UAV-based inspections of metallic panels

With special thanks to Vasilis Tzitzilonis, Research Fellow, Cranfield University

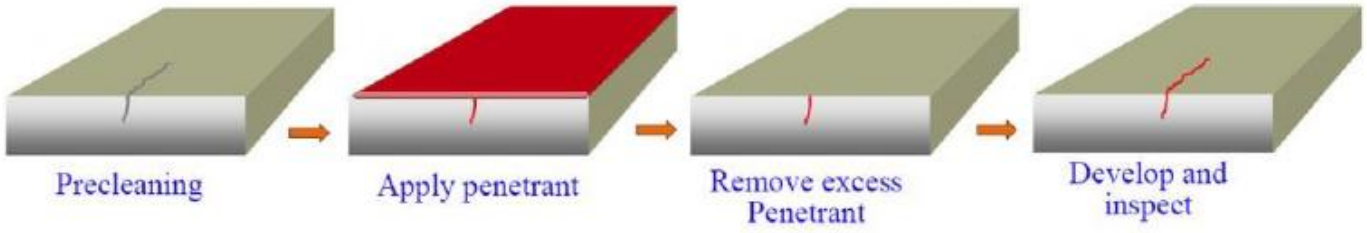
www.cranfield.ac.uk

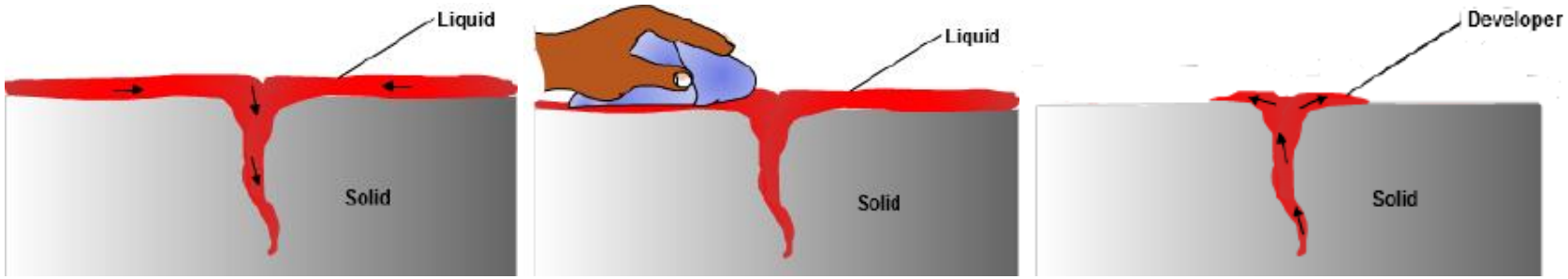
Summary

- Liquid penetrant testing for NDT
- Vision-based damage detection
- Defect detection in operational conditions
- NDT automatization
- Fully automated UAV based inspection procedure

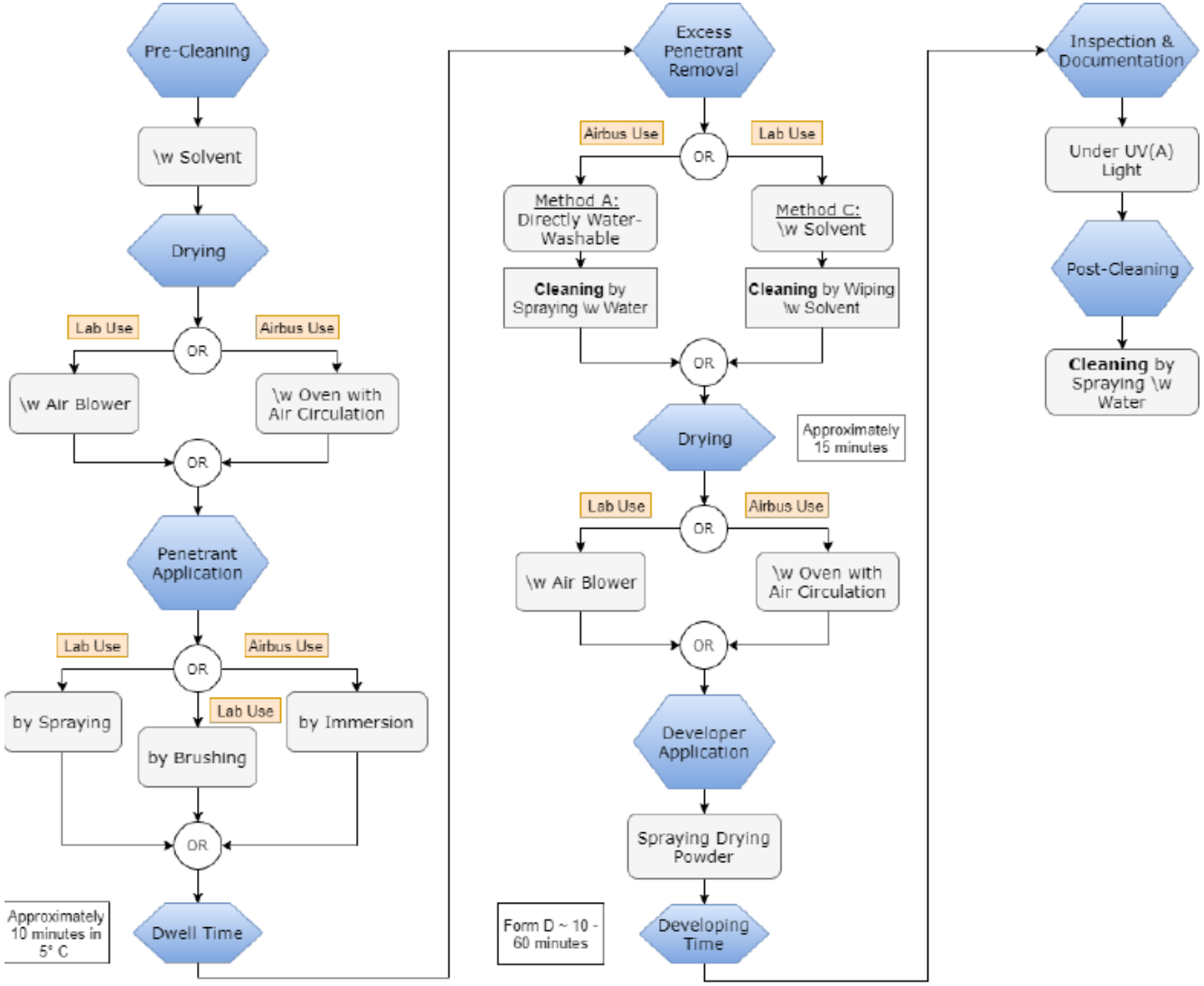
Liquid penetrant testing for NDT

- Pre-cleaning
- Penetrant application
- Removal of excess penetrant
- Application of developer
- Inspection
- Post-cleaning





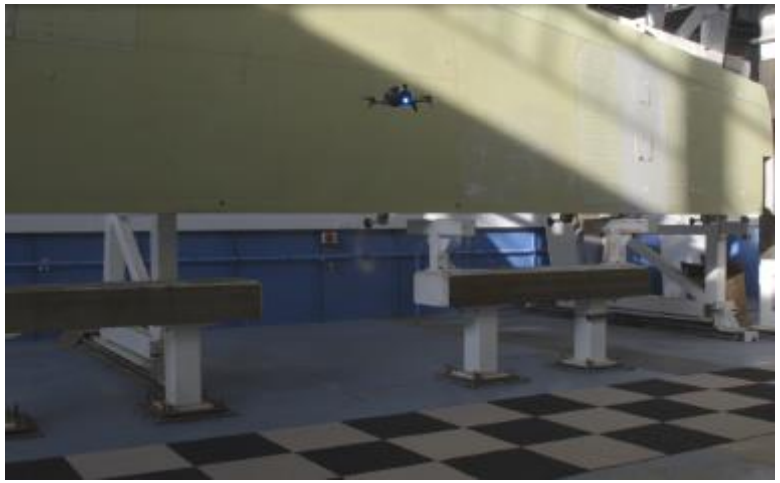
Airbus Procedure (Broughton Facility)



Experimental setup and requirements (feasibility)

Setup

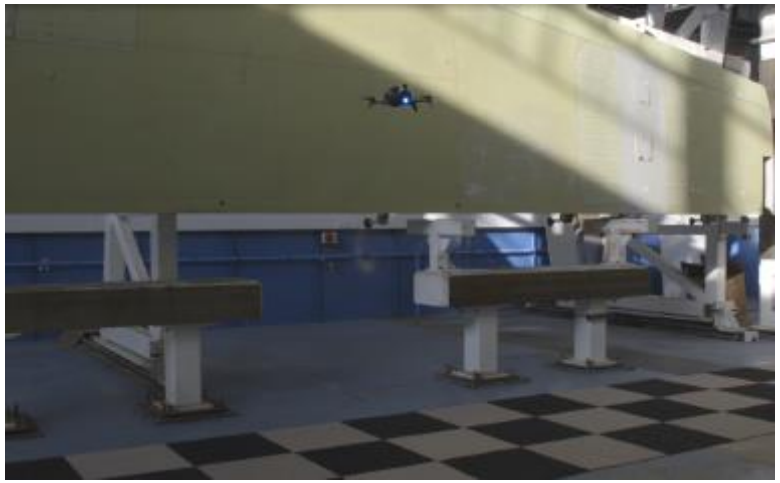
- Bebop 2 Power UAV (30 min autonomy)
- UV-light
- 8 GB flash memory
- CMOS 14-megapixel wide-angle camera (1080p and 30fps) with anti-distorsion system
- Overall mass: 0.52 kg
- Size: ~30 cm
- Autonomy: 30 minutes
- WiFi communications to GCS



Experimental setup and requirements

Payload requirements

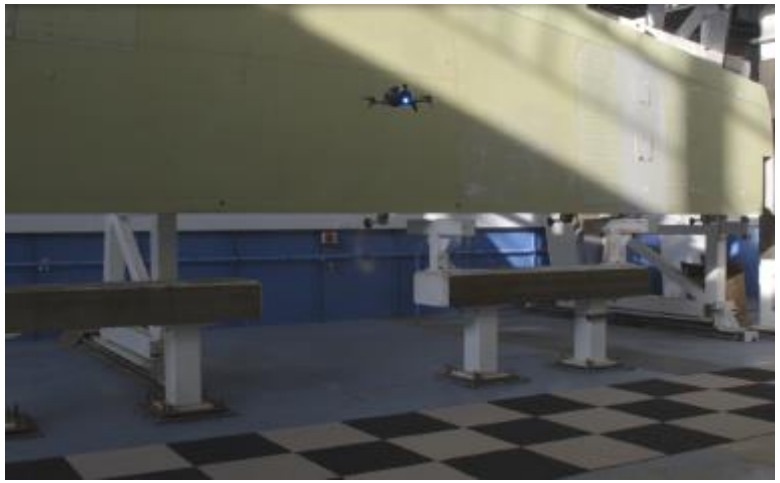
- Wavelength UV: 315 nm to 400 nm, peak at 365 ± 5 nm
- Intensity between 12 and 50 $W m^{-2}$
- Rechargeable battery
- As light and small as possible



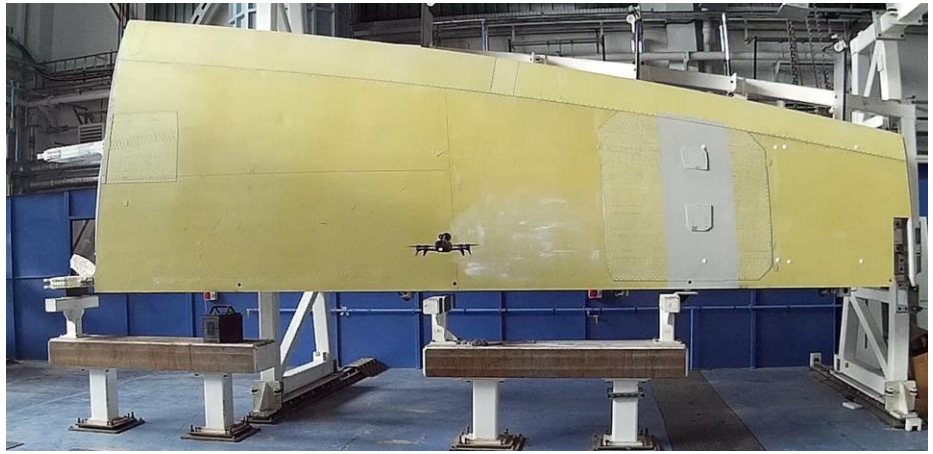
Experimental setup and requirements

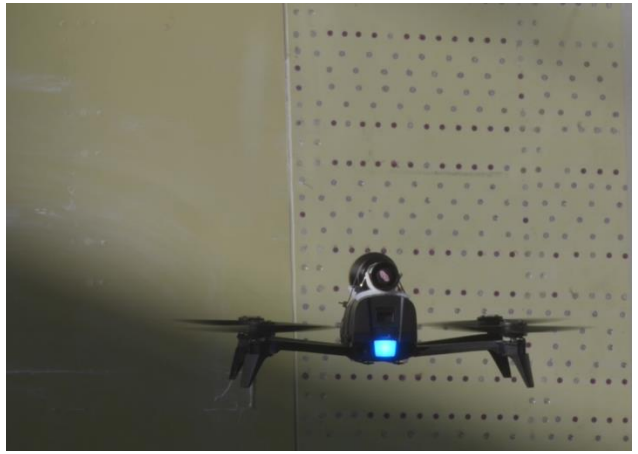
Payload

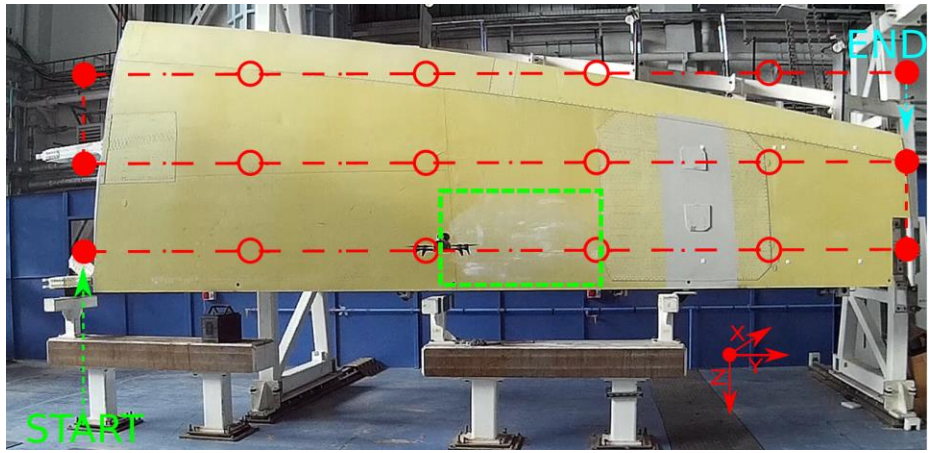
- UGV3 UV LED Torch (Labino) was used
- 0.21 kg
- 160 mm length
- 18 Wm^{-2} mid-light beam
- At 1 m distance from the object the cone diameter is 0.26 m



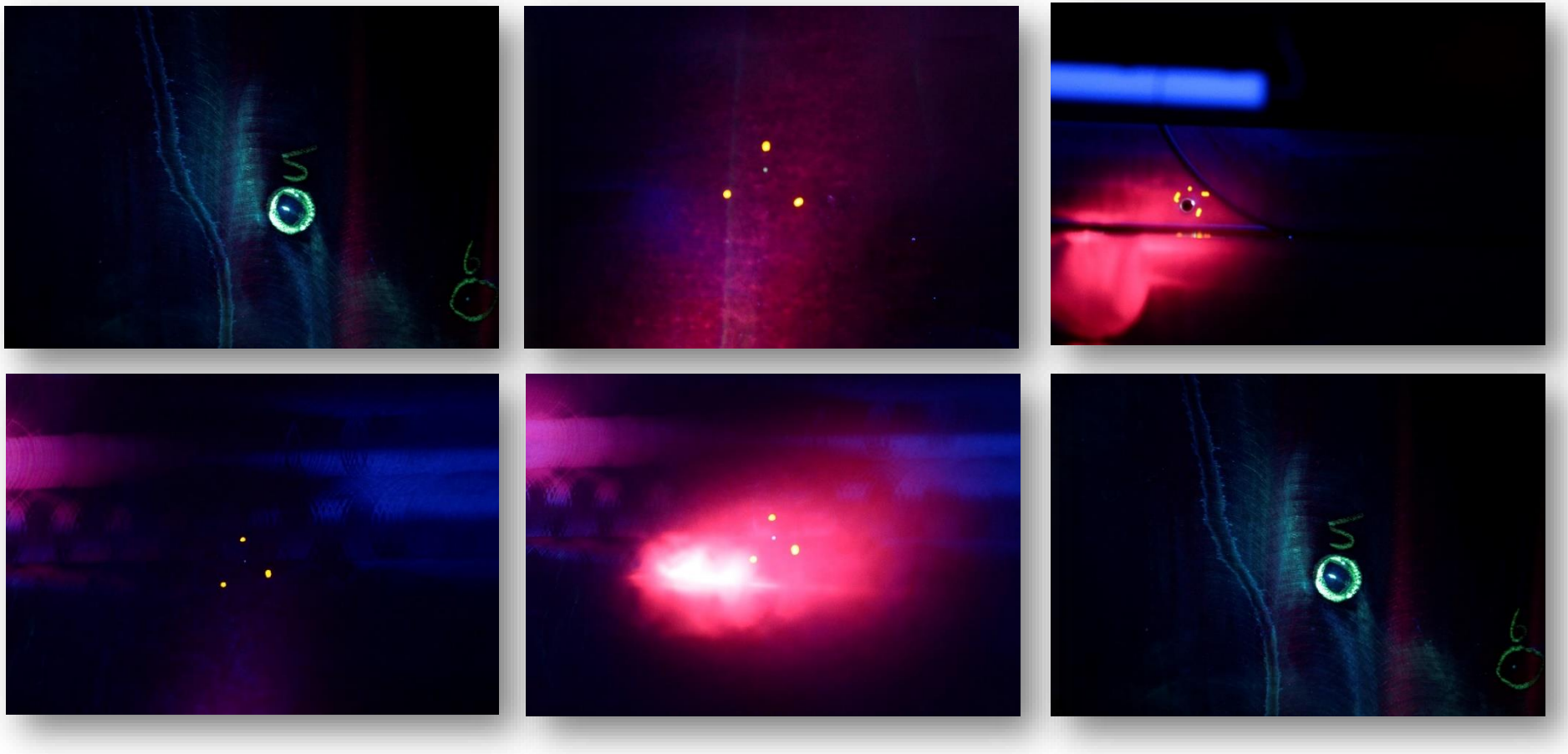
In laboratory wing-inspection







Defects detection: examples



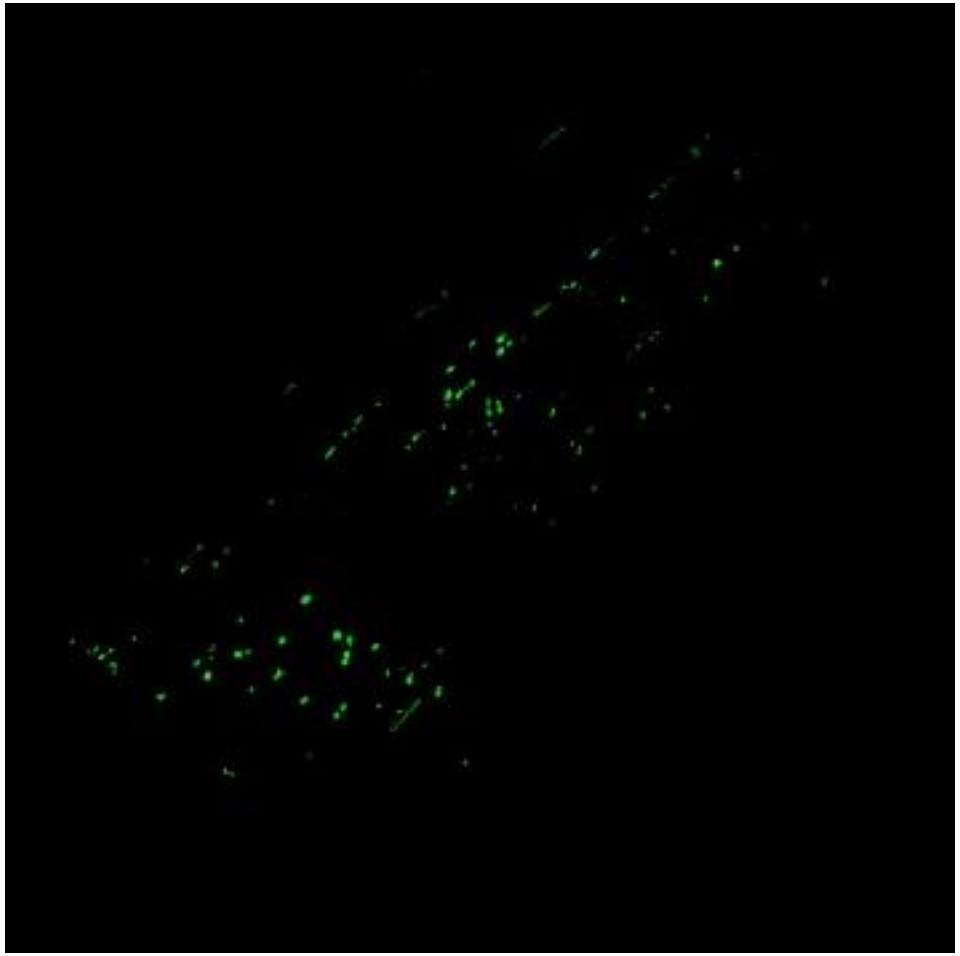
Need to spot defects in a difficult working environment

Vision-based damage detection

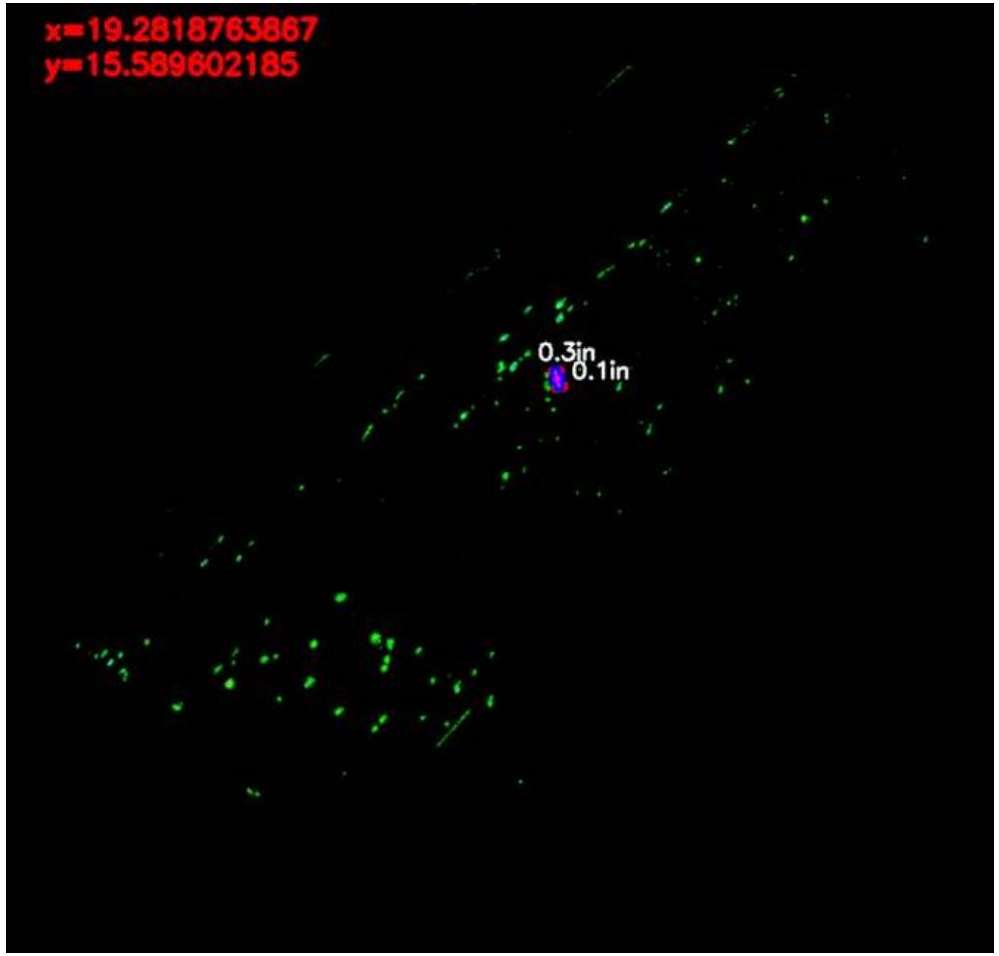
- The procedure is currently long and unpleasant for operators
- The need for an automatization is obvious
- Image processing could substitute NDT technicians (for a first defect-detection)

- An image processing algorithm was implemented in Python (OpenCV).
- Raw RGB images were acquired under UV lighting

Image processing and defect detection

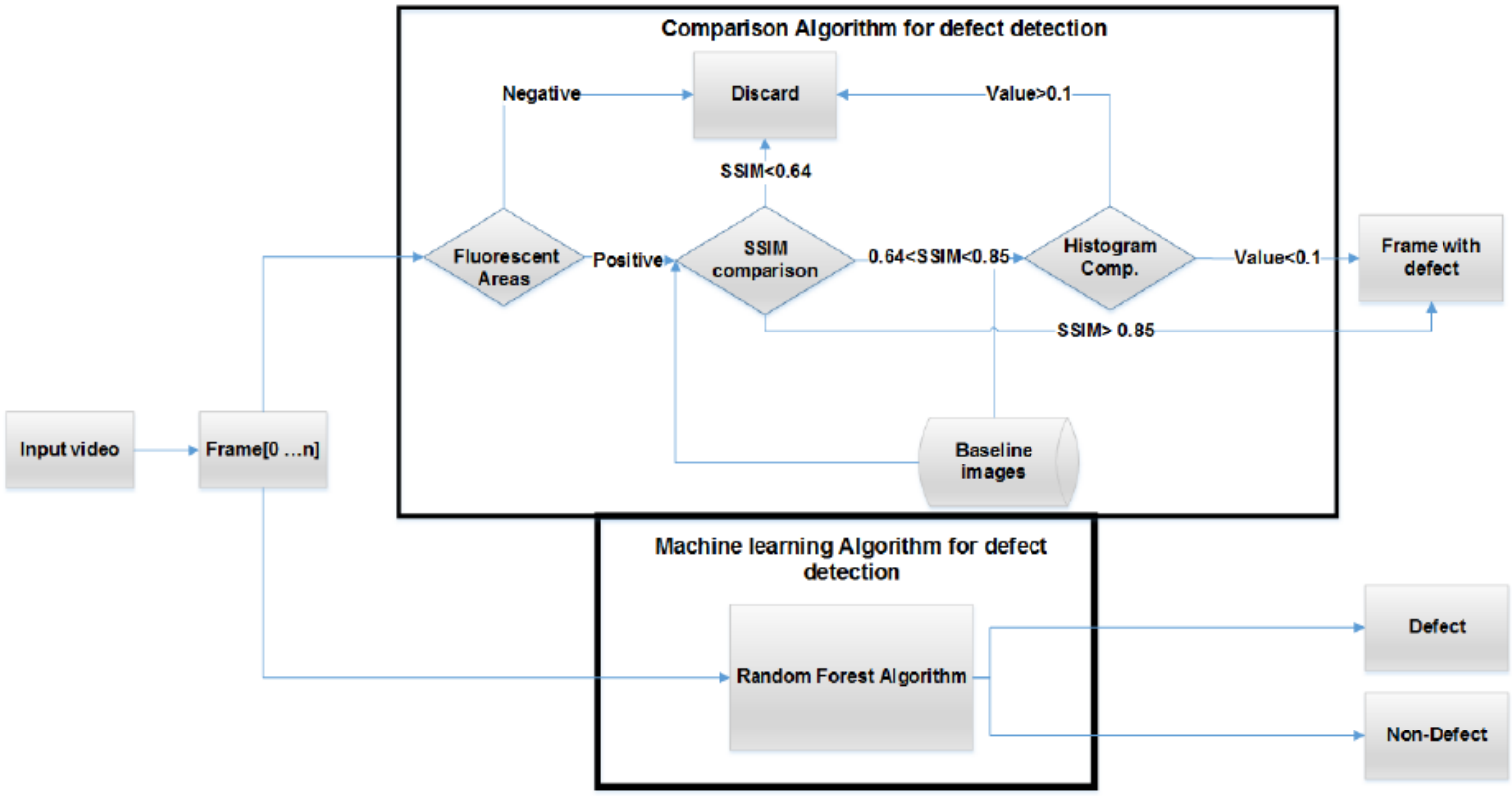


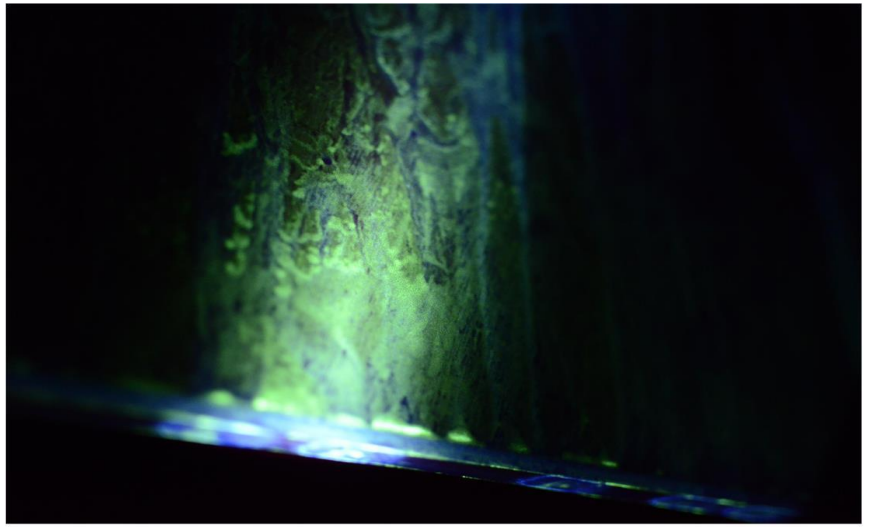
Gamma-corrected image

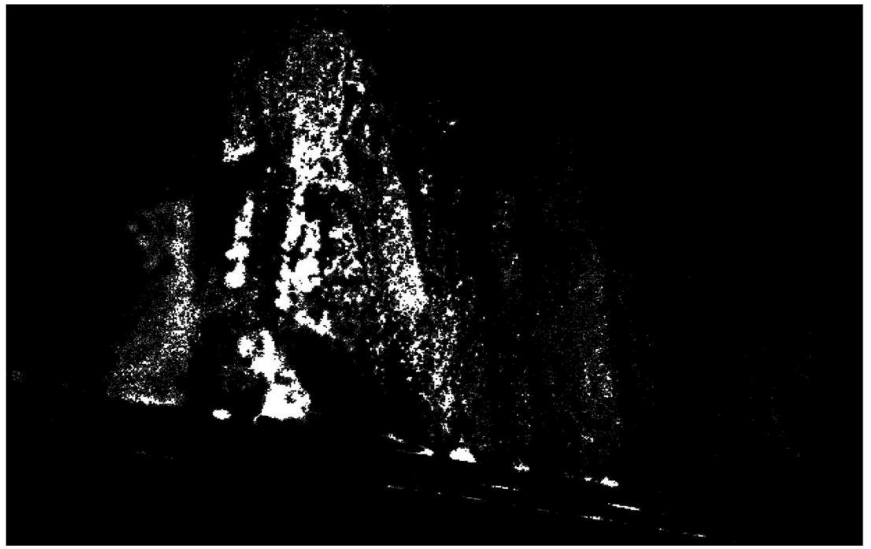


Canny-edge and sizing

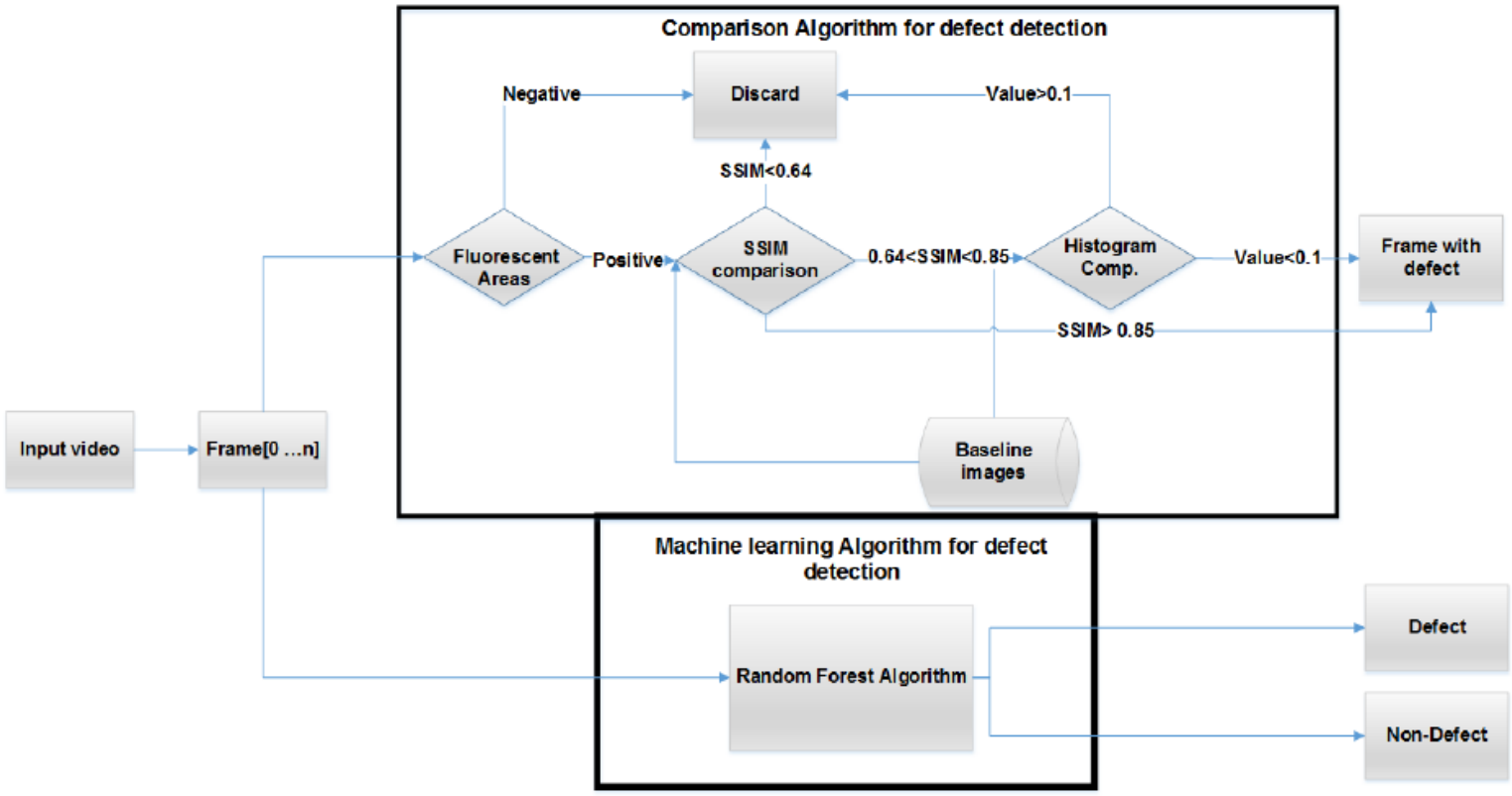
Defect detection algorithm in operational conditions

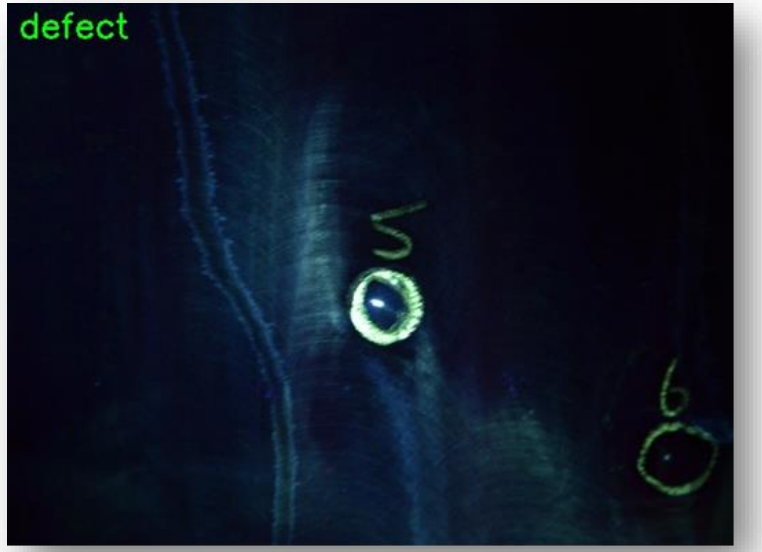


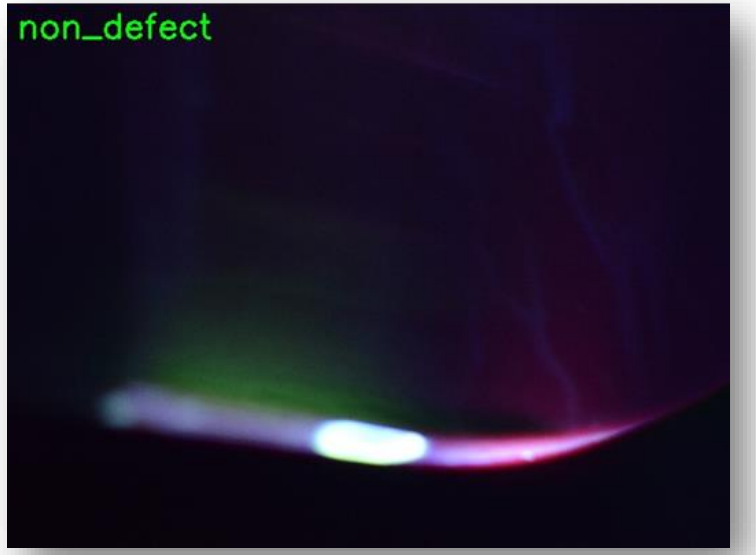




Defect detection algorithm in operational conditions







Experimental results

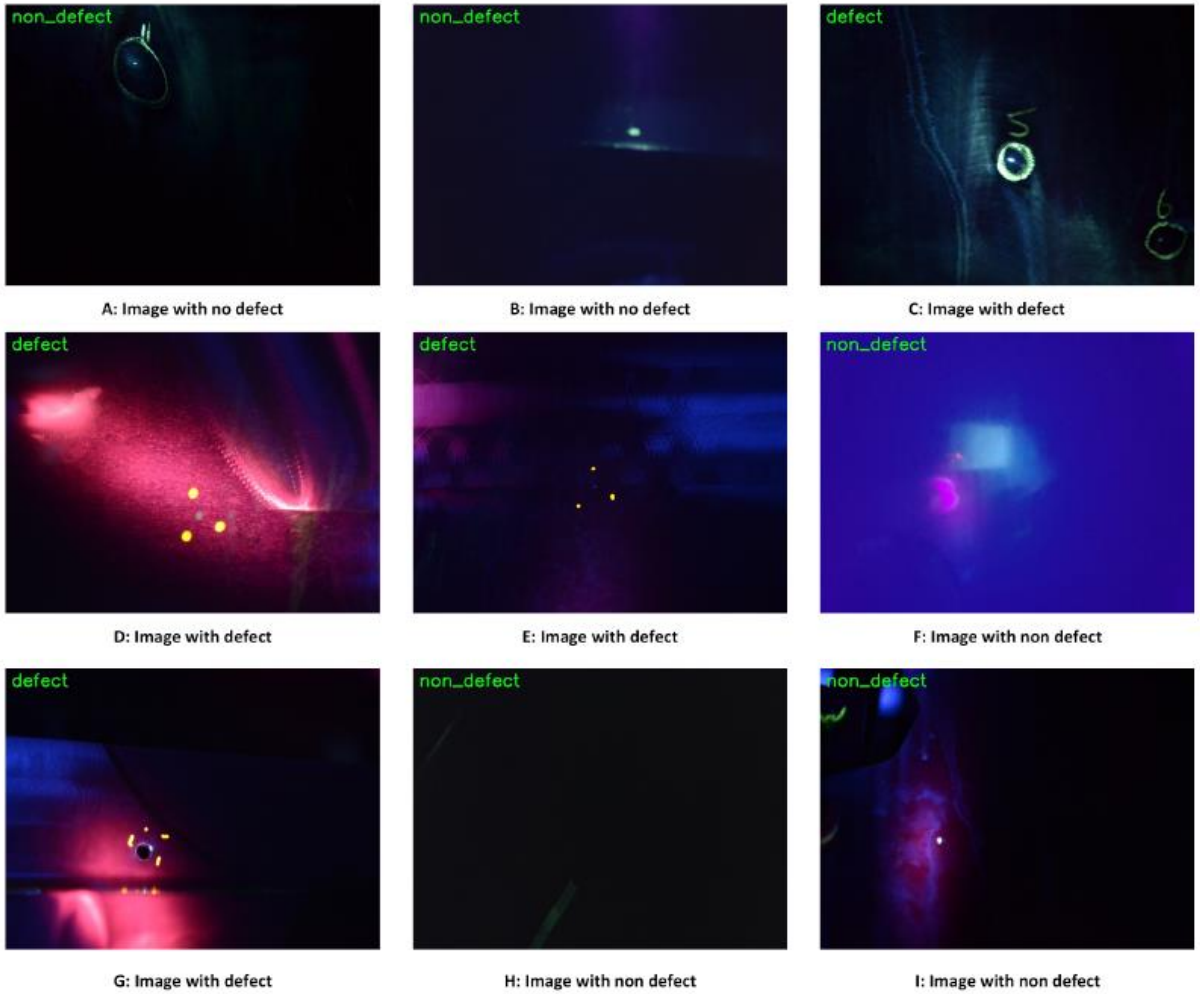


Table 1. Random Forest Validation Results.

Category	Precision	Recall	*F*1-Score	Support
Defect	0.86	1.00	0.92	6
Non-defect	1.00	0.95	0.97	16
Avg/Total	0.97	0.96	0.96	25

Conclusions

- A methodology to reduce risk, time and cost of NDT
- Integration of a UV lightbulb on a commercial UAV
- Automated record-keeping in a database
- Defect size of roughly 2 mm without further image processing (for real-time processing)
- Further works to be done are about the probability of detection of the procedure
- Database of labelled images still to be developed

sensors

MDPI

Article

Inspection of Aircraft Wing Panels Using Unmanned Aerial Vehicles †

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