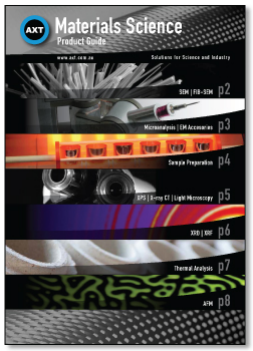
AXT - The Affordibility of DR in Aeronautics

AXT - A Broad Partner for Science and Research



Fast review of the *CR & DR*

computed radiography (CR) vs digital radiography (DR).

computed radiography (CR)

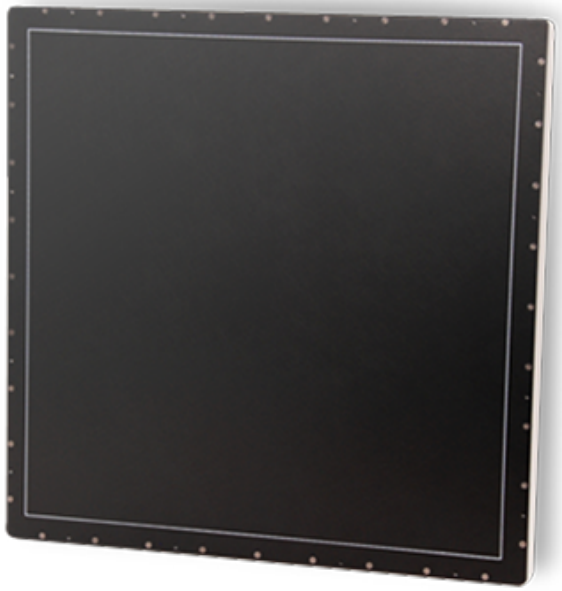
- Photo-stimulated luminescence screens capture the X-ray image, instead of traditional X-ray film.
- The “pixel” size can be quite good at 20-30um.
- The CR cassette (sheet) goes into a reader
- A laser triggers phosphor to give of visible light - reads off the sheet
- A higher power laser “resets” the sheet

- (+/-) CR enabled digital imaging within the traditional workflow of X-ray film. With CR, like film, no synchronization to the generator is required, which had been a requirement for DR imaging. However, recent advances in DR panels are improving their flexibility, portability, and affordability.

digital radiography (DR).

An active matrix flat panels consisting of a detection layer deposited over an active matrix array of **thin film transistors and photodiodes**.

With DR the image is converted to digital data in real-time and is available for review within seconds.



Why Digital????

Advantages of CR and DR

- a wider dose range than film.
- post processed to eliminate mistakes and avoid repeat examinations.
- Fast, in field , no chemical

Advantages of DR

- improves workflow by producing higher quality images instantaneously.
- Wireless , portable, adaptive, faster setup
- provides two to three times more dose efficiency than CR. Higher contrast/faster
- X-ray detection
- tractability and meta data

The combination of ***Digital Radiography*** *flat panels* ***(DR)*** *with* ***micro-focus portable Xray*** *generators* ***(µF)*** *offer* ***oustanding solutions*** *in* ***aircraft maintenance***

RT

(+) Easy interpretation (« objects become transparent »)
(+) Precision (« anomalies » can be seen and located at 0.1 µm)
(+) Wide area inspection (= film or detector size)

(-) Difficult settings (kV, mA, ...)
(-) Difficult positioning
(-) Ionizing radiations

(-) Chemicals
(-) Film development (→ delays)

RT with DR flat panels

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(-) Chemicals → **no more chemicals**
(-) Film development (→ delays) → **CR → DR immediate result**

RT with DR flat panels

(++) Digital : higher image quality and easier interpretation
(+) Precision (« anomalies » can be seen and located at 0.1 µm)
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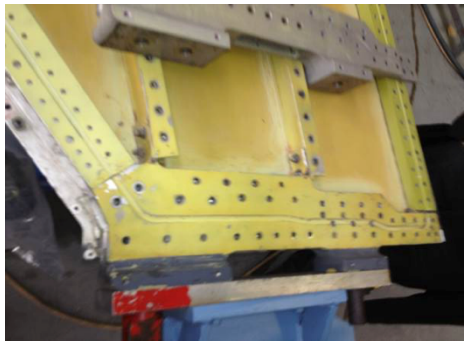
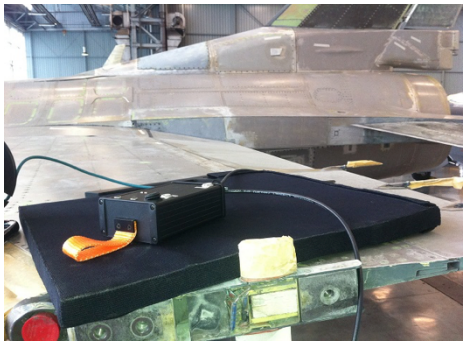
Case study 1 : F-16 maintenance





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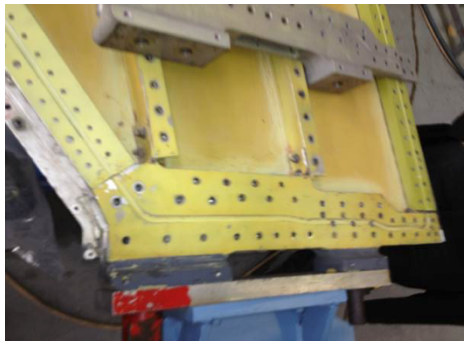

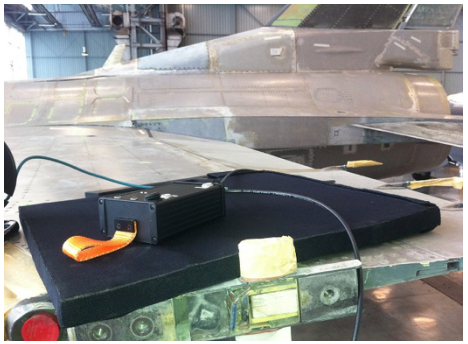

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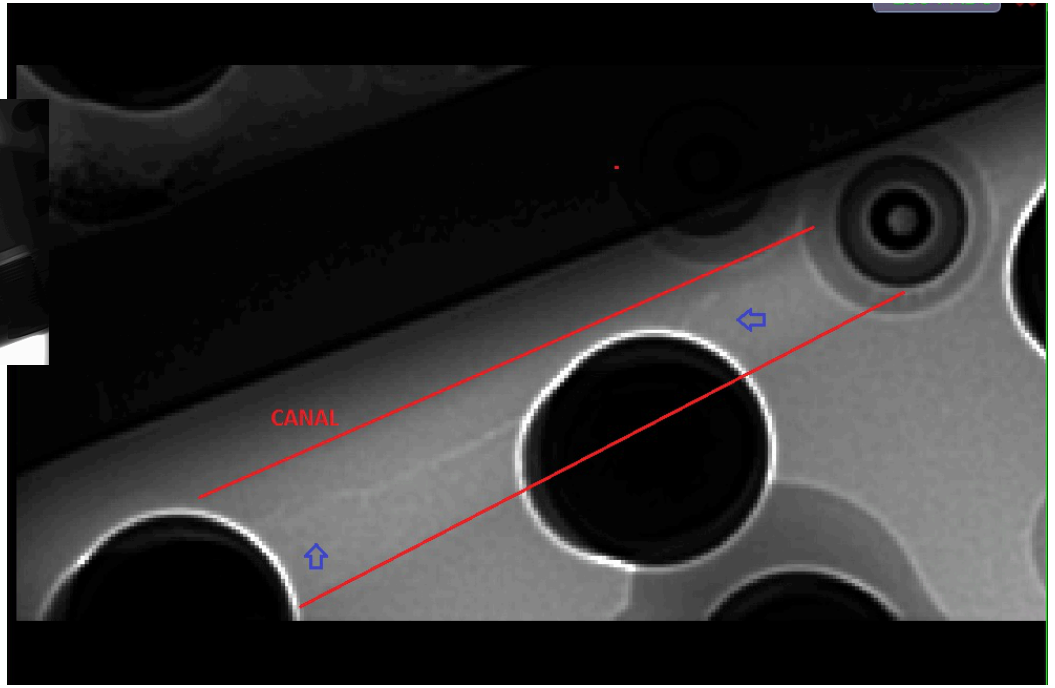
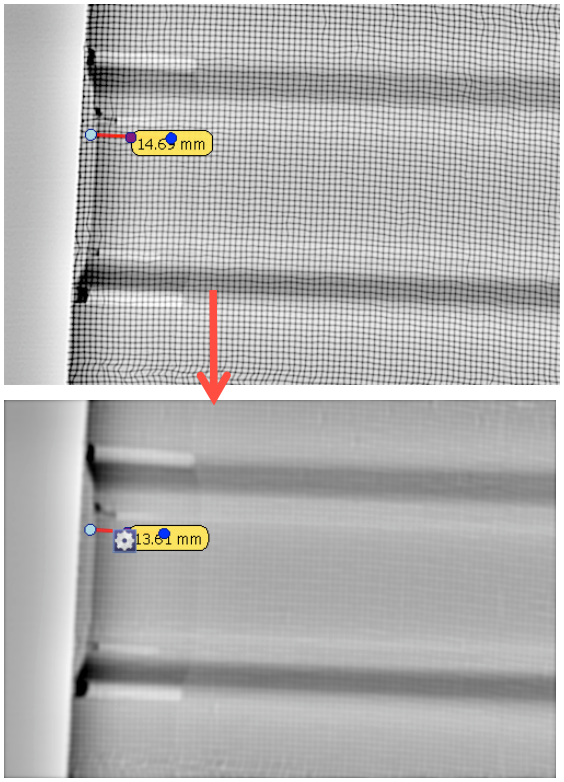
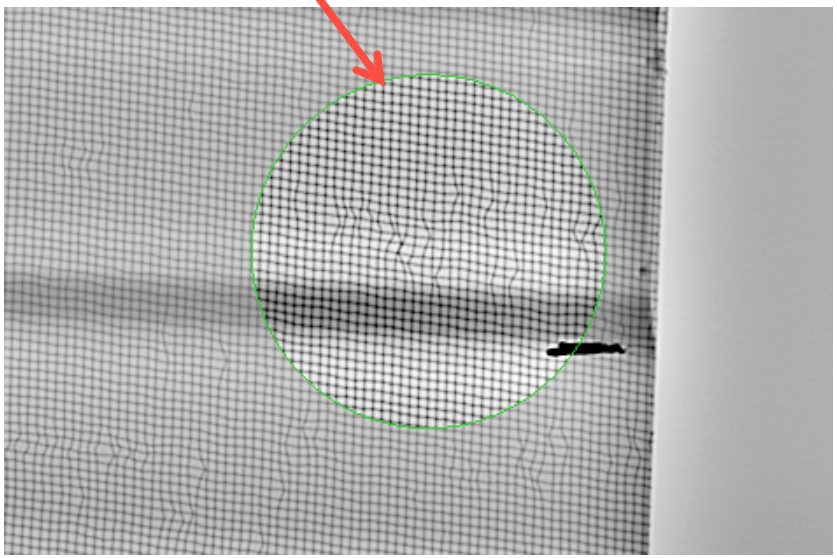


Cracks in the injection channel

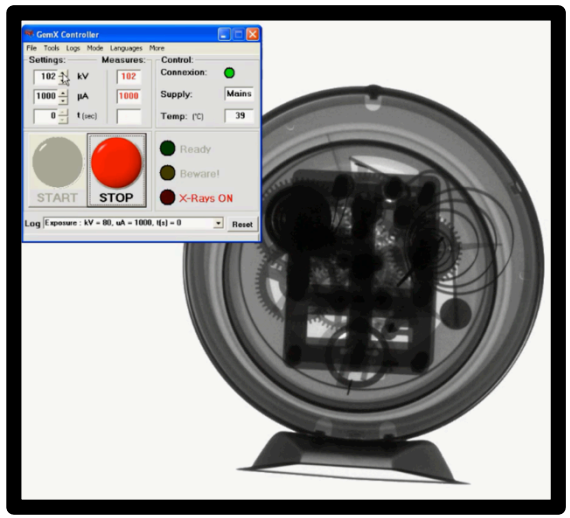
Case study 1 : Structure Analysis



Filters - magnifier



Innovation : *Portable Real Time DR*



RT with *real time* DR flat panels

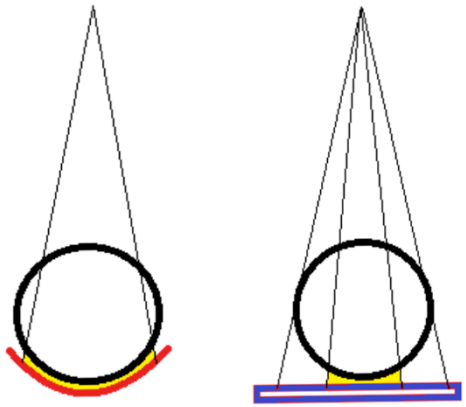
(++) Digital : higher image quality and easier interpretation
(+) Precision (« anomalies » can be seen and located at 0.1 µm)
(+) Wide area inspection (= detector size)
(+) Immediate result

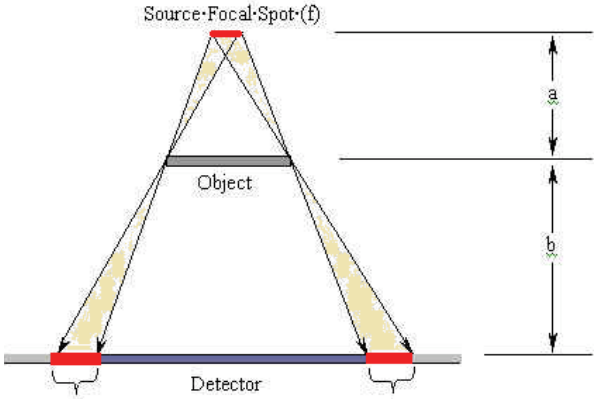
(+) Easy radiological parameter settings (kV, mA, …)

(--) Not a flexible support
(-) Ionizing radiations

Issue of no-flexibility

Why is the lack of *flexibility an issue ?*

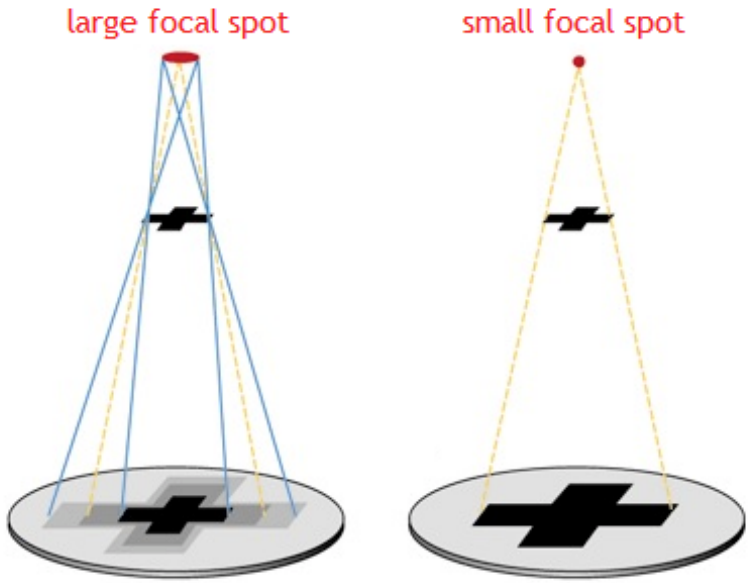




penumbra

→ **Film/detector has to stick to the part to avoid: penumbra / blurring / geometric unsharpness**

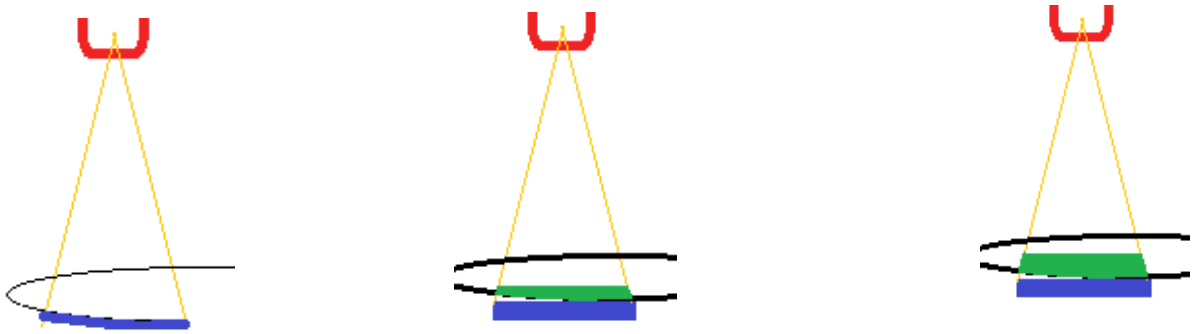
Why is the lack of *flexibility an issue ?*



RT restriction due to focal spot size

With a FOD of 30 inches and a target resolution of 100 µm
The distance between the area to inspect and the detector has to be :

Focal spot :	3 mm	1 mm	0.5 mm
Max dist. :	1 inch	< 3 inch	< 6 inches



Only film !

DR is ok

And if the focal spot is even smaller

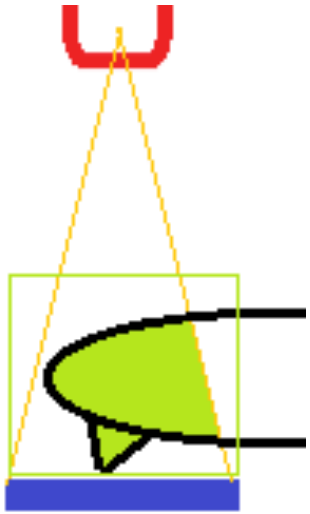
Focal spot size of 200 µm

Analysis is **not** restricted to surface
Analysis can be done on a ***whole volume*** !

With a focal spot of 200 µm and a DR of 200 µm
The whole area between ***D/2 and D can be checked*** !
! That is impossible with current portable generators !

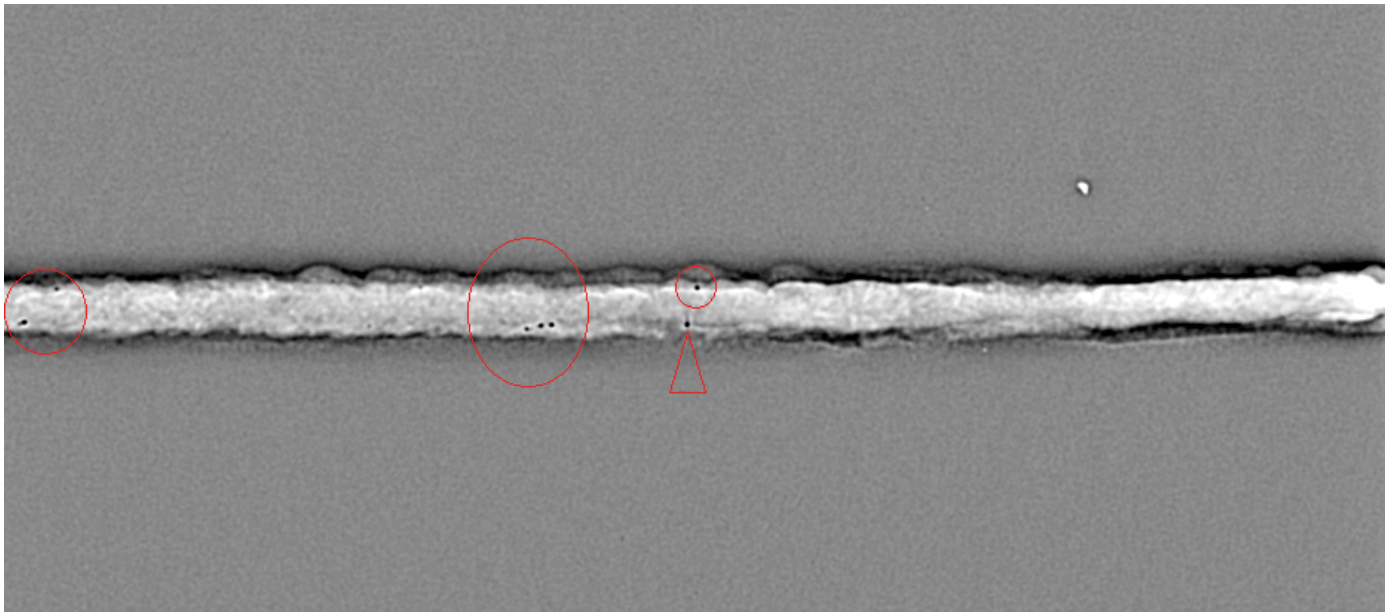
Spatial resolution is increased (see below)

→ small focal spot is helpful to avoid blurring
→ µfocus opens the gate to RT inspect in volume



Innovation : magnification with a µ-focus

Case study 3 : Ti welding – 6 mm thick



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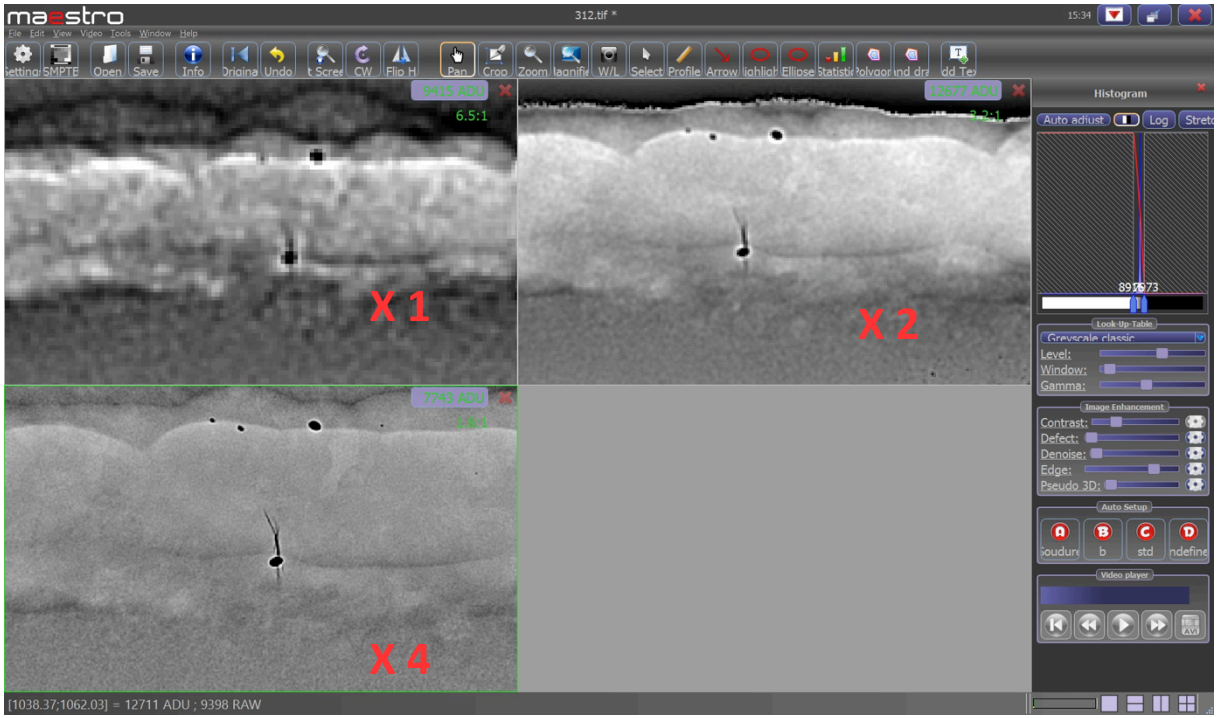


Case study 3 : Ti welding – 6 mm thick

Effective pixel size at D/2 : **100 µm**
Measured SRb : **D11**

RT with real time DR flat panels and µfocus

RT with *real time* DR flat panels and *µfocus*

(++) Digital : higher image quality and easier interpretation
(+) Precision (« anomalies » can be seen and located at 0.1 µm)
(+) Wide area inspection (= detector size)
(+) Immediate result

(+) Easy xray parameter settings with real time (kV, mA, …)
(++) Complete volume inspection
(++) increased spatial resolution with magnification

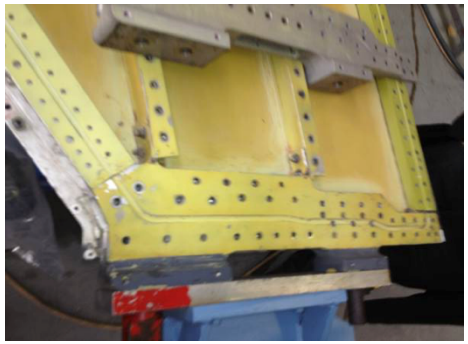
(-) Ionizing radiations → DR are 10 x more sensitive than film

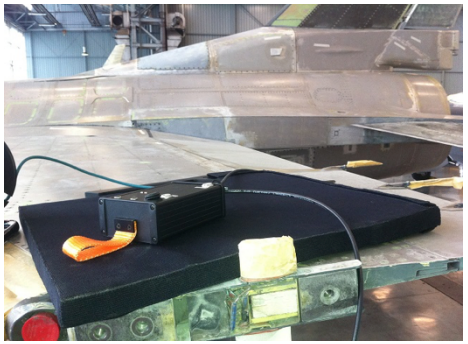
ROI

	Film Radiography		DR (XRIS)		
	Cost of 1 film	Annual Cost (6000 Films)	Cost of an DR Image	Annual Cost (6000 DR Images)	Annual Savings
Exposure	5.00 €	30,000 €	2.00 €	12,000 €	18,000 €
Developing Time	4.20 €	25,200 €	NA	0 €	25,200 €
Film&Chemicals	2.10 €	12,600 €	NA	0 €	12,600 €
Analysis&Report	2.00 €	12,000 €	2.00 €	12,000 €	0 €
Management Costs	0.80 €	4,800 €	0.80 €	4,800 €	0 €
Unavoidable Reshots (%10)	14.10 €	8,460 €	NA	0 €	8,460 €
Depreciation & Maintenance Costs	0.90 €	5,400 €	1.40 €	8,400 €	-3,000 €
Documentation&Storage Space	0.15 €	900 €	0.04 €	240 €	660 €
	29.25 €	99,360 €	6.24 €	37,440 €	61,920 €

Case study 1 : F-16 maintenance

10 days > 2 Days





Portable and Ruggedised DR Panels

- Active area : from 4'' x 2'' to 17'' x 14''
- Pixel size : from 48 µm to 200 µm
- CMOS – GadOx (selection of scintillators)

- Self detection of Xrays
- Adjustable sensitivity
- Adjustable capture time per frame
- Real time + averaging
- Battery powered
- Wifi

Microfocus Sources

- μfocus portable battery-powered Xray generator
- monobloc - 30 x 30 x 20 cm - 14 kg (all included)
- dedicated to Digital Radiography
- 150 kV – 1 mA – 150 W
  → enough for 15 mm Fe after 60 s
  → class B from 1.5 to 15 mm of Fe
- wireless control
- micro focal spot
  < 0.2 x 0.2 mm (ASTM E 1165-12)
  0.15 mm (IEC 60336)
- constant potential (100 kHz) → averaging

Microfocus Sources

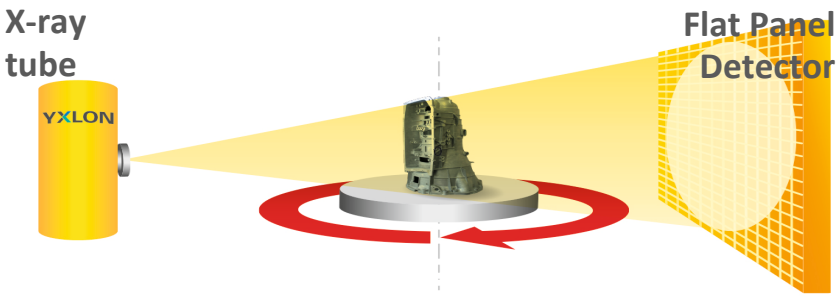
Mini-focus-tubes

- Energies from ~ 20 keV to ~ 600 keV
- Power typically some 100 W up to ~ 1,8 kW
- Focal spot typically ~ 0,25 mm up to ~ 1 mm
- Available as unipolar (to 225 keV) or bipolar (> 225 keV) systems

Micro-focus-tubes

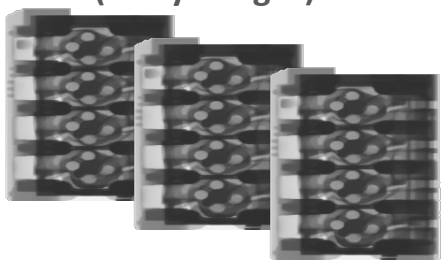
- Energies from ~ 20 keV up to ~ 300 keV
- Power typically from some 10 W up to ~ 0,3 kW
- Focal spot from ~ 1 µm up to ~ 300 µm
- Mechanical design as transmission- or direct beam tube

Mainly Used Methods in Industrial CT – Cone Beam CT



Acquisition of X-ray images (2D), while inspection item is rotated

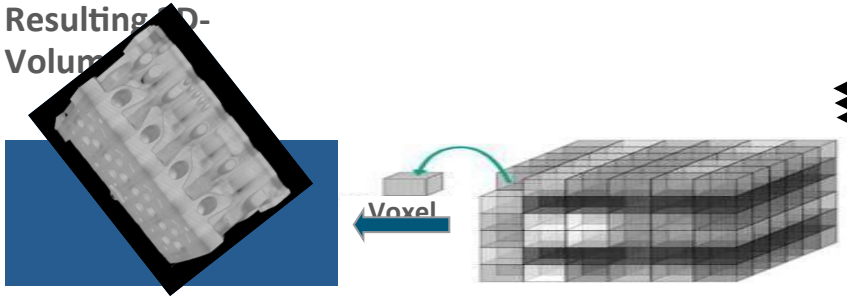
1



2

Reconstruction-algorithm, e.g. with "filtered back

Slice
1
2
3
Reconstructed slices

3

Voxel