SHM-France

7ème JOURNEE NATIONALE
CONTROLE SANTE ET MONITORING DES STRUCTURES

19 septembre 2024

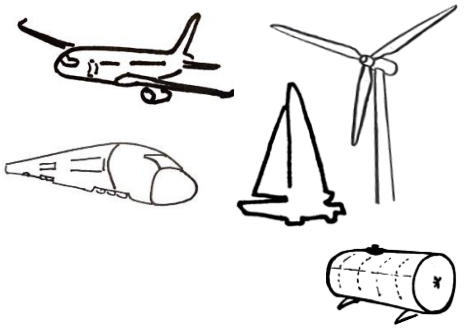
precend
Le réseau des compétences en CND & SHM

Automatic Predictive Maintenance by optical fiber Bragg sensors with integrated intelligence - examples in Wind Turbine and Aeronautic sectors

M-A. De Smet

DFinder

Ref.: SL02.0457-24



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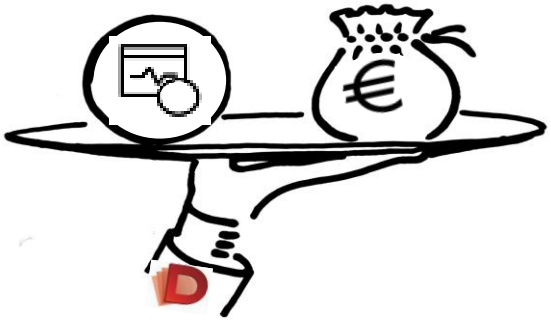
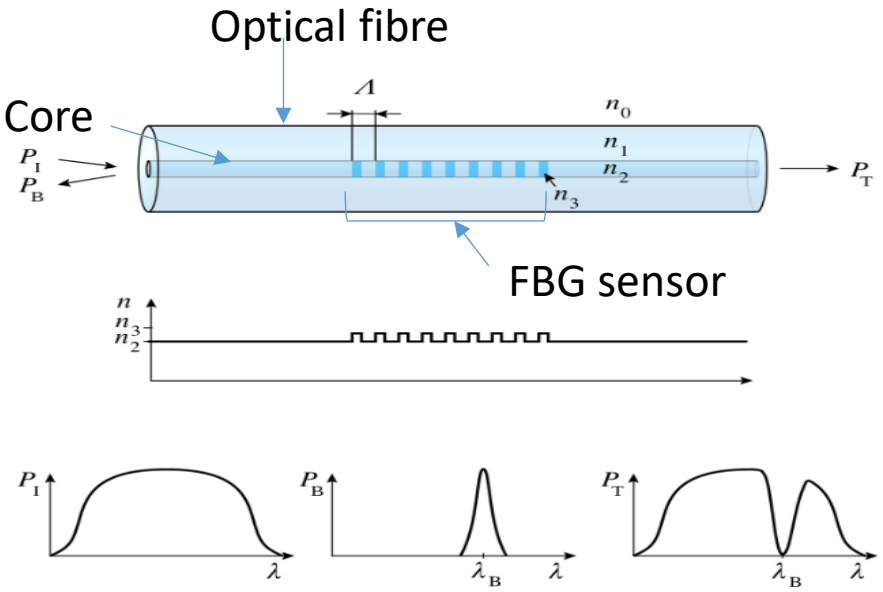


1 –Selected optical fiber sensing solution - Basics

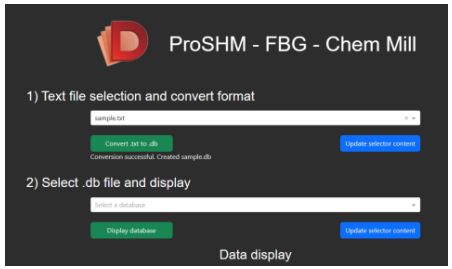
$$\vec{E} = \overrightarrow{E_0}\cos(\omega t + \vec{k}\cdot\vec{r}) \qquad \vec{k} = \frac{2\pi n}{\lambda}\vec{u}$$

FBG- Optical fiber sensing solution - Wavelength caracteristics analysis

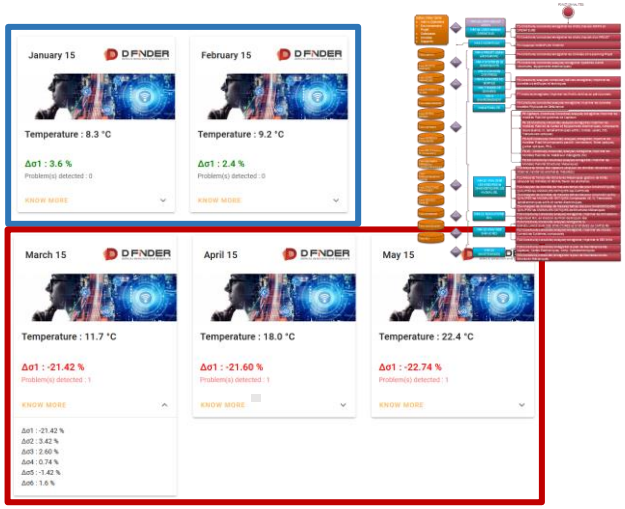


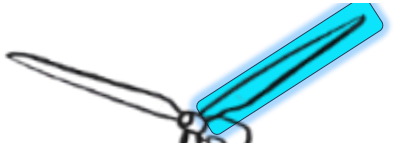
Automatic Predictive Maintenance by optical fiber Bragg sensors with integrated intelligence

2 –Solution description for predictive maintenance

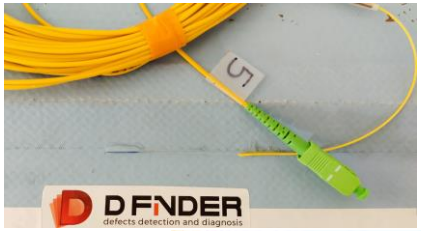


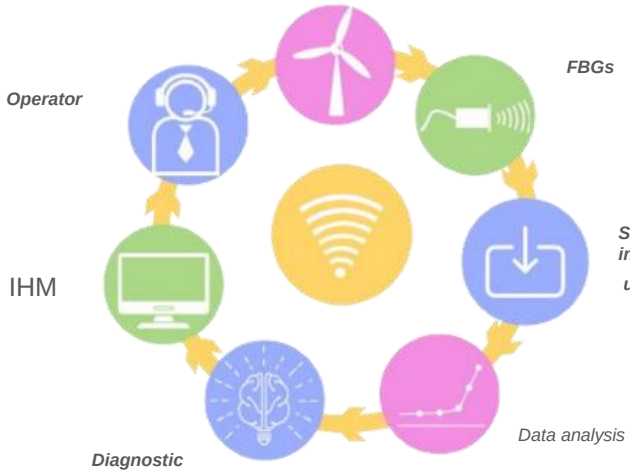
Potential condition and predictive (

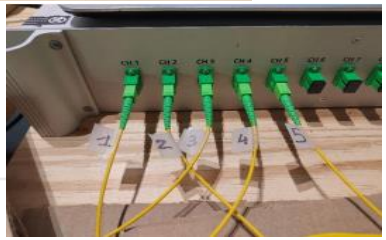


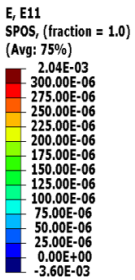


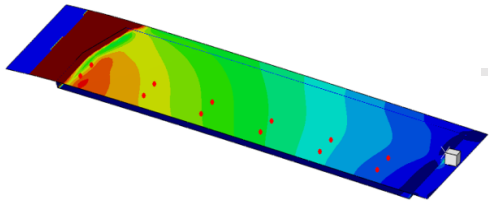
Optical fiber with Bragg sensors bonded with NASA qualified adhesive

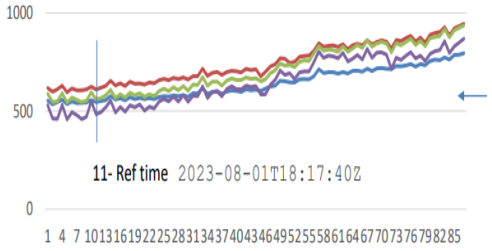












Low energy needed because questioned on demand
Cyber-security: limited accesses to data

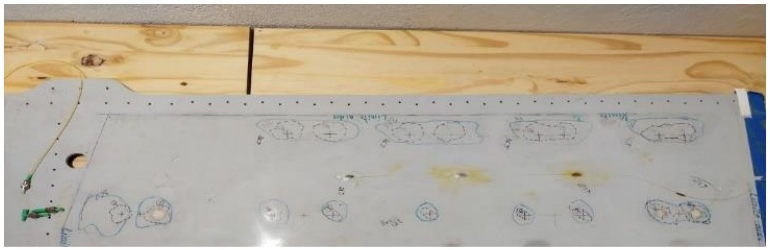
D FINDER
defects detection and diagnosis

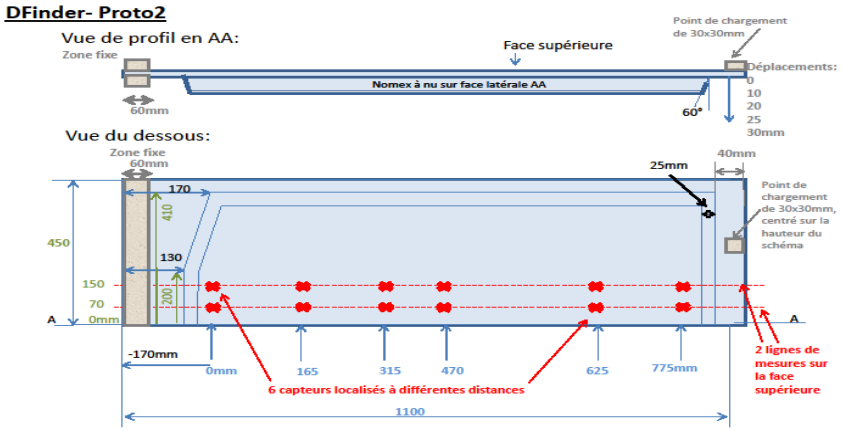
Automatic Predictive Maintenance by optical fiber Bragg sensors with integrated intelligence

3 –Use cases – Results/Performance demonstrations

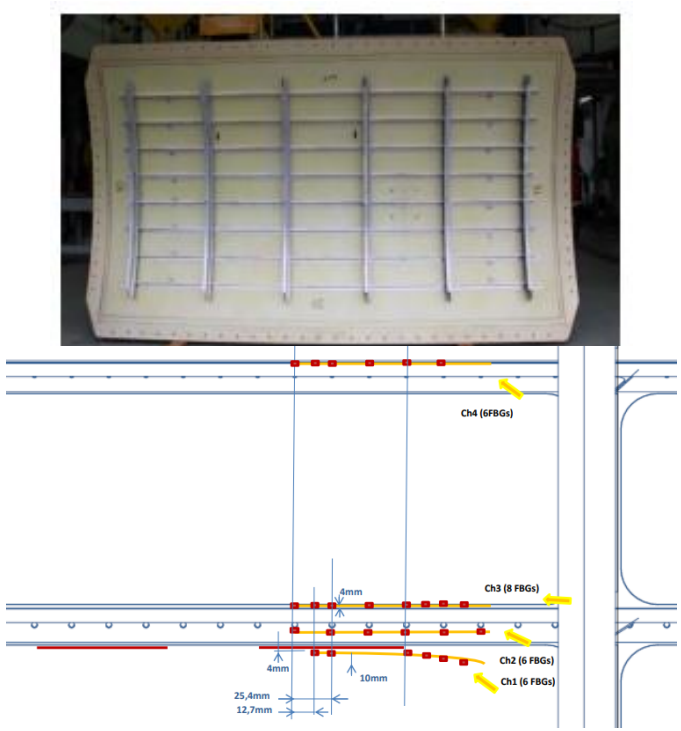
FBG architecture is adapted to Design-stress repartition and inspection requirements

Use case 1 : Composite sandwhich
2 chanels distribution





Use case 2 : Metallic fuselage panel
4 chanels distribution

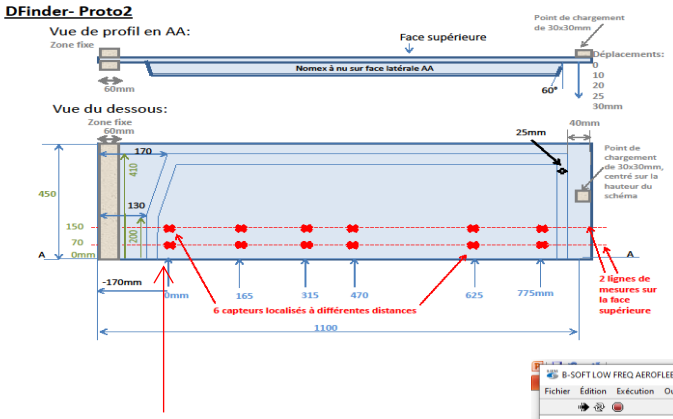


Automatic Predictive Maintenance by optical fiber Bragg sensors with integrated intelligence

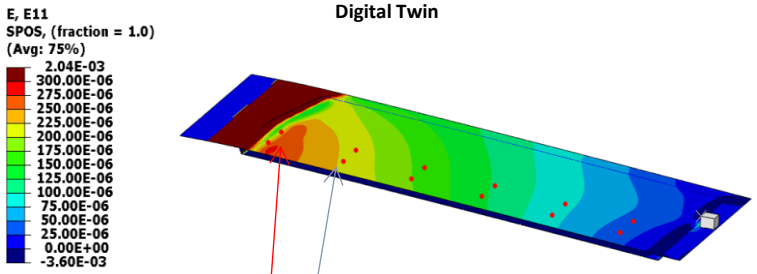
3.1 -Performance on use cases – Composite sandwich

Results on composite thermoplastic foam sandwich with delamination

Sandwhich structure damaged description :



Evidence of strain value impacted by damage :



Delaminated area due to 36J impact

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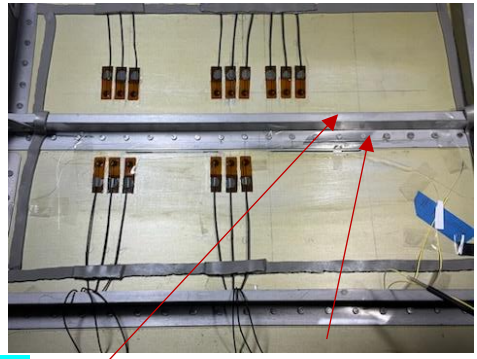
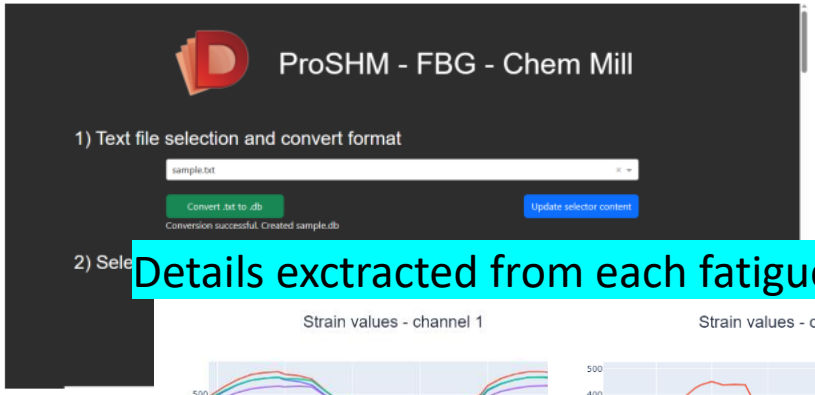
Automatic Predictive Maintenance by optical fiber Bragg sensors with integrated intelligence

3.2 -Performance on use cases

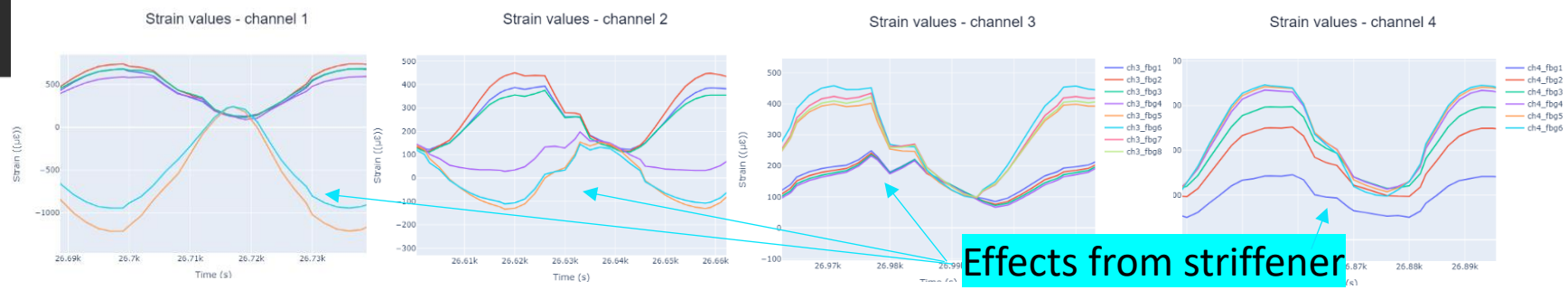
Results on metallic fuselage panel with fatigue crack





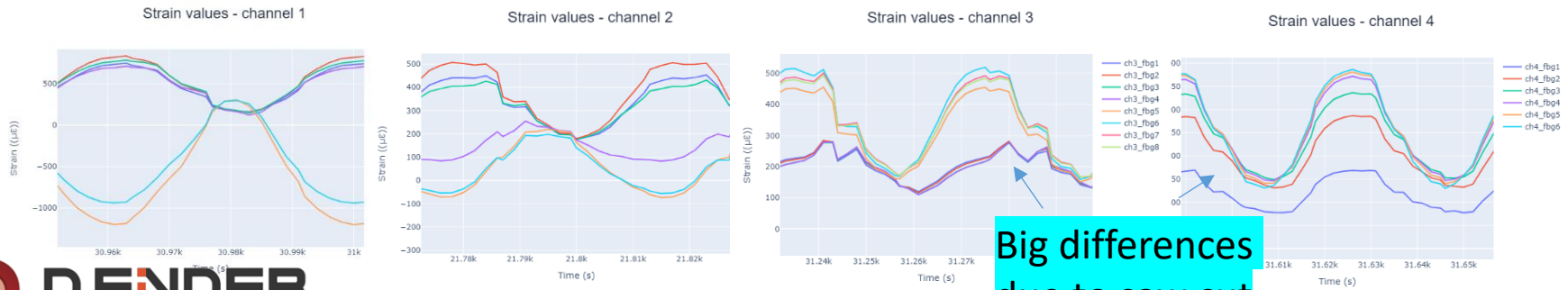
Details exctracted from each fatigue campaign – with reference data

08 121833



Effects from striffener

08 115646



Big differences due to saw cut

Automatic Predictive Maintenance by optical fiber Bragg sensors with integrated intelligence

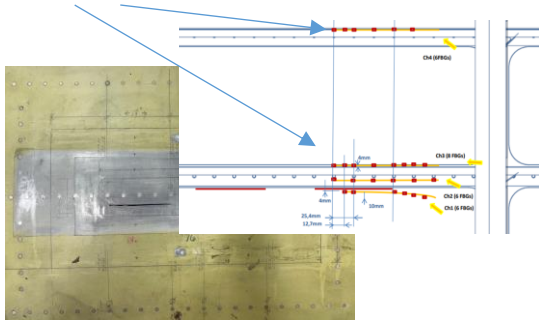
3.2 -Performance on use cases

Results on metallic fuselage panel with fatigue crack

FAA Test Center data – « Chem Mil August 2023 »
ProSHM-FBG detection compared with assited visual inspection

D FINDER defects detection and diagnosis

FBGs repartition



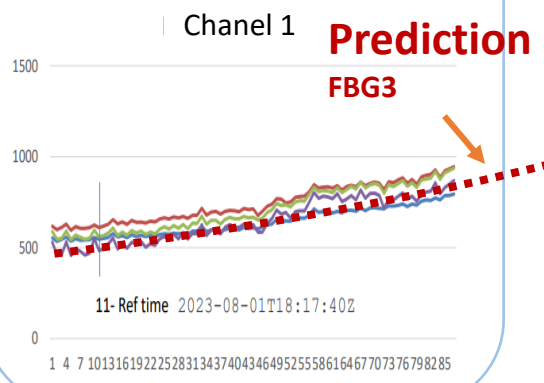
Combiné avec le logiciel d'analyse ProSHM-FBG

FAA inspection results:

			Crack Extension from Notch Tip			
			A		B	
			CR	TB	CR	TB
Date	Cycle	OffsetCycle				
31/07/2023	38250	0	0	0	0	0
01/08/2023	38350	100	0,01	0,007	0,014	0,013
	38600	350	0,025	0,03	0,044	0,035
	38850	600	0,04	0,05	0,061	0,05
02/08/2023	39000	750	0,057	0,07	0,087	0,06
	39100	850	0,059	0,074	0,094	0,074
	39350	1100	0,078	0,095	0,117	0,096
03/08/2023	39600	1350	0,092	0,114	0,15	0,121
	39850	1600	0,117	0,137	0,177	0,134
	40100	1850	0,136	0,165	0,199	0,157
07/08/2023	40275		ARAMIS and Strain Survey			
08/08/2023	40300	2050	0,141	0,177	0,221	0,167
	40350	2100	0,148	0,186	0,224	0,168
	40600	2350	0,163	0,213	0,247	0,186
	40850	2600	0,176	0,234	0,277	0,212
09/08/2023	41100	2850	0,203	0,254	0,313	0,235
	41350	3100	0,209	0,287	0,352	0,254
10/08/2023	41600	3350	0,237	0,318	0,386	0,283
	41890	3640	0,274	0,359	0,449	0,316
14/08/2023	42050	3800	0,286	0,403	0,48	0,344

D FINDER defects detection and diagnosis

ProSHM-FBG output



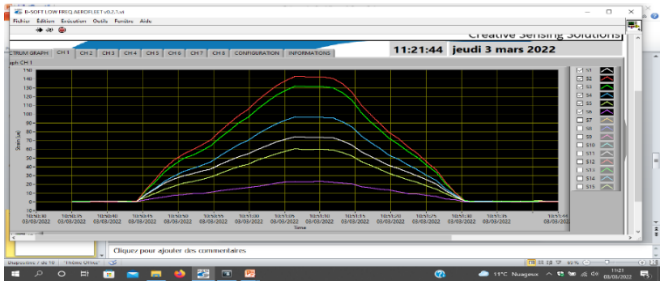
Conclusion:early detection of crack propagation enabling predictive maintenance

Automatic Predictive Maintenance by optical fiber Bragg sensors with integrated intelligence

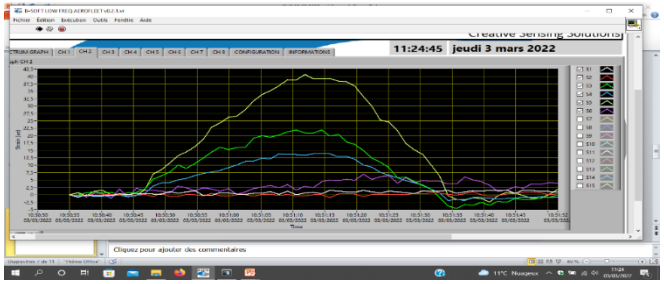
4 – Installation process effects

During installation process, check of adhesive polymerization performance

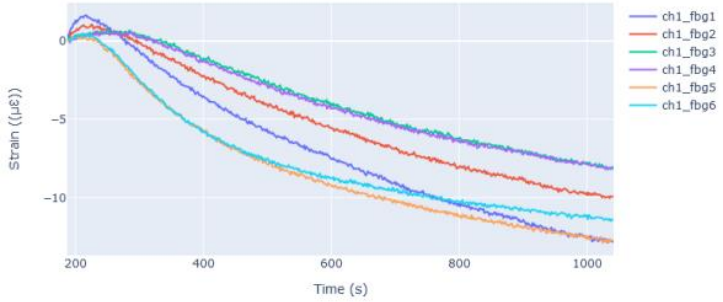
Good



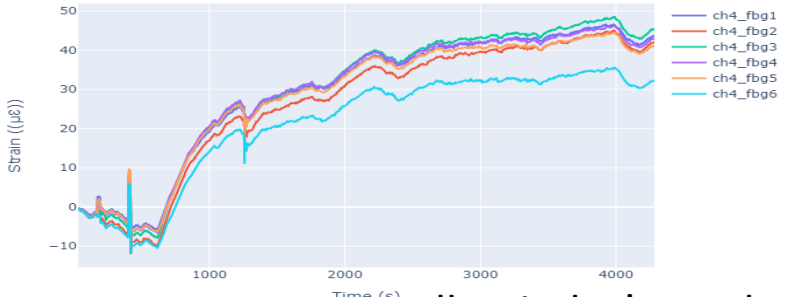
Not good



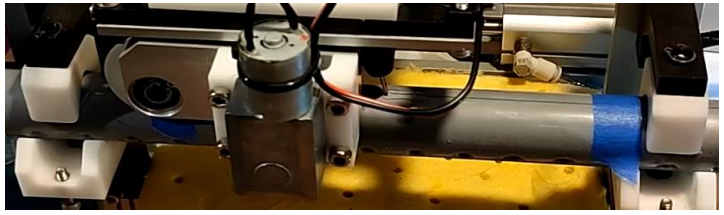
Good



Not good



Pro-Install DFinder's product



DFINDER
defects detection and diagnosis

5 – Resume

- FBG with numerical fatigue prediction deliver evidence of strain value impacted by damage

  ! taking care of installation conditions and sensing ageing

- Open to large spectrum of damage type inducing strain reduction such
  -delamination due to impact or cutting
  -material degradation due to liquid ingress-
  -high temperature - fire - mechanical fatigue- friction…
- Discrete measurement reducing data storage impacting environment- energy - and logistics
- Enough sensitivity to anticipate - reducing repair cost
- Possible to characterize strength status of component in case of life extension
- Neutral to EMI

  -No operator action on aircraft , only check of signal analysis by ProSHM-FBG IHM
  -Intervals of questioning adapted to inspection requirements