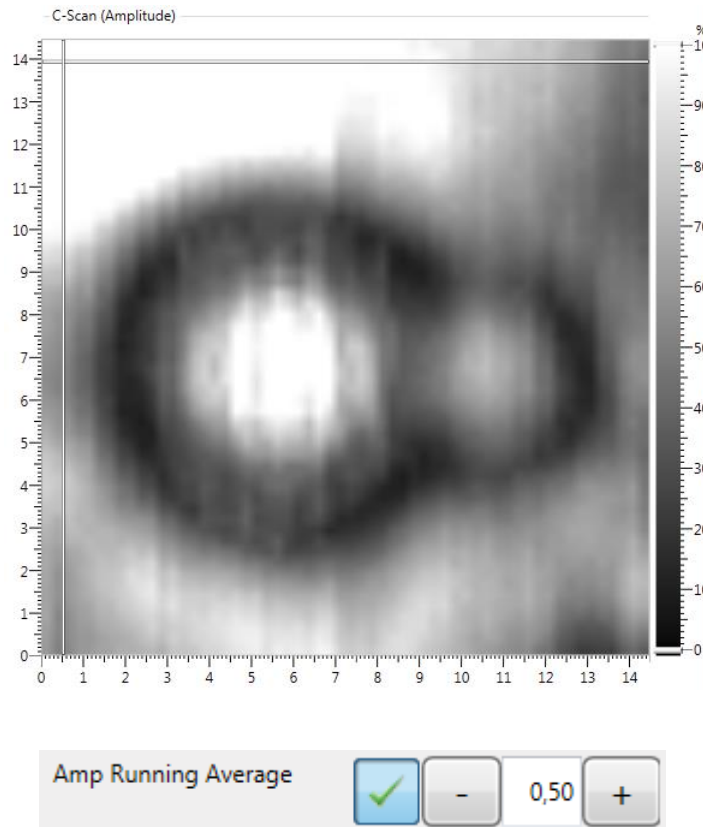
- Reduces elements from 15376 to 3306
- Fast frame rate to up to 30 FPS
- Very fast user feedback!
- Concentrated area gives even easier complete coupling over the area of interest



C-scan Time-Of-Flight - Statistical Mode



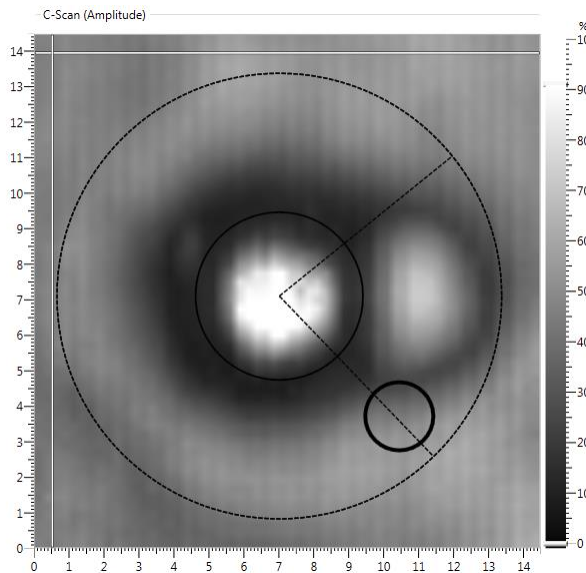
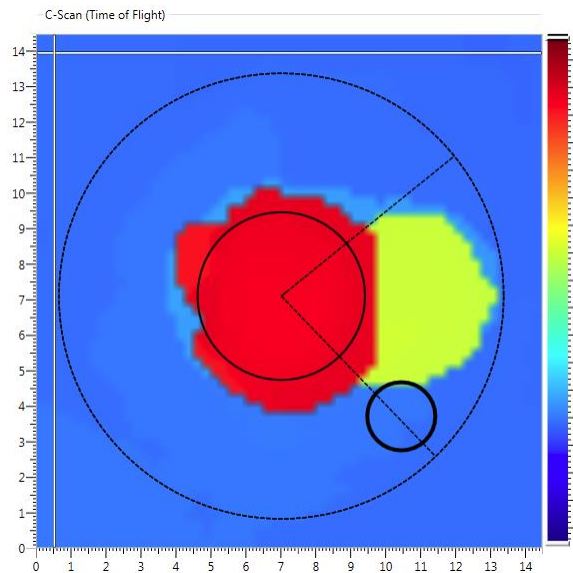
C-Scan Amplitude - Running Average



Alpha = Forgetful factor

Alpha

Measuring Tool



Drilled Hole Inspection Close

Damage Size

Radial (mm)

Circumf. Arc (mm)

Circumf. Angle (deg)

Drilled hole dimension

Size of hole (mm)

Radial damage (mm)

Circumferential Damage

Sector Start (deg)

Sector End (deg)

Drilled Hole Adapter

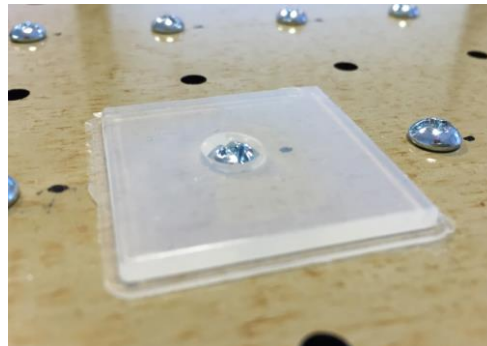
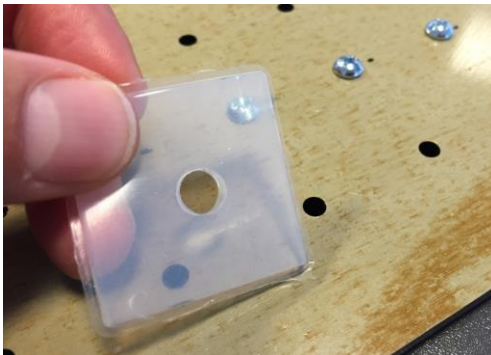
Challenge:

Inspect drilled holes with protruding bolt head, disabling coupling to the material



Solution:

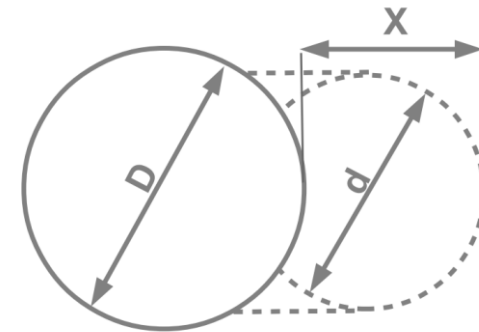
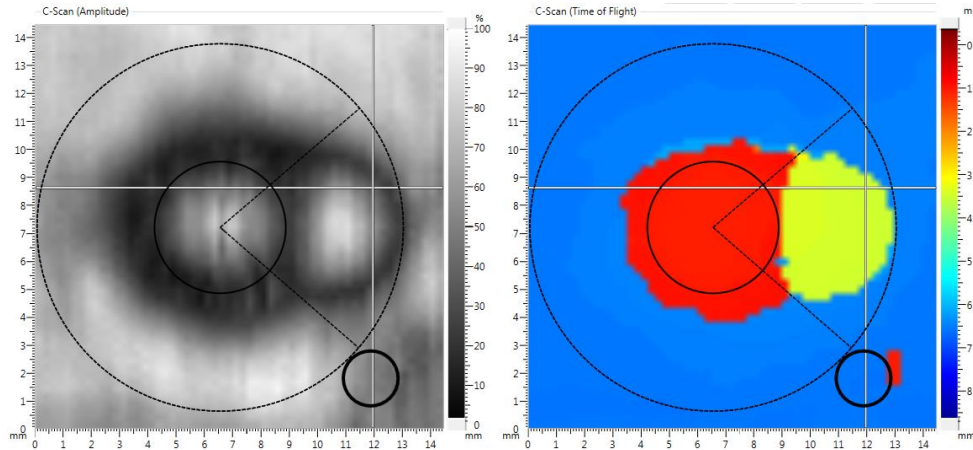
Drilled Hole Adapter



- Invisible vision

Drilled Hole Adapter - Results

Reference – no bolt head – no adapter:



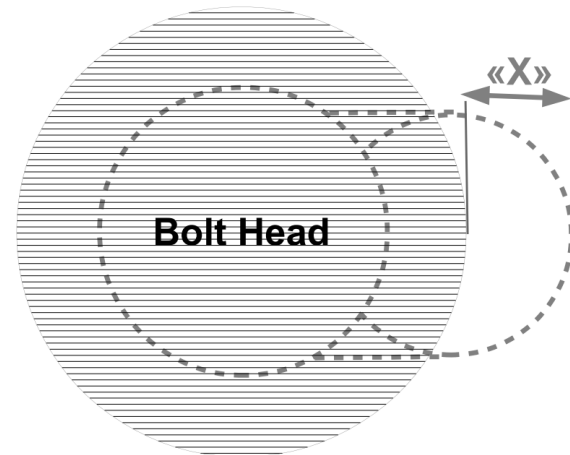
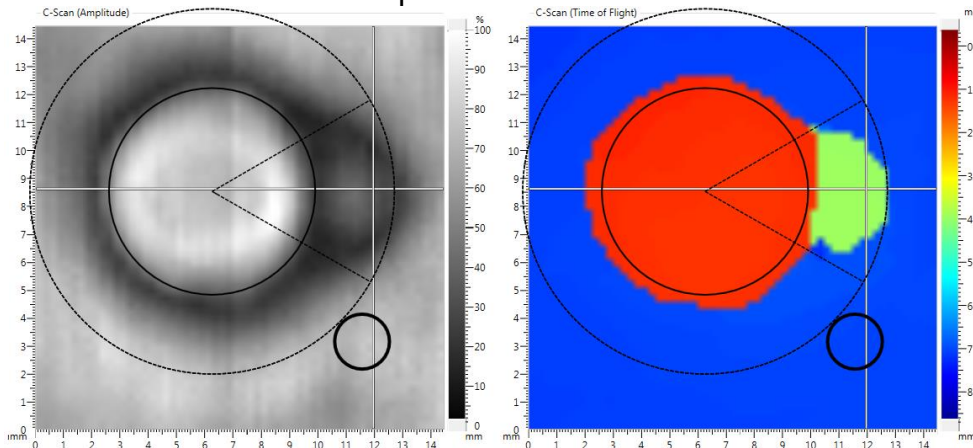
$D = 4.8\text{mm}$ (0.19 inches)

$d = 4.0\text{ mm}$ (0.16 inches)

$X = 3.0\text{ mm}$ (0.12 inches)



Bolt head with adapter:



Bolt diameter = 7.5mm (0.3 inches)

«X» = 1.65 mm (0.065 inches)



- Invisible vision

Thank You!



Questions?