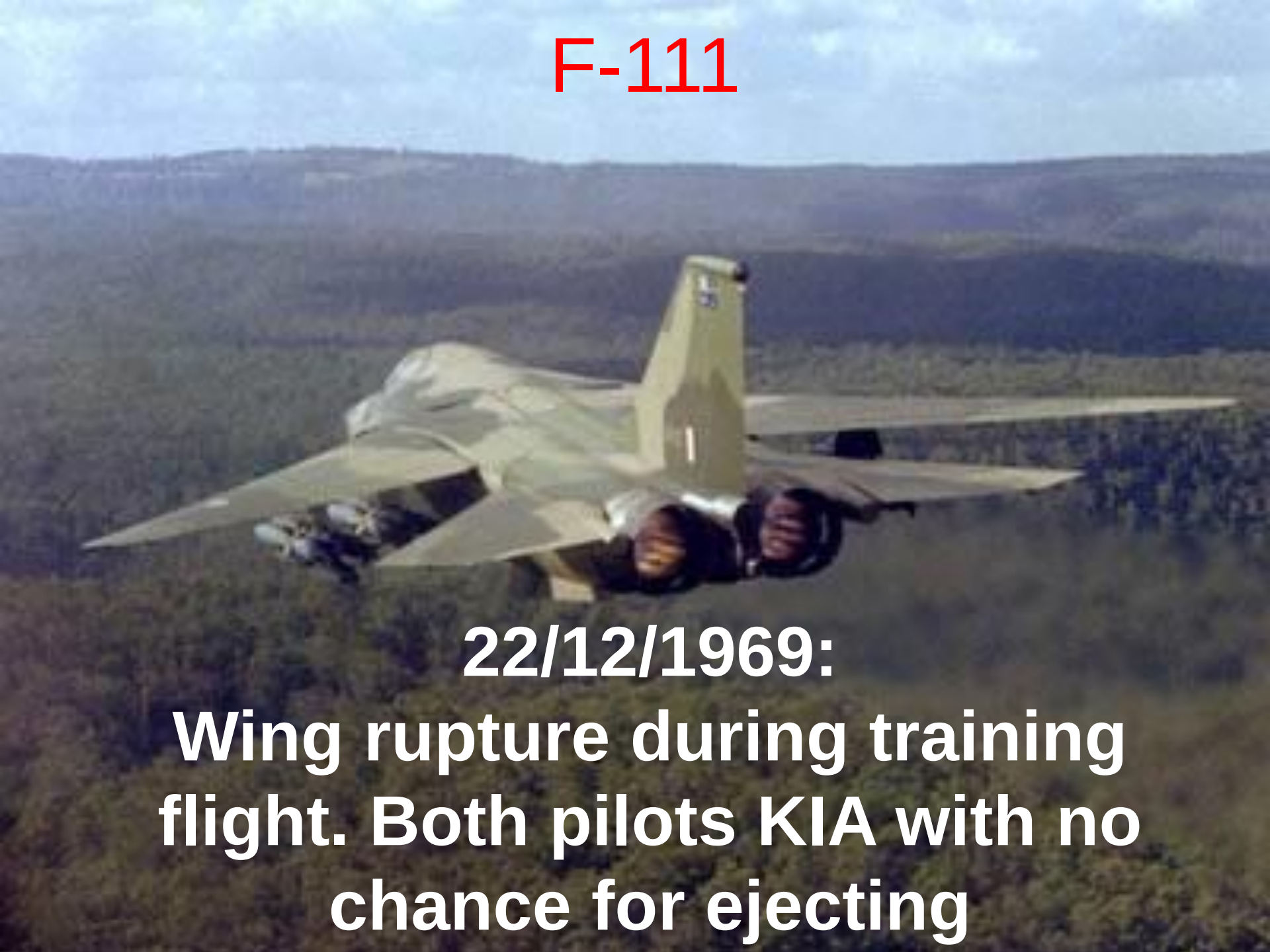
C-130

F-111



22/12/1969:
Wing rupture during training flight. Both pilots KIA with no chance for ejecting

Cause: Crack at the steel wing pivot fitting of F-111

Microphotograph of Crack Area .
Flaw was not revealed during production NDT due to neighboring vertical elements masking the area

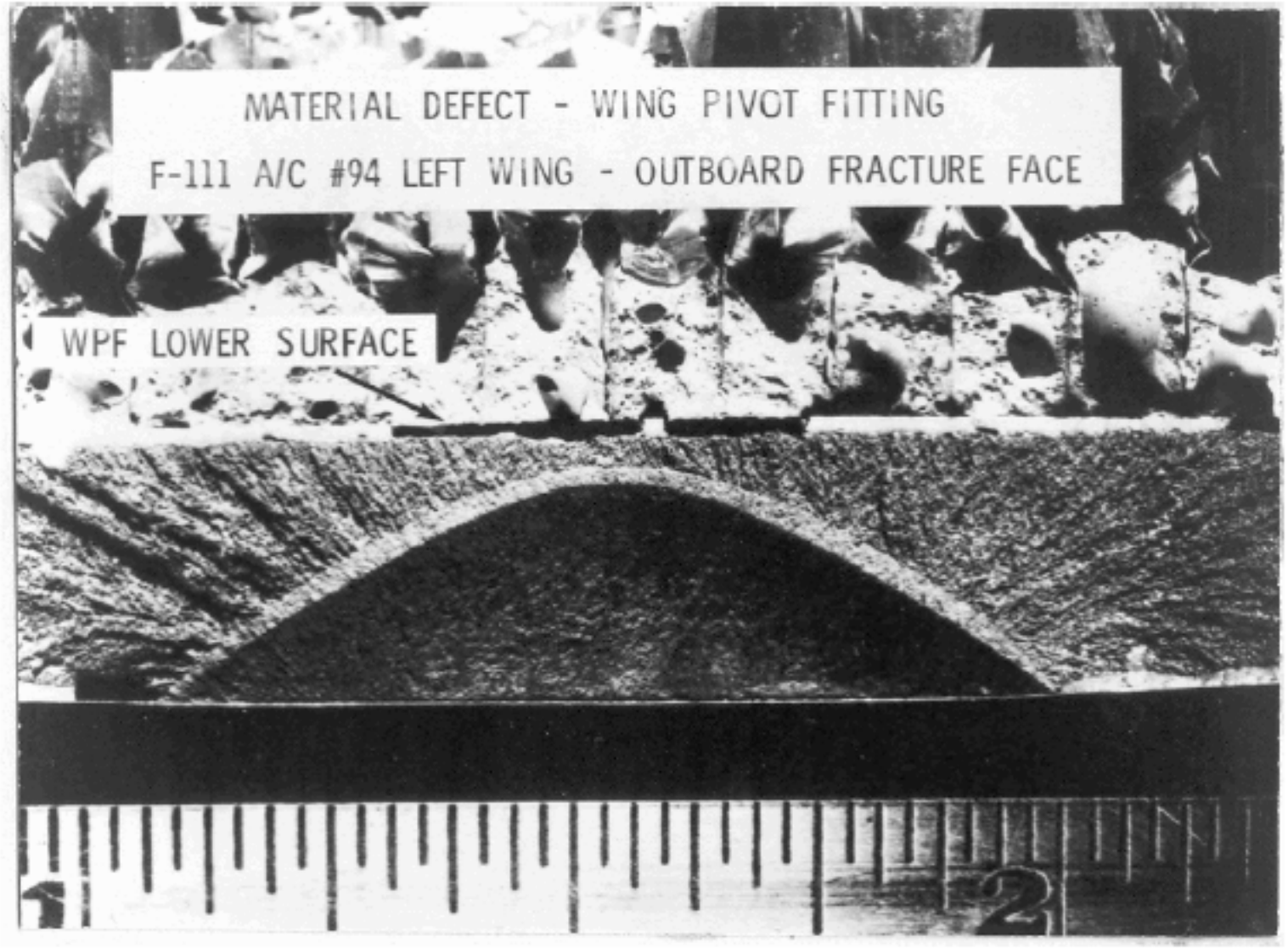
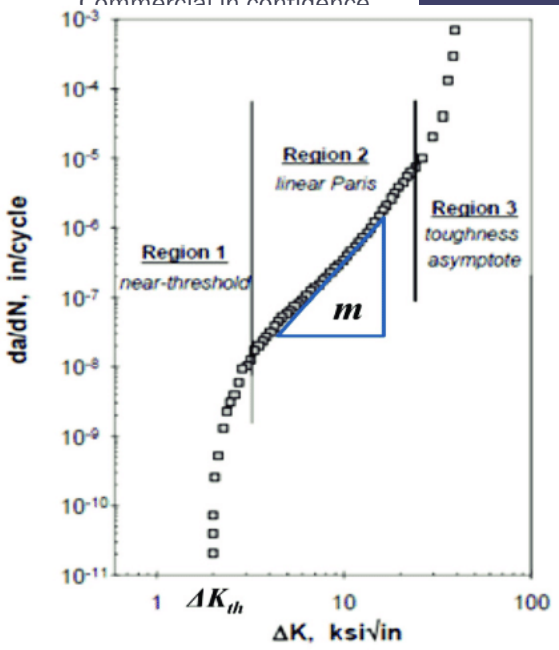
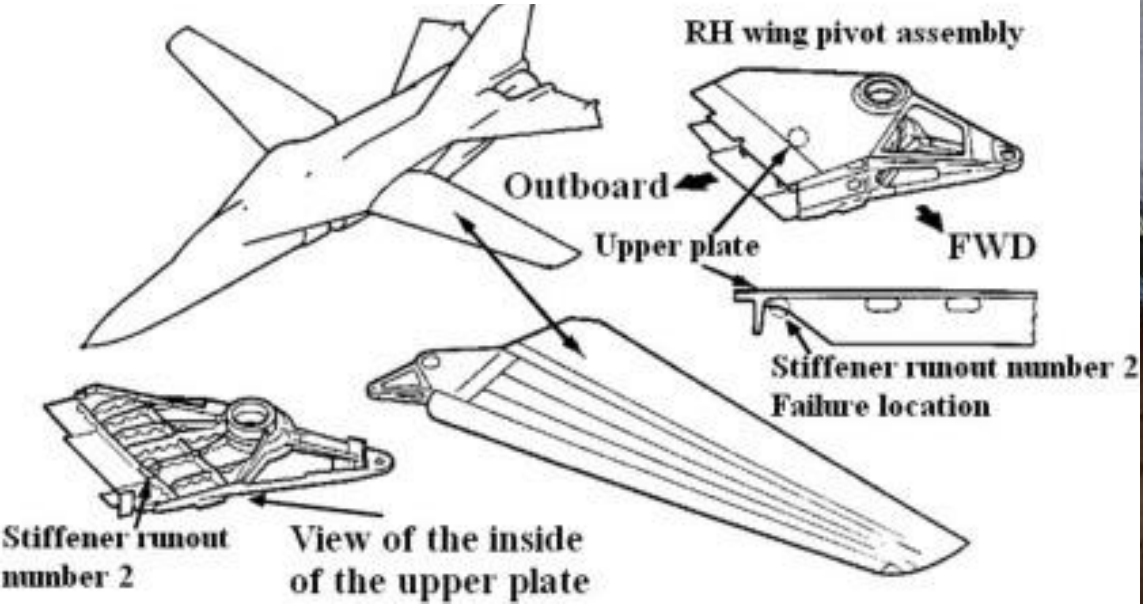


Figure 1.1.1. Origin of the F-111 Wing Defect [Rudd, et al., 1979]

Application of Boron Patches to carry structural loads, "deviating" the flaw area, in order to significantly reduce K



$$\frac{da}{dn} = C(\Delta K)^m ,$$

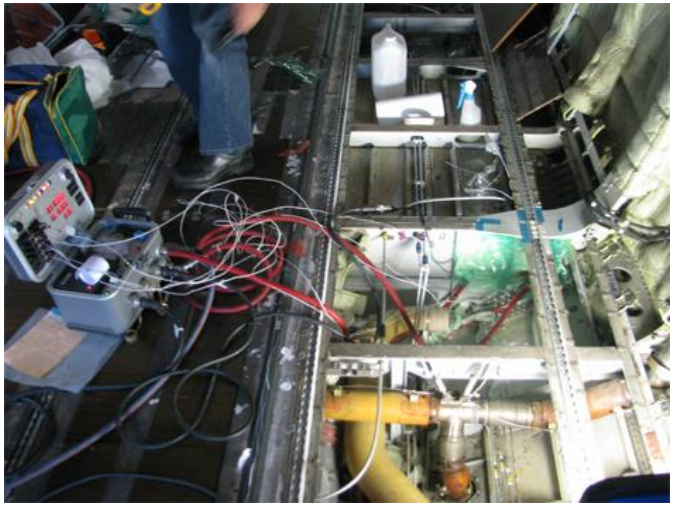


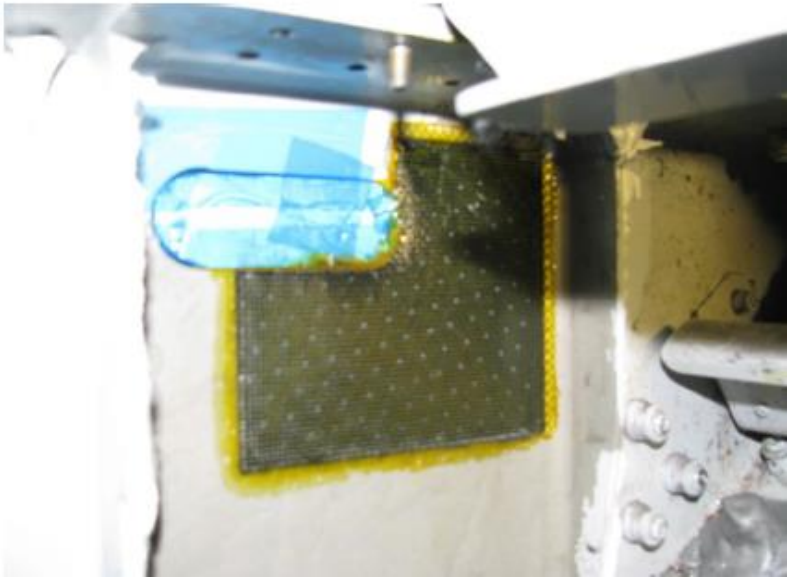
GMI AERO

Commercial in confidence

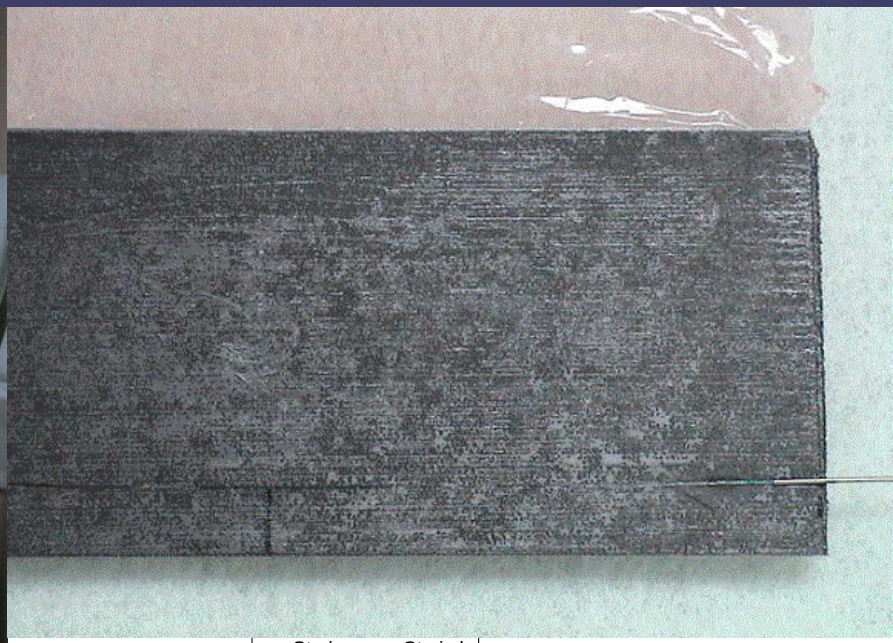
Advanced composite repairs to metallic parts on ATR aircraft by GMI Aero

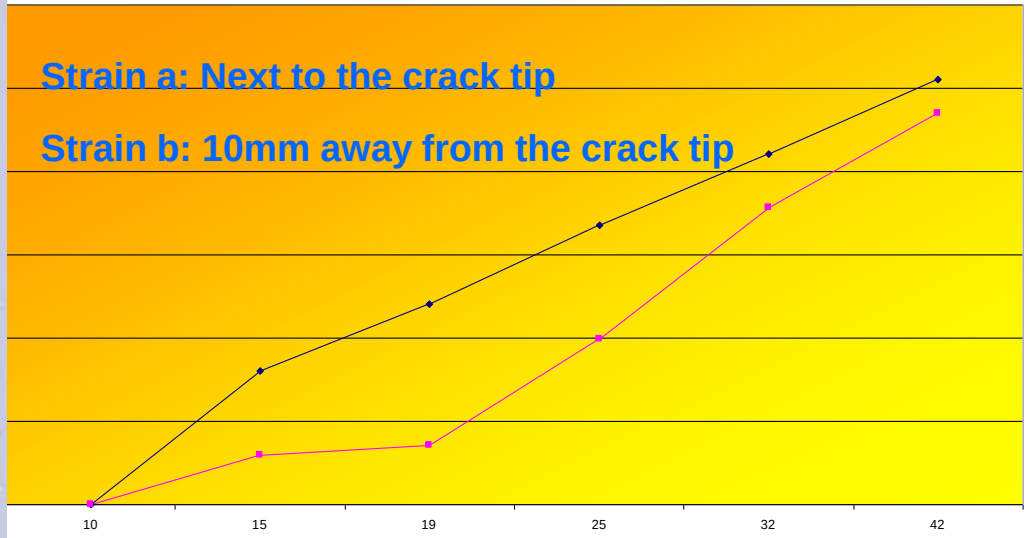
Repair of an ATR-72 aluminium floor beam using a bonded carbon patch, performed in situ by GMI Aero, in cooperation with the ATR company.





Research & Innovation






JURASSIC PARK
"Life will find a way"
- Michael Crichton, Jurassic Park


"Bonded Composite Repair will find a way"
- Bremen E-LASS 29/1/2020

GMI Aero – 13 rue Georges Auric, 75019 Paris - France
www.gmi-aero.com – gmi@gmi-aero.com

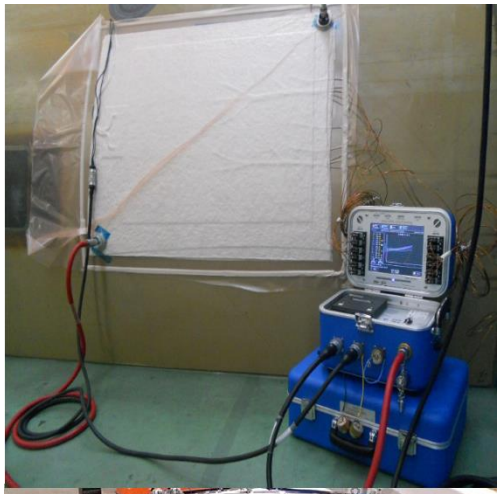
Commercial in confidence

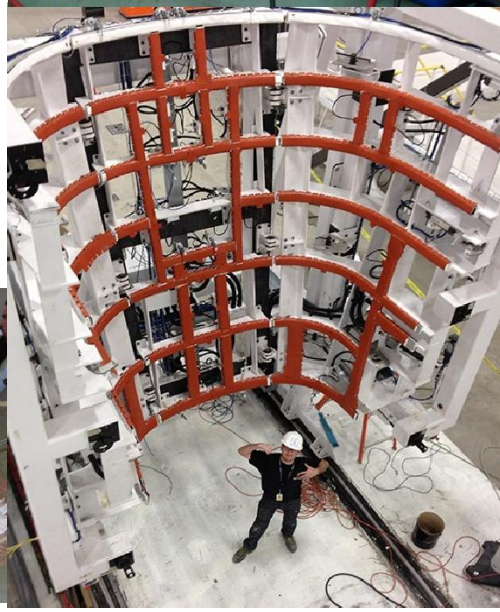
Bonded Composite Repair Methodologies – Latest Advancements and Developments

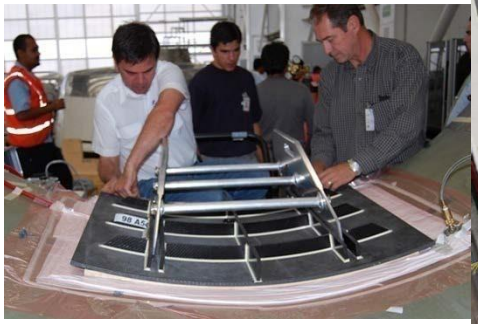
George Kanterakis
Sarah Baglione

>30 years of experience

- **Fabrication and Repair of Composite Structures :** Heating Systems, Process Models, Advanced Sensors, Advanced Bonding, NDT, Surface treatment.
- **Services :** Engineering solutions at customer's requests
- **Research :** for internal development & in Collaborative Projects with European Constructors and Universities
- **Consultancy & Training Worldwide :** at GMI's premises or at customer's facility

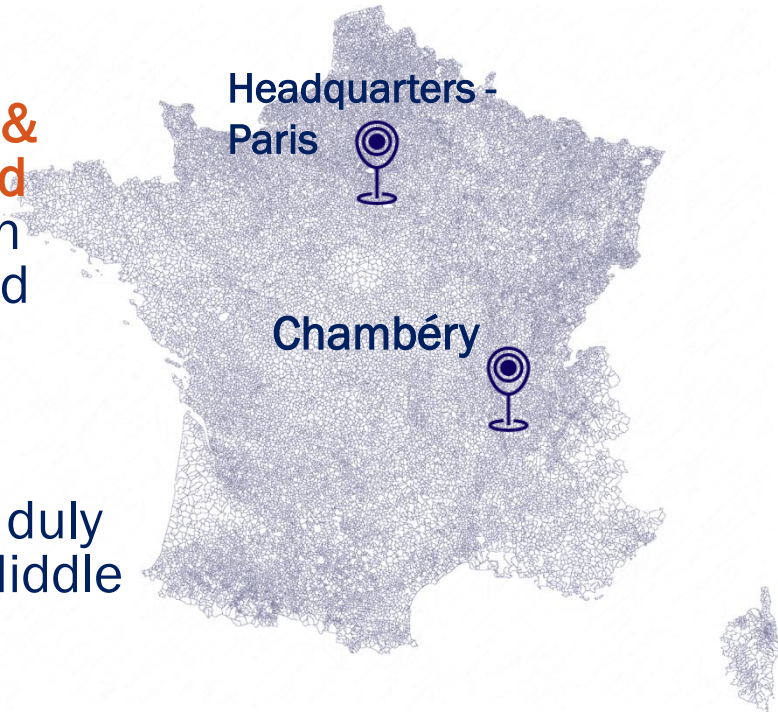






GMI Aero : The Company…

- More than 30 years experience
- Team composed of 20 Engineers and Technicians
- Departments of R&I , Production, Design & Engineering managed by Researchers and Engineers of long experience and in depth knowledge of all mechanical, sensors, and other physical aspects of this specialized science.
- Represented in the world through agents duly trained (Asia, Central & South America, Middle East, Europe).
- Several agreements of equipment through Airbus, ATR, Dassault, Bombardier, Boeing etc.
- Qualified ISO 9001:2015



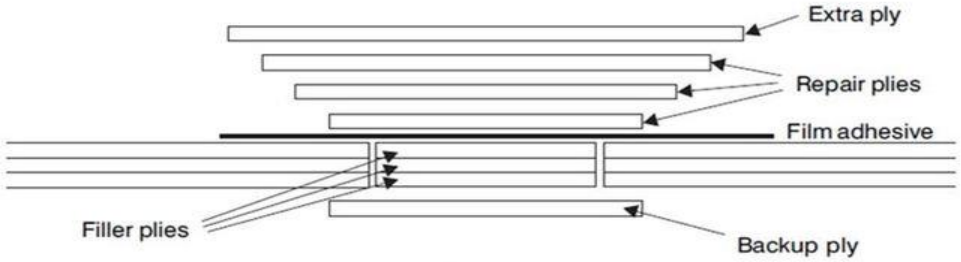
Who are our customers ?

Aircraft manufacturers, MRO Centers, OEMs, Airlines, Universities

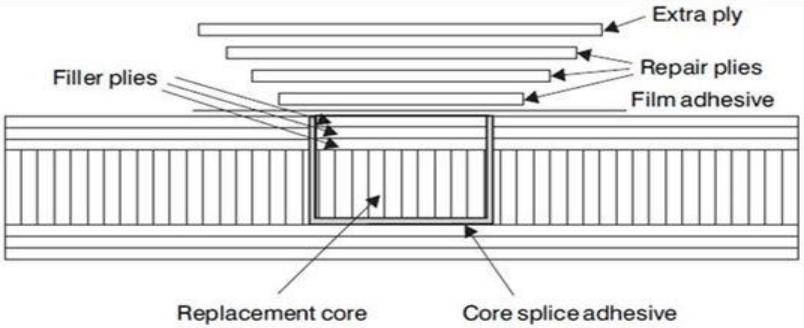
MoUs and Partnerships

- ✓ ADAMANT Composites, Greece
- ✓ Fraunhofer IFAM, Germany
- ✓ Hellenic Aerospace Industry, Greece
- ✓ Institute of Aviation, Poland
- ✓ IPSA, France
- ✓ Jordan University of Science and Technology, Jordan
- ✓ Malaysian Institute of Aerospace Technology, Malaysia
- ✓ Nat.Inst. for Aerospace Research "Elie Carafoli", Romania
- ✓ National Technical University of Athens, Greece
- ✓ SWEREA, SICOMP, Sweden
- ✓ University of Patras, Greece
- ✓ University of West Attica, Greece

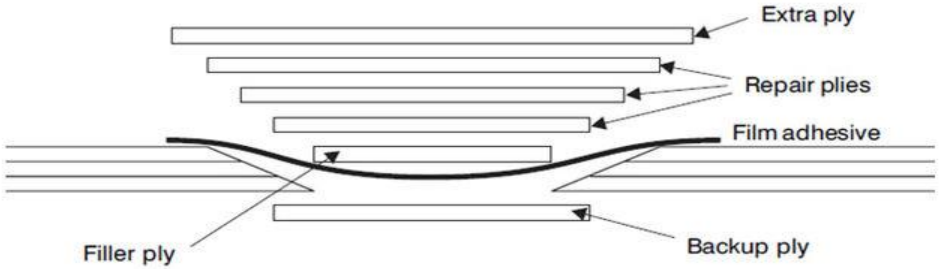
Typical Composite Repairs



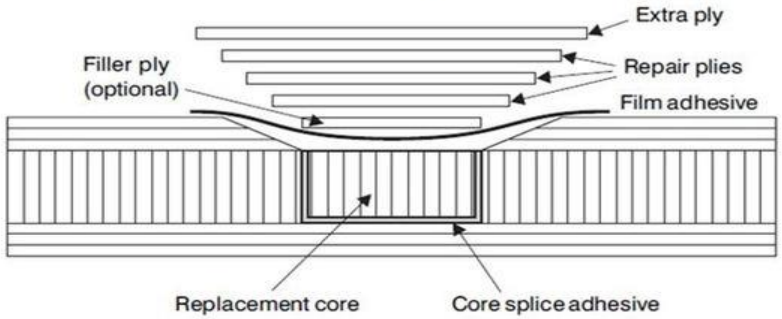
Patch repair



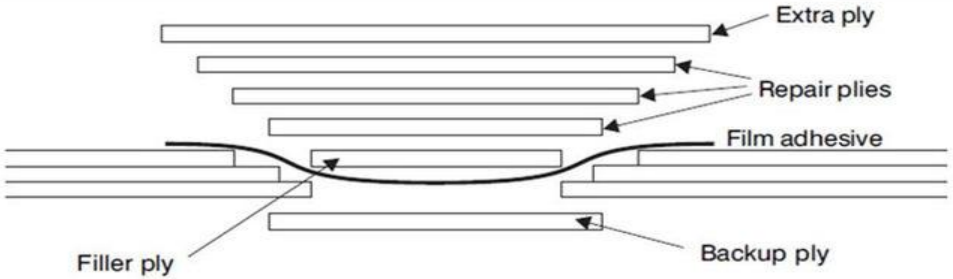
Patch repair



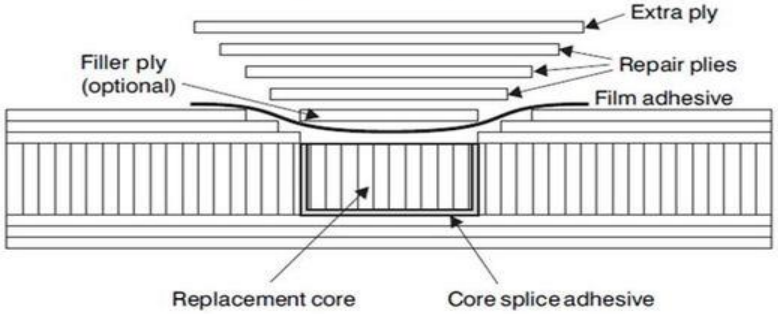
Scarf patch repair



Scarf patch repair

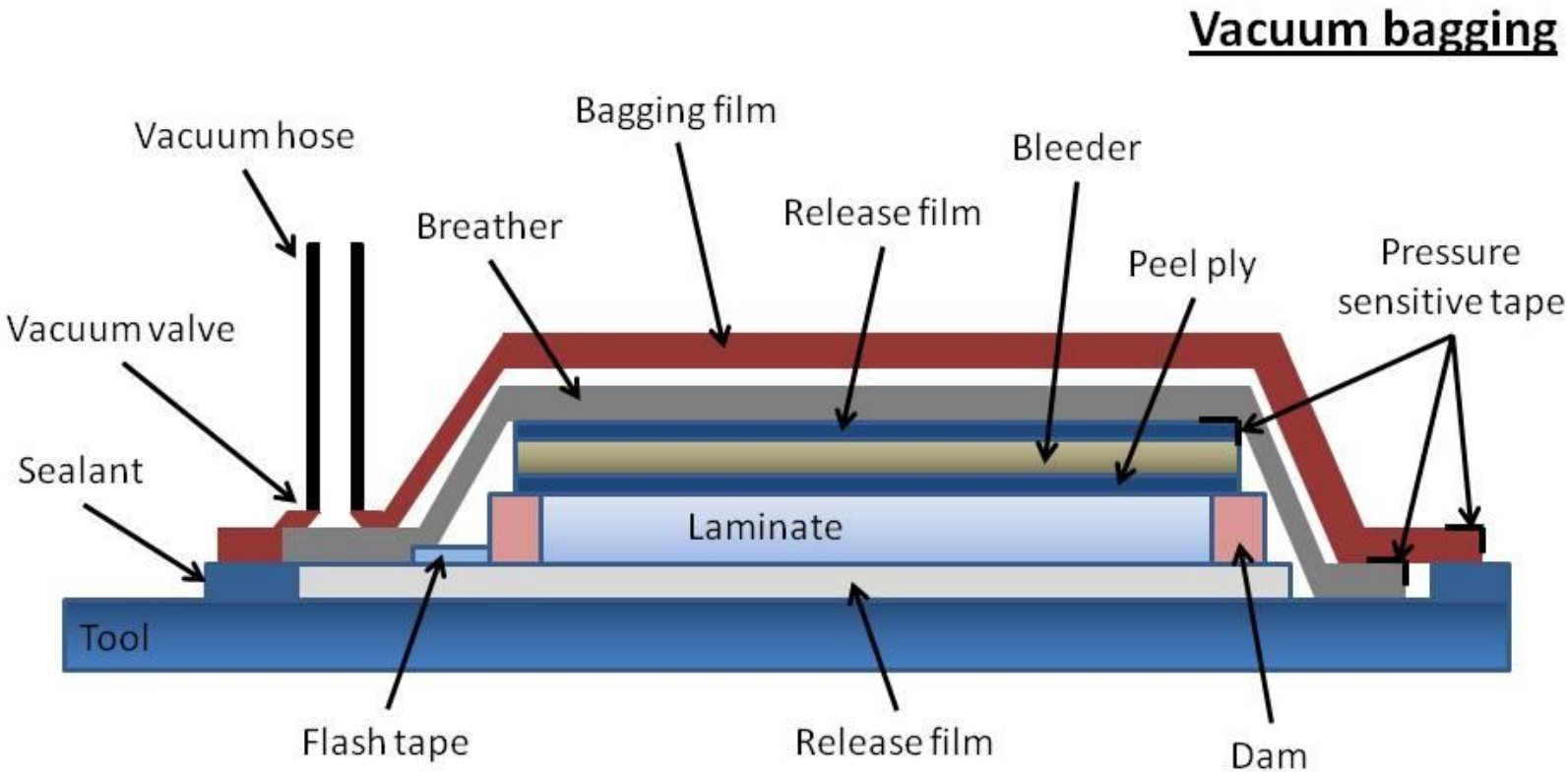


Stepped repair



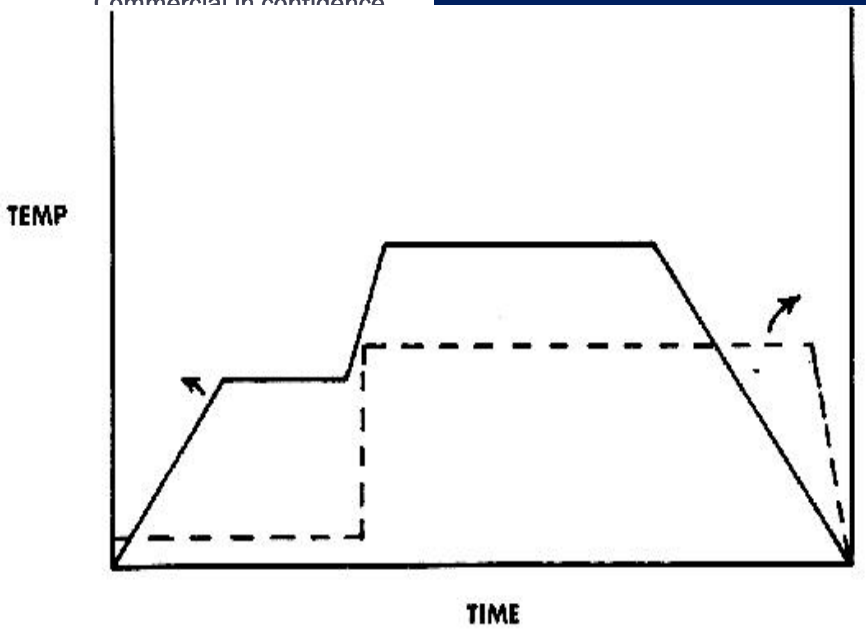
Stepped repair

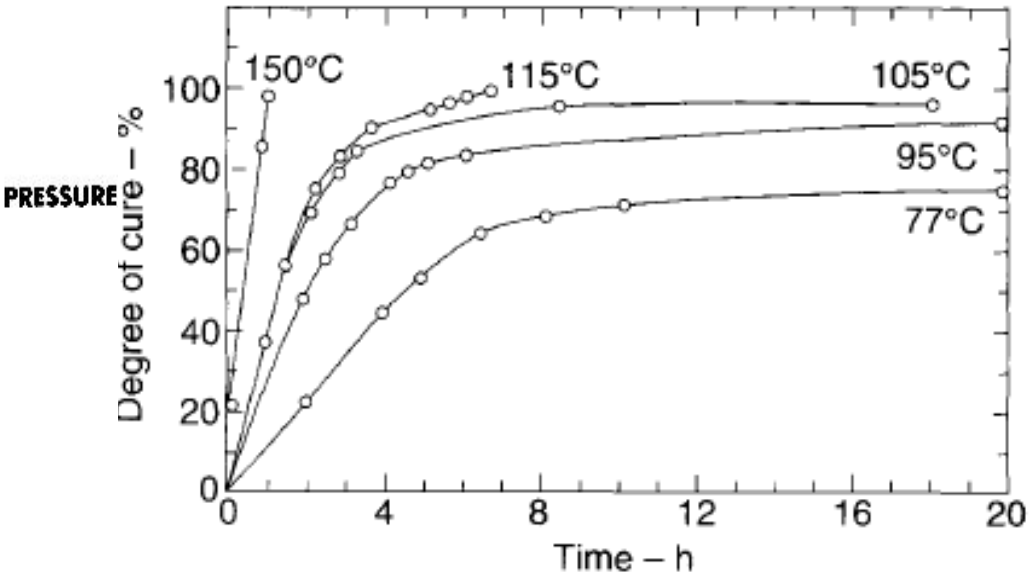
Vacuum Bagging

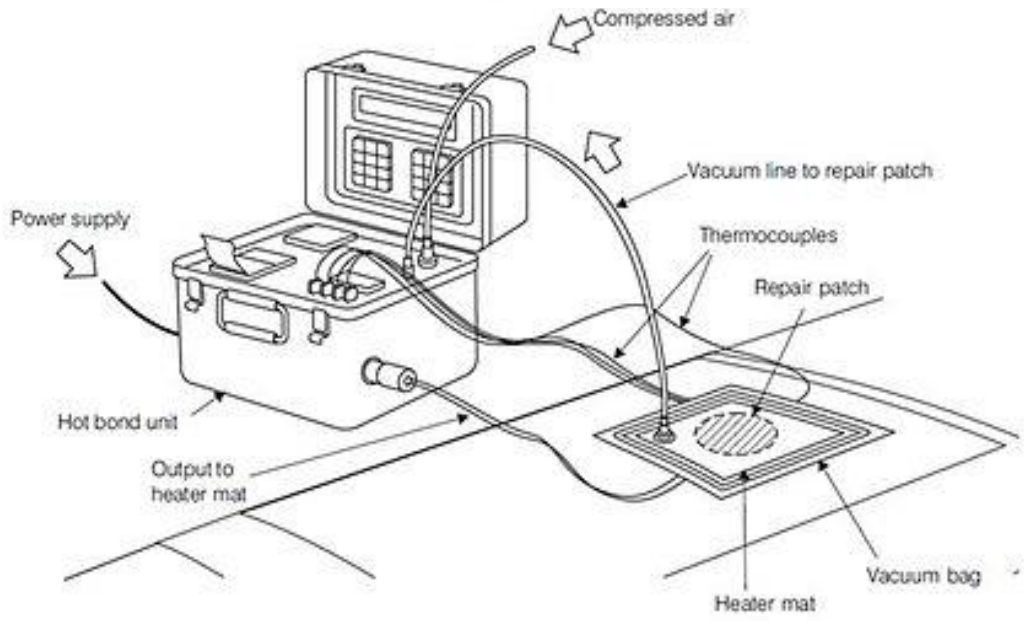


The vacuum bagging technique can be used to improve the quality of composites produced by the wet lay-up method. A bagging film is placed around the laid-up composite material and is secured to the tool surface with sealant. Air is evacuated from the bag, leaving the composite under an external pressure of up to 1 atmosphere. This forces resin into any remaining voids and helps to ensure an even distribution. Higher viscosity resins can be used in comparison to the wet lay-up technique.

Repair Curing







whole,

ANITA Family of Bonding Consoles

Anita EZ

Anita EZH

Anita QS

Anita EZ4Z

April (PR)

Anibolt

Anita 6Z

Wide range of heating elements

Heating Technology

High Temperature heating elements

BriskHeat®

FGH and SXH High Temperature Composite Curing Blankets

Product Highlights

- Designed for use with the newer high temperature thermoplastic and polymide composite materials
- Highly flexible up to a 1" (25mm) radius
- Compatible with ACR® hot bonders and your current equipment
- CE RoHS Compliant

Temperatures up to

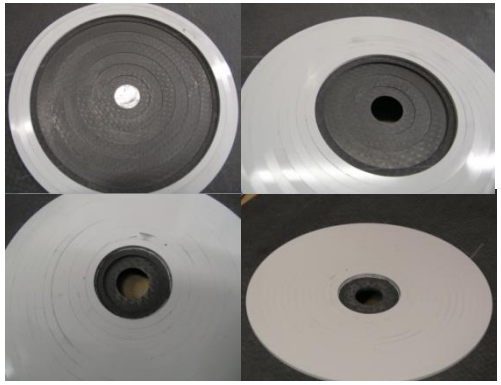
1100°F (593°C)

Specifications:

- Heating element and a 1" (25mm) layer of high-density fiberglass is covered in an abrasion resistant fiberglass cloth (FGH) or Samox® cloth (SXH series)
- Maximum exposure temperature:
  - FGH series: 800°F (425°C)
  - SXH series: 1100°F (593°C)
- Power density:
  - FGH series: 7 watts/in² (0.011 watts/mm²)
  - SXH series: 13 watts/in² (0.020 watts/mm²)
- Dielectric strength of over 2000 volts
- Power cord 6-foot (1.8m) long with choice of power plug

Leslie mobile Workshop

Surface Preparation – Innovative toolings have been designed to allow technicians to perform easily typical works on carbon surface for patch installation

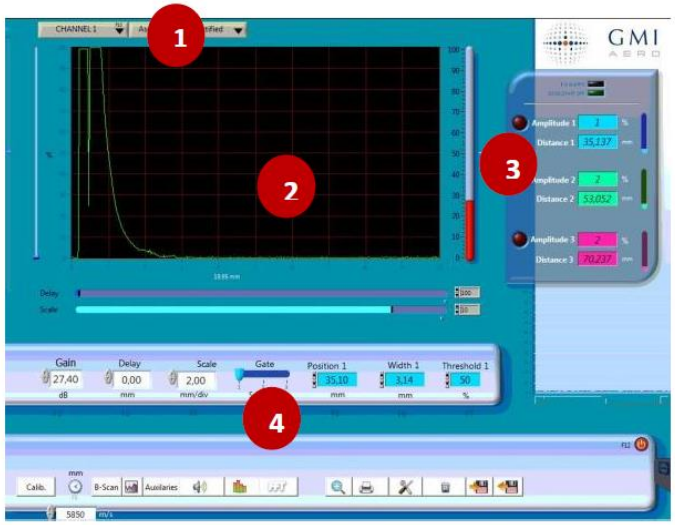


Stepping

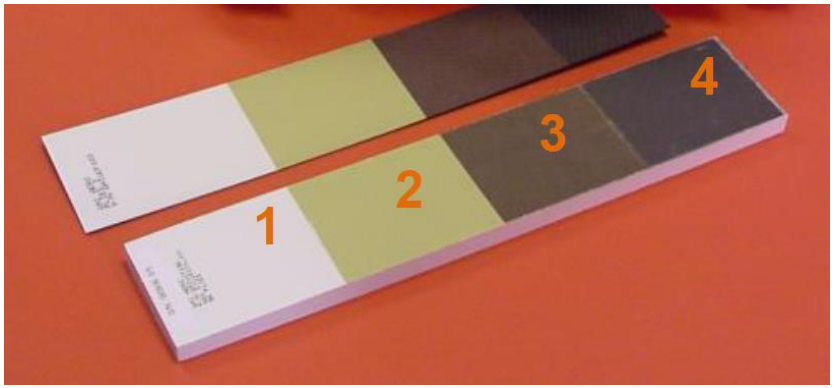
Scarfing

A complete set of tools for all tasks – Easy to handle and use – Presented in a complete Mobile Workshop

Elisa U/S NDT Console



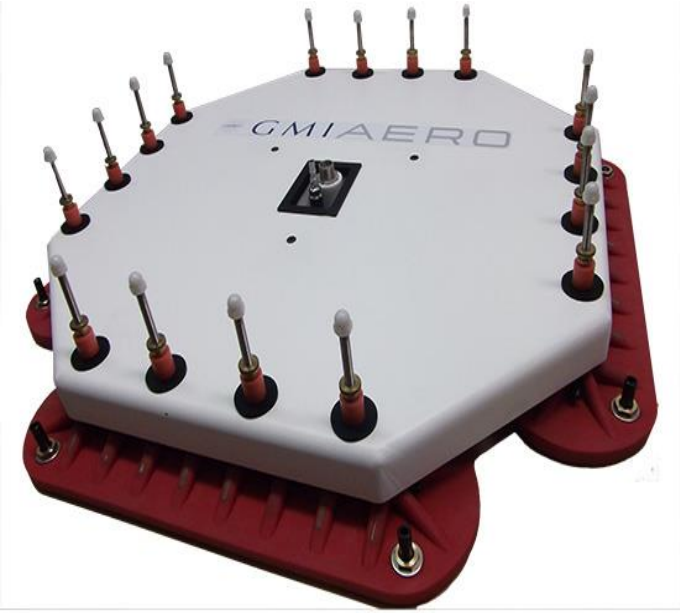
Advanced Software Tailored to Composite Repairs

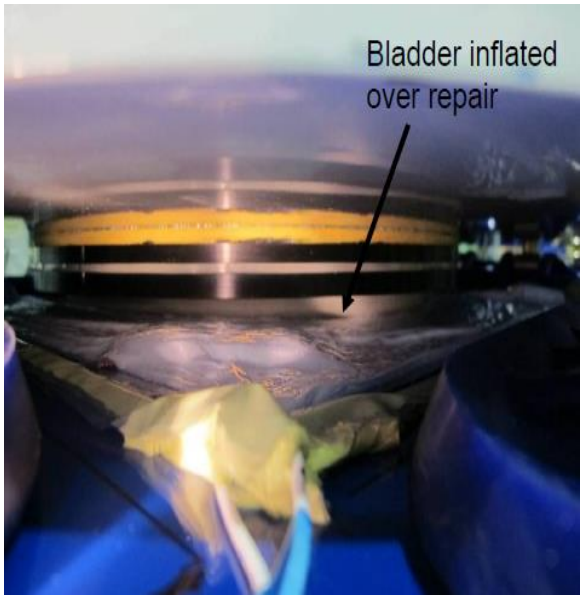


Range of Calibration Specimens

OLGA Positive Pressure Application

Repairs using OLGA patch preparation (to overcome porosity issues) and secondary bonding on aircraft





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GMI AERO

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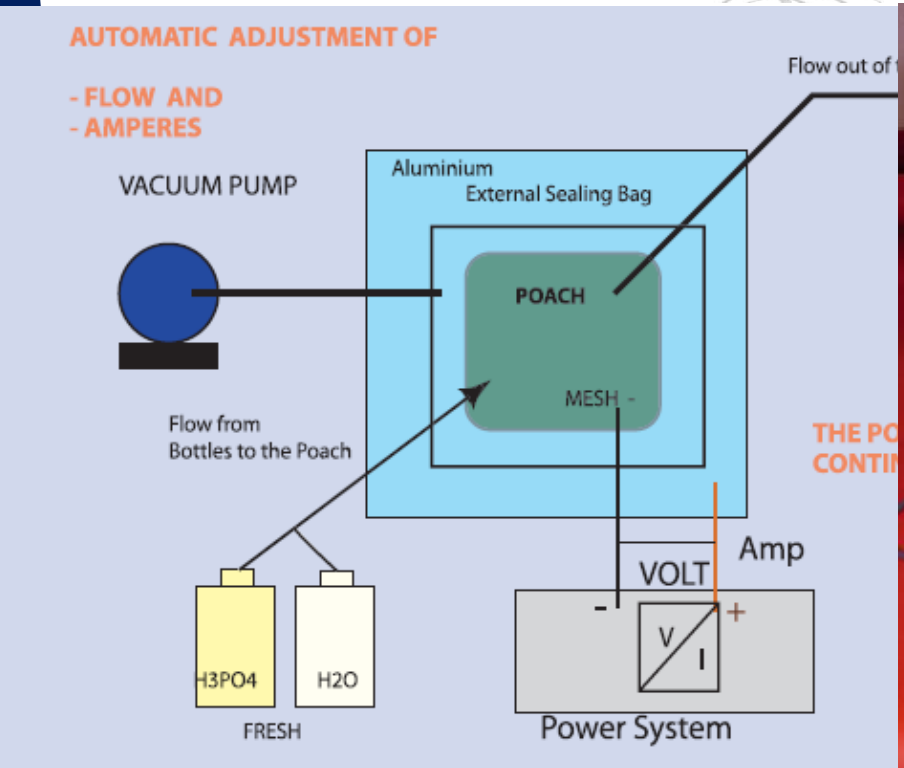
GILDA Phosphoric Anodizing



Autoclaves & Ovens

Various dimensions and specifications
Fully controlled by our computers
GMI ANIFIB

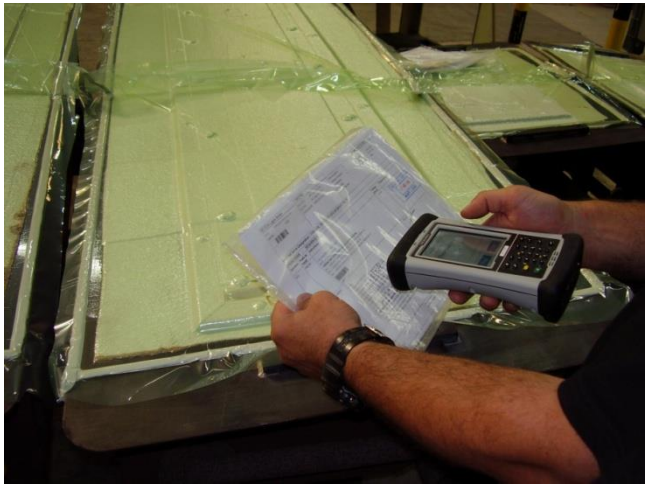
Model standard of internal dimensions
2,5 x 2,5 x 4 m
Fully equipped.
With vacuum system
*With **GMI ANIFIB** Computer control*

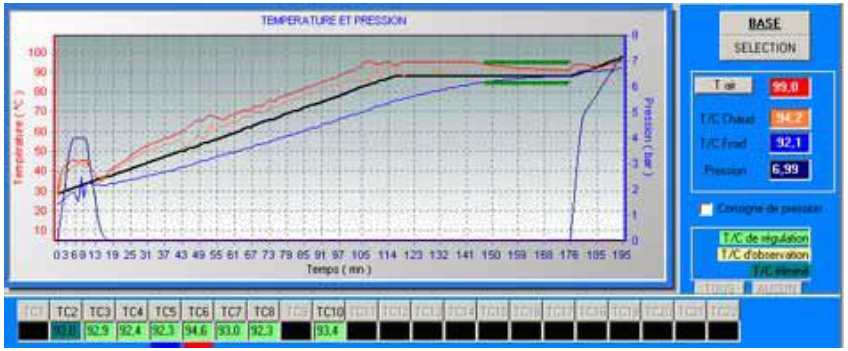
Autoclave Control: ANIFIB Software

GMI autoclaves are controlled by our system **ANIFIB ™** that offers several unique solutions:
The **ANIFIB ™** system is composed of two sub-systems:

a) An Industrial Computer called itself ANIFIB and which is mounted near the oven/autoclave.

b) A PC linked to the **ANIFIB ™** computer as a supervisory station with cycle programming and supervisory software.





Example of Autoclaves Installation

With Anifib, GMI has developed an activity of autoclave control.

Helping companies ease their production process and qualify it.

We are now turning to a development of **Industry 4.0**

Research & Innovation

Participation in **more than 30 EU Research Programs**
focusing on bonded composite repairs

FP5, FP6, FP7, **H2020**, Cleansky, Cleansky 2,
Research for the Benefit of SMEs, Eurostars, EUROGIA+,
Ten (10) *Cleansky* & *Cleansky 2* R&D Projects

In cooperation with :

AIRBUS
LEONARDO
DASSAULT AVIATION
SAFRAN AIRCRAFT ENGINES
ATR
EADS

Co-funded by:

SEVENTH FRAMEWORK PROGRAMME
eurostars™
EUROGIA +
A EUREKA initiative
HORIZON 2020
CLEANSKY
Clean Sky 2

GMI R&D Activities 1997 – 2020

58 Research Papers
"Revolutionizing Aircraft Materials and Processes", Edited by Sp.Pantelakis and K.Tserpes
Chapter: "Bonded Repair of Composite Structures"
G. Kanterakis, R. Chemama, K. Kitsianos

Research & Innovation / Main Projects

H2020: MG.1.1+2014.-RIA 636494-2

Quality assurance concepts for adhesive bonding of aircraft composite structures by advanced NDT – ComBoNDT

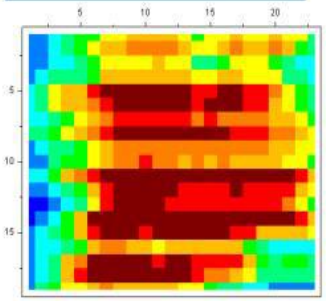
Consortium: Fraunhofer IFAM, EADS, CNRS, UoP, ASTRIUM, EASN

State of the art

ENDT techniques can detect:

- **Single** *surface* **contaminations** (pre-bond) on **simple** sample **geometries**
- *Weak bonds* due to single contaminations/poorly cured adhesive (post-bond) on simple geometries

1st step



Maturation of ENDT techniques to detect:

- Different **multliple** *surface* **contaminations** down to a certain threshold value (pre-bond) on **test coupons**
- *Weak bonds* due to multiple contaminations/ poorly cured adhesive (post-bond) on test coupons

2nd step

Adaptation and improvement of ENDT in terms of:

- *Pre-bond/post-bond* inspection on pilot samples with **realistic geometries**
- **Automation and industrialization** of ENDT techniques, including its use on a demonstrator and automated data evaluation
- **Validation** of measuring results/round robin test

Final results/innovations of ComBoNDT

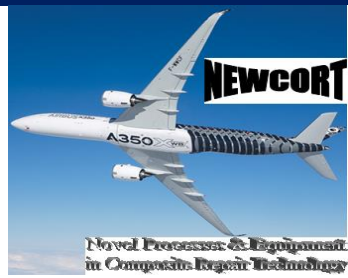
Validated ENDT techniques for:

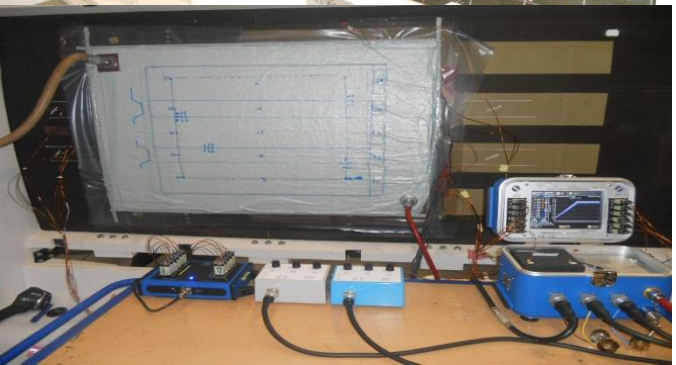
- Surface quality assurance (pre-bond)
- Adhesive bondline quality assurance (post-bond)

…for integration into future adhesive bonding processes

Research & Innovation / Main Projects

Cleansky 2: AIR-02-05-686701
Novel Processes & Equipment in Composite Repair Technology – NEWCORT
Topic Manager : Airbus





Support of mid-term needs for innovative faster repair process of monolithic composite airframe and long-term repair processes for future epoxy and thermoplastic materials

DL-1 Composite repair heating and polymerization process monitoring

DL-2 Composite Repair Associated Procedures

Validation of selected solutions based on aeronautical qualification process	WP5
Demonstration of performance of proposed innovations	WP4
Development of novel repair processes and equipment	WP2-3
Definition of novel repair processes and equipment requirements	WP1

NEWCORT Background knowledge in Bonded Composite Repair Processes

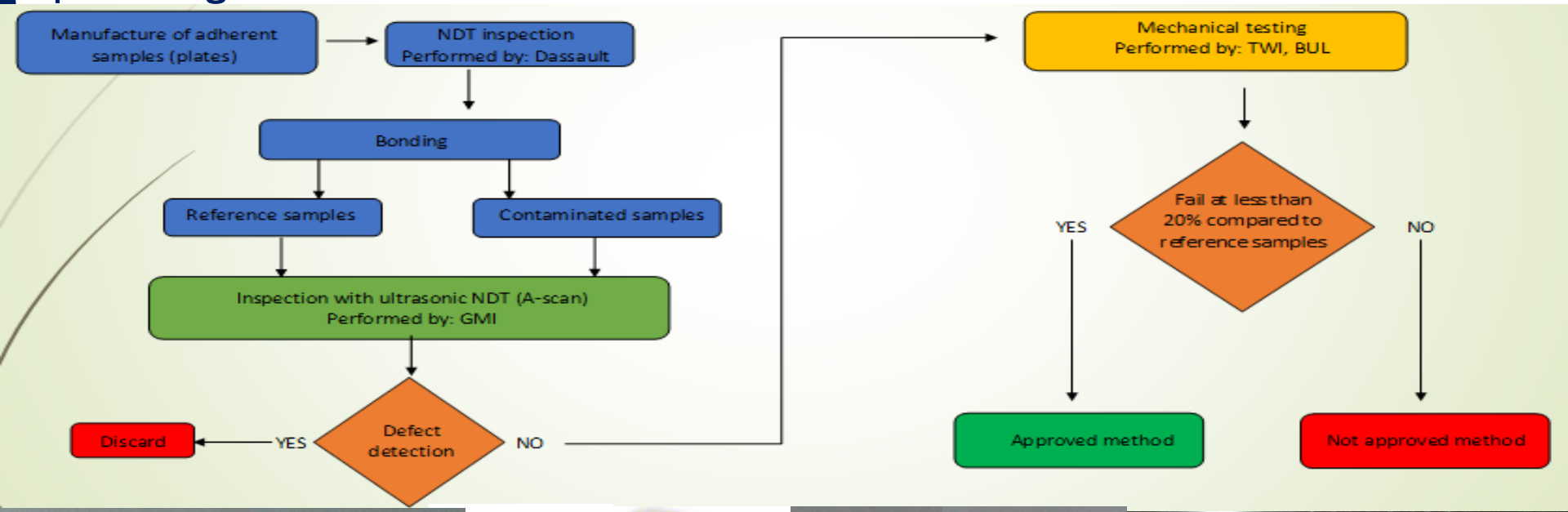
GMI commercially available Composite Repair Equipment and Solutions *(110-page equipment catalogue)*

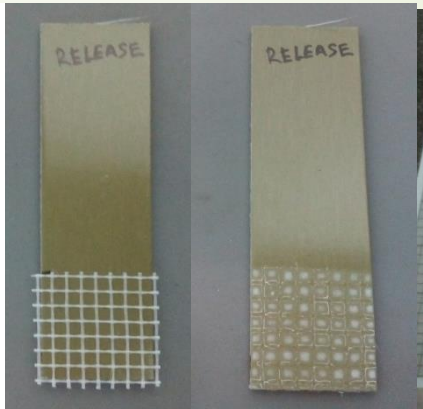
NEWCORT Partners' R&D projects in Bonded Composite Repairs *(~20 R&D projects)*

Research & Innovation / Main Projects

Cleansky 2: AIR-03-02-831882
Non-destructive testing (NDT) of bonded assemblies– SealedWithoutAKiss
Topic Manager : Dassault Aviation

SealedwithoUTaKiss





Latest innovations related to bonded composite repair application

Participation to EU Research Programs Brite Euram (FP5), FP6, FP7, H2020, Cleansky JTI, Research for the Benefit of SMEs, Eurostars & EUROGIA+

	Innovation Description	Challenges answered
1	Repairs using **OLGA** (positive pressure application equipment) for patch preparation and secondary bonding on aircraft.	Enhancement of bonding quality, and overcoming patch porosity issues
2	**Adaptive** (multi-sectorial) **heating blankets** using existing 2-zone ANITA bonders combined with variable insulation.	Improve temperature homogeneity on geometrically complex structures.
3	"Plug-and-play" **24-Thermocouple scanner**, together with appropriately prepared sensing mats.	Increased quality control requirements during repair on complex structures.
4	Real-time transmission of repair data, for curing duplication using **dielectric sensors** to enable curing degree monitoring.	Increased quality control requirements during repair on complex structures.
5	**Heating solutions for quick repairs** of small number of plies and limited dimensions tailored to aircraft needs.	Fast aircraft turnaround when limited repairs need to be applied.
6	**CONDUCTOR consumable heating blankets** that could be cut in different shapes to adapt to geometrical requirements.	Improvement of T homogeneity and suppression of blankets' lead time.
7	**MAGNASENSE magnetostrictive sensors**, for fast and accurate strain mapping of new or repaired composite structures.	Ensuring bonding adequacy both for SHM and certification requirements.
8	**Autonomous mobile composite repair workshop** to be used by airlines that need to perform repairs outside of their hangars.	Flexibility in repair application. Reduction of aircraft turnaround time.
9	Advanced heating system & control mode for homogeneous **Out-Of-Autoclave** curing of large composite repairs - **ADVANCED**	Reduction of energy consumption and CO_2 footprint for repair / production.
10	**Heating Bolts** provide localized heating to repair damages associated with drilling & reaming operations in carbon laminate.	Curing of resin inside drilled holes, achieving required T homogeneity.

In cooperation with

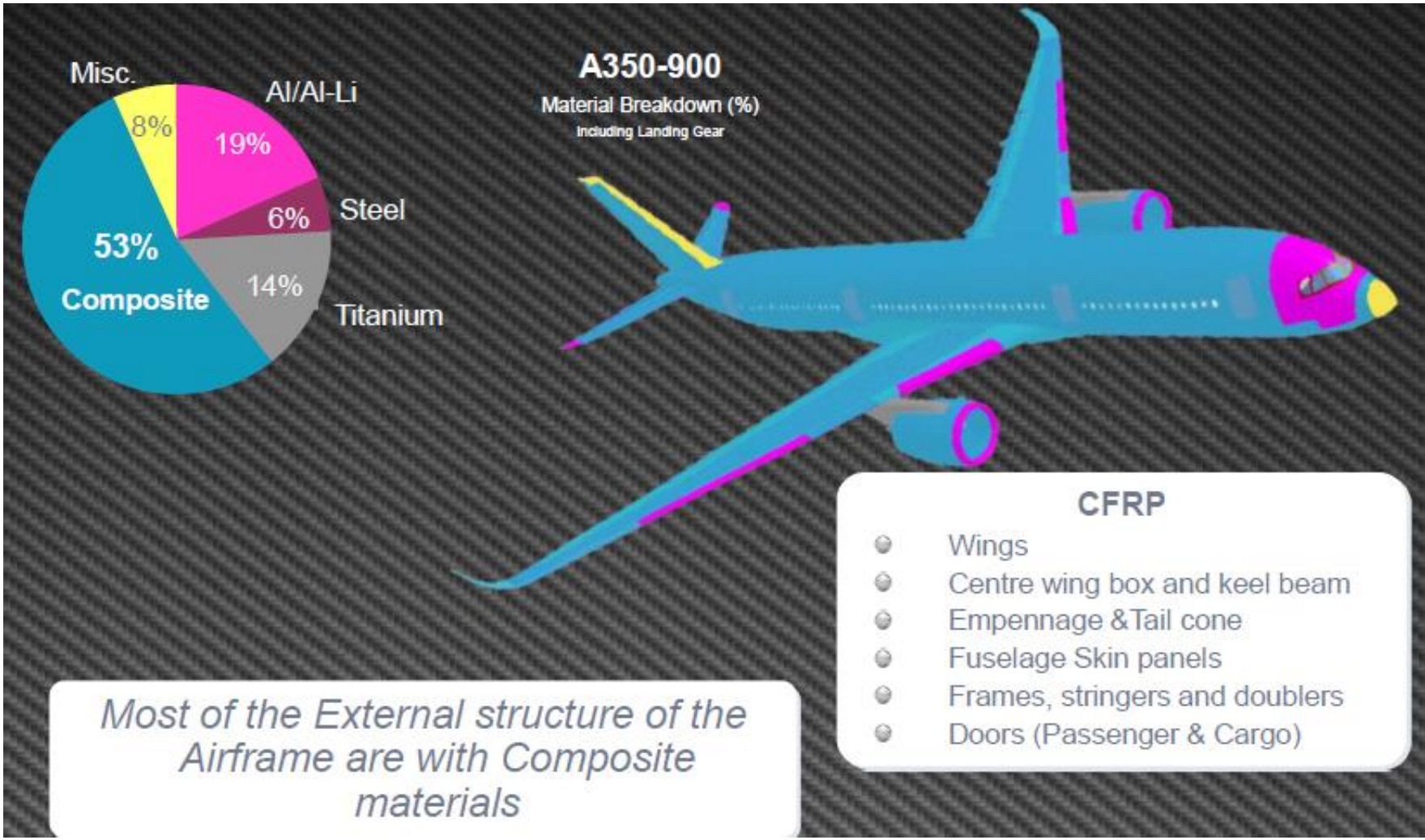
AIRBUS
AleniaAeronautica
ATR
DASSAULT AVIATION
SAFRAN Aircelle
EADS

Co-funded by:

SEVENTH FRAMEWORK PROGRAMME
eurostars™
EUROGIA +
A EUREKA initiative
HORIZON 2020
CLEANSKY
Clean Sky 2

A350 : Composite Materials overview

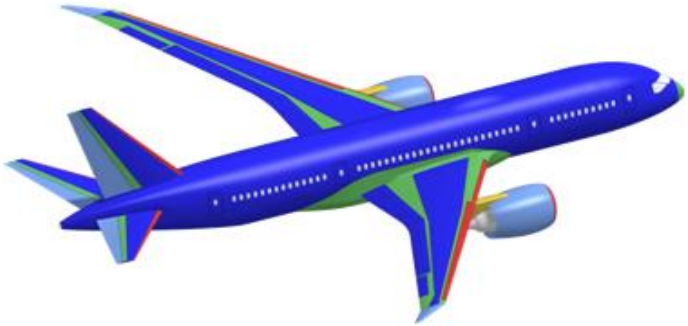
(Source Airbus)

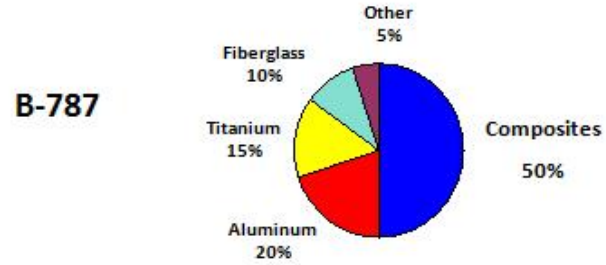


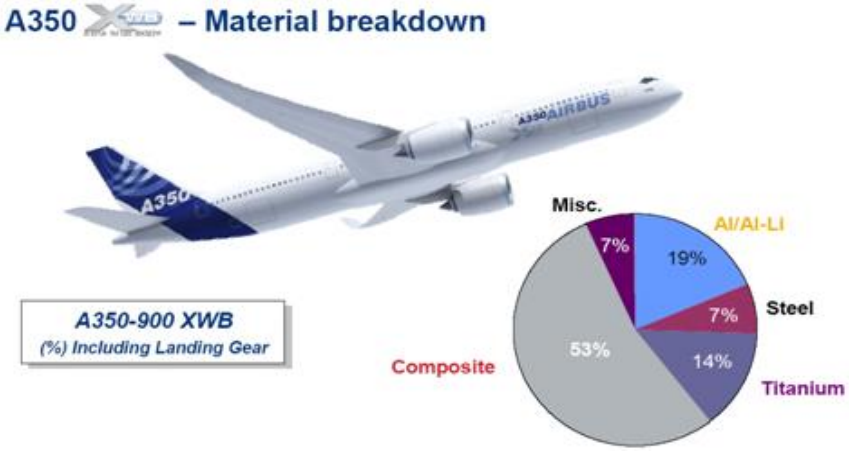
A350 : Involving Large & Complex Structural Panels

(Source Airbus)

Increase of **volume** of Composites per aircraft







Together with
Increase of **complexity** of Composite parts

Aircraft Composite Repair Evolution and Challenges

Answer to Challenges:

a. Adaptive Heating Solutions

b. Integration in 4.0 concept

c. Training & Continuous Professional Development

Adaptive heating solutions for aeronautical applications

If the only tool you have is a hammer, everything looks like a nail.

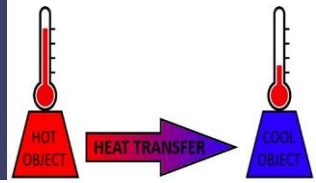
To change your perspective
(and find new solutions.)

Pick up new tools.

Please consider. . .

GMI AERO

Expertise and Innovation for Composite Repair



Carbon Structures Hot Bonding Issues

- The main challenge : to match in temperature the **resin manufacturer specs:** respect of a set-point of temp. at +/-5 °C max. on the whole surface.
- Heat transfer on structures heated by conduction though mats leads to **gradients up to 40 °C** and more, due to :
  - Large dimensions
  - Orientation of structures
  - Variation of skin thicknesses
  - Variability of materials covered by the patch

Question!

Question: Why do we have temperature differences?

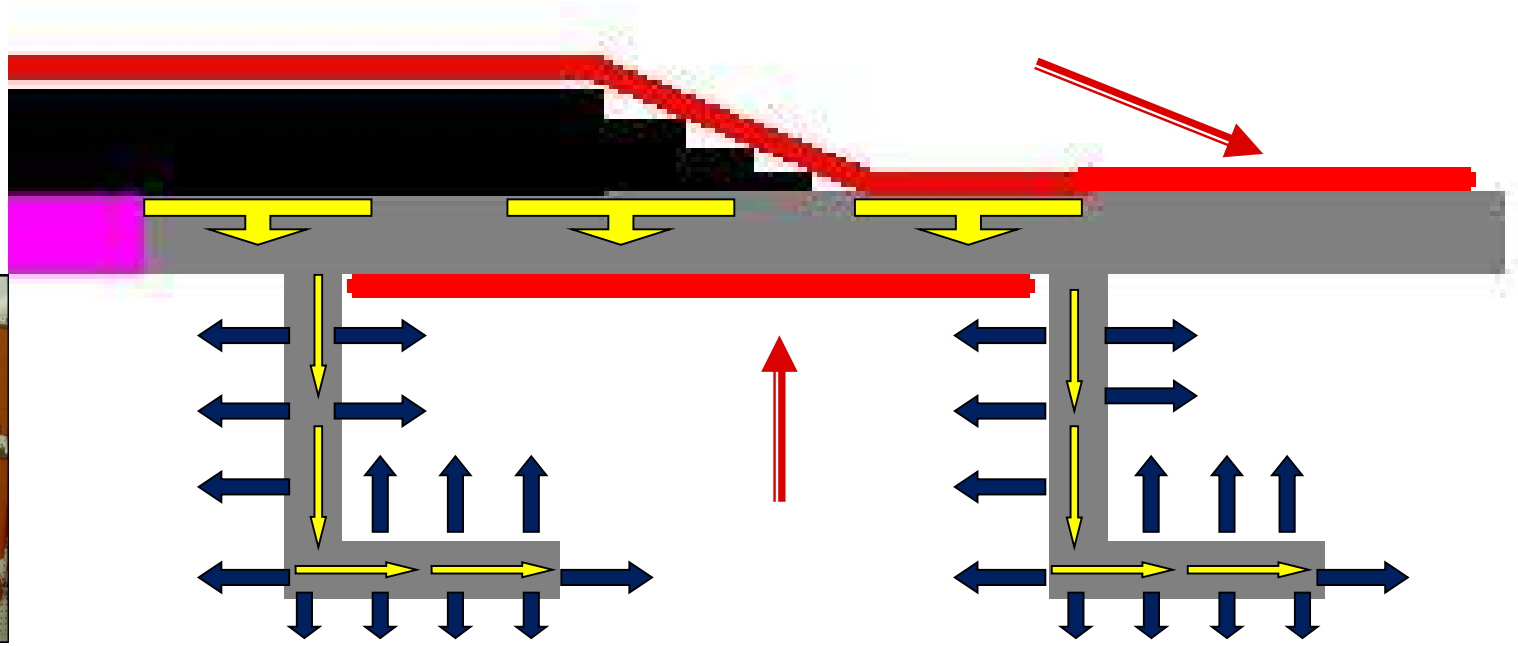
Answer: The problem starts due to the continues interaction of the thermal transfer modes, as follows:

- Heat is **directed to the repair area** (composite patch & peripheral structure) **through the heating** blanket by conduction, at a uniform rate across the blanket surface (increase of temperature).
- Heat is **propagating through conduction to the whole structure** which is surrounding the repair according to its geometry (i.e. in a non-uniform way) and, at the same time,
- Heat is **lost by the whole repair area through convection to the environment** according to the geometry of free surfaces of the surrounding structure (i.e. in a non-uniform way)

As is it well understood the result of uniform thermal heating, minus non uniform heat losses due to conduction and convection

is a non-uniform temperature distribution

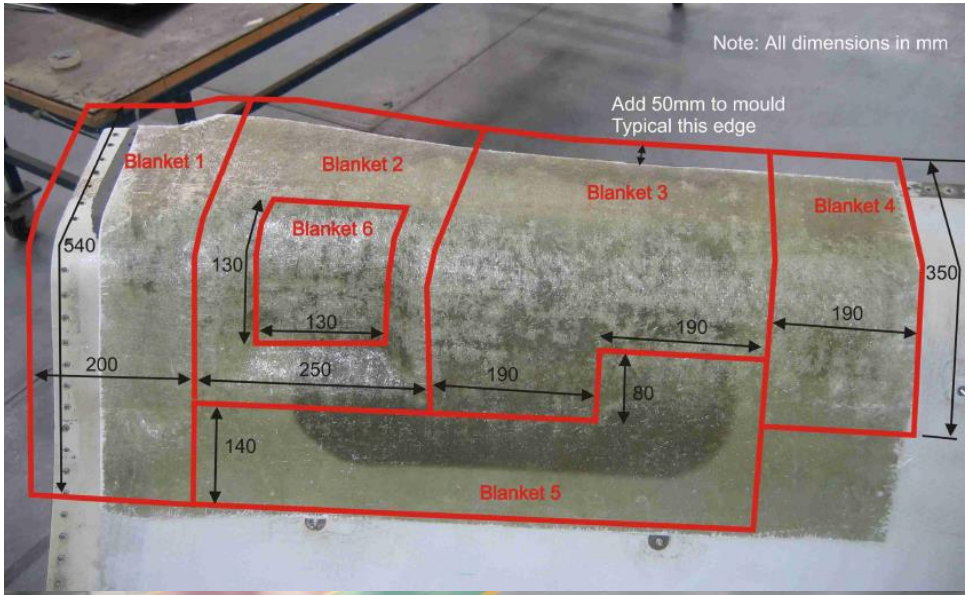
Tips for achieving better temperature distribution

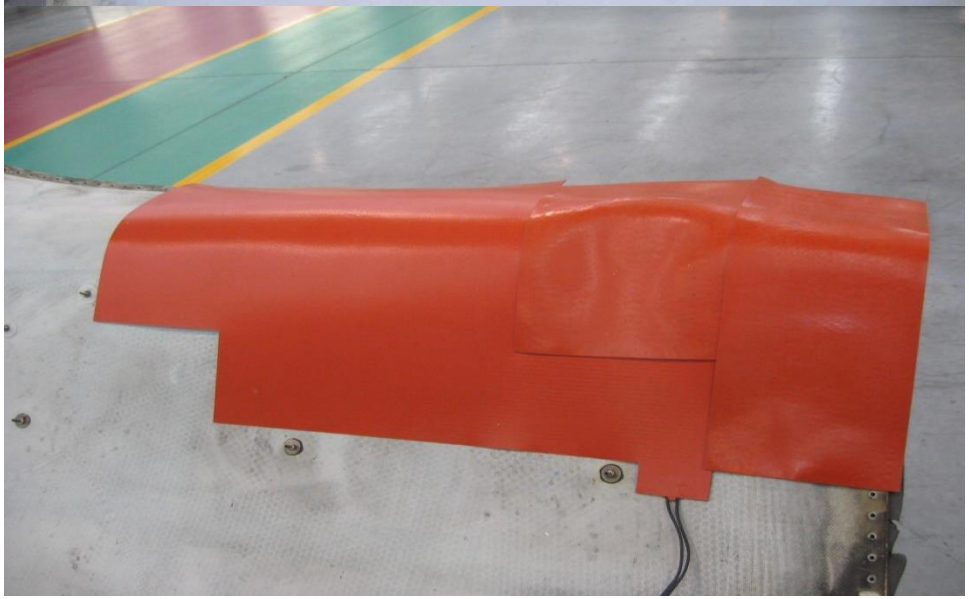


Tip: Impose additional heat to areas affected by “heat sinks”

Structure below or near the repair may act as “heat sink”, by transferring heat to the environment. These areas are better identified during the “heating survey”, which should be performed BEFORE the actual repair. To compensate for these losses, additional heat should be offered to these areas, either by increasing the overlap length or by an additional blanket (see GMI’s blanket inventory). A multi-zone heating strategy should be considered, as well.

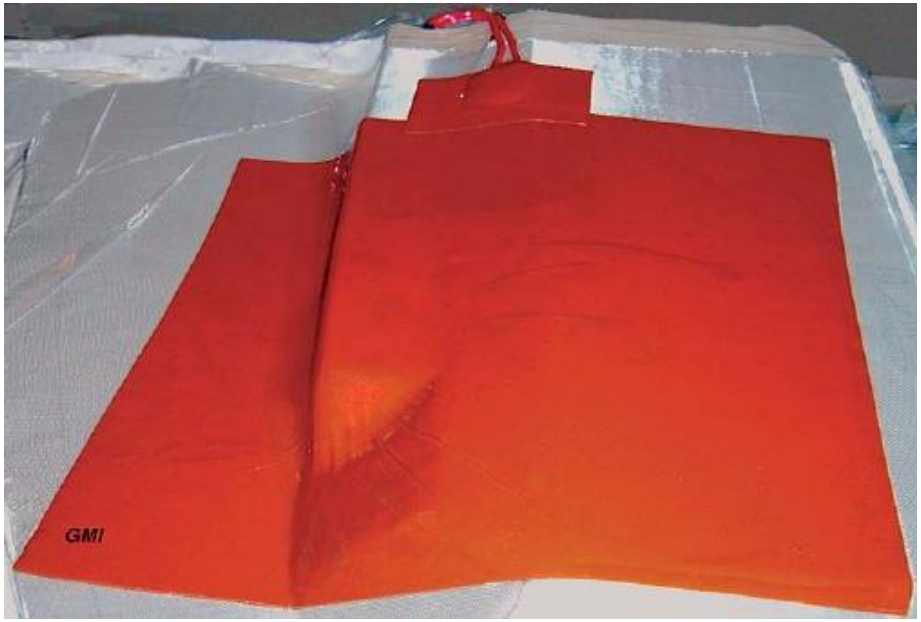
Multi-zone Heating Blankets

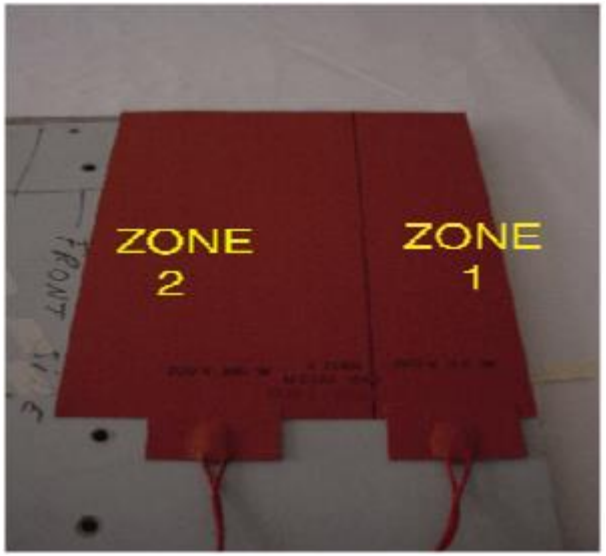




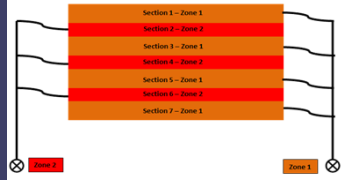
Example of multi-zone configuration, used for other demanding repair heating applications and corresponding heating blanket manufactured according to the definition calculated for this structure

Multi-zone / Shaped Blankets





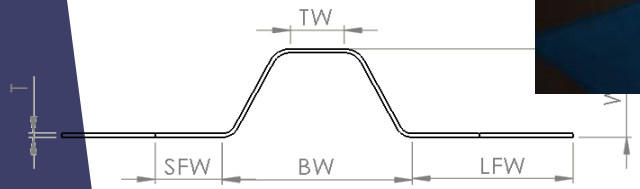
Adaptive Heating



A350/B787 Increased complexity

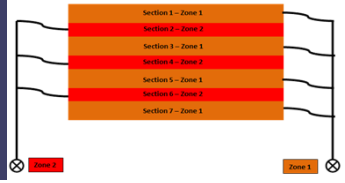
Thermal issues associated with A350 / B787 Panels repair

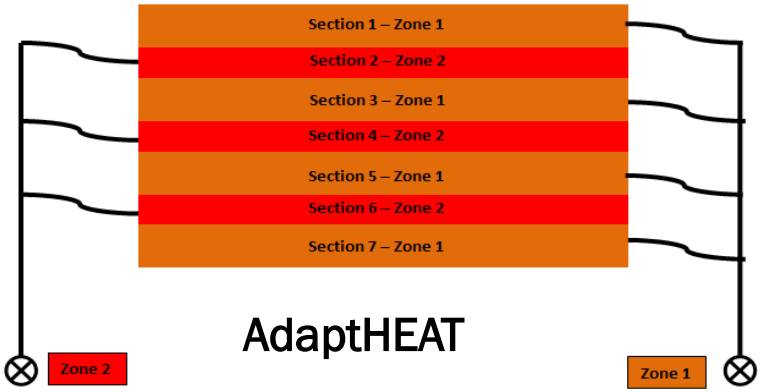
- Significant temperature fluctuation due to "Omega stringers" effect: trapped air acts as insulator
- Single heating zone approach is no longer valid.

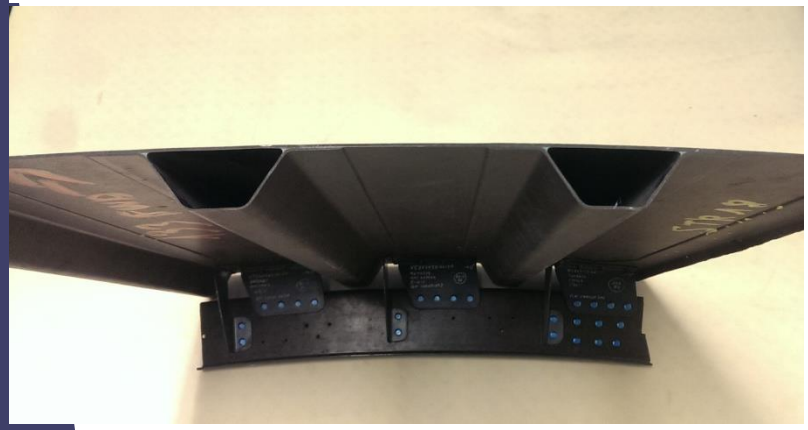


Zonal Approach is required…

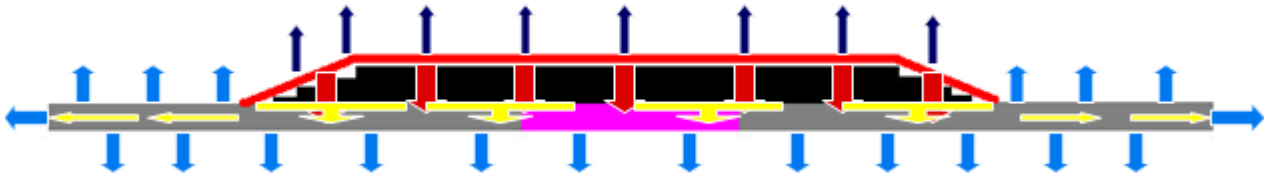
Adaptive Heating





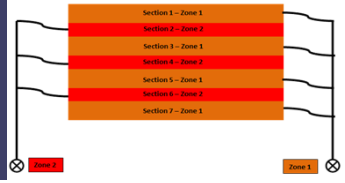


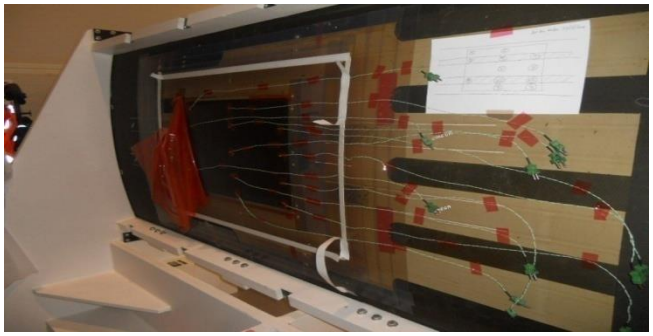
AdaptHEAT solution designed for A350 Omega stringers

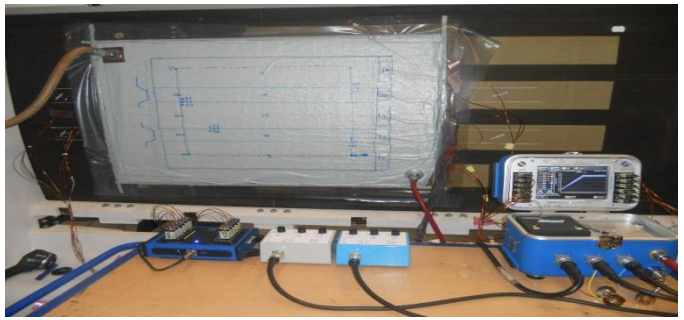


Heat Equilibrium = Algebraic Sum of Thermal Routes No 1+2+3+4

Adaptive Heating







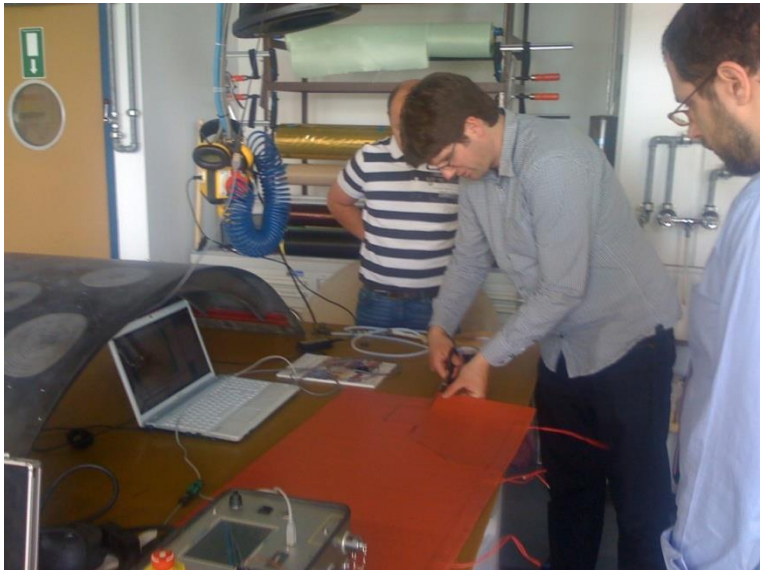
AdaptHEAT: Overall A350 panel application example

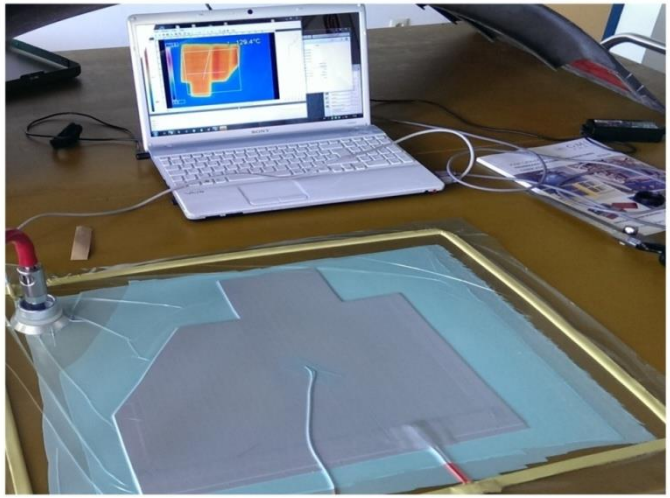
- Specially designed to ADVANCED / ANITA legacy equipment (no need for upgrade)
- Heating elements' geometry adapted to A350/B787 composite structures (fuselage / wings)
- Heating performance optimized for Ω/T/I stiffened composite structures
- Compatible with 2- zone controllers of all bonding console manufacturers (adaptors required)
- Standard procedure followed for preparation and vacuum bagging operations
- No need for additional training of operators
- Flexible dimensions, according to requirements
- Further customization possible, according to repair area configuration

"Cuttable" Blankets

Blankets

Heating Blanket "Cut-to-Measure" **CONDUCTOR**

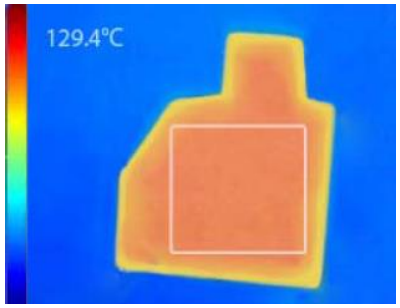




Conductor Blanket cut to measures under verification test

Developed and tested under the guidance of

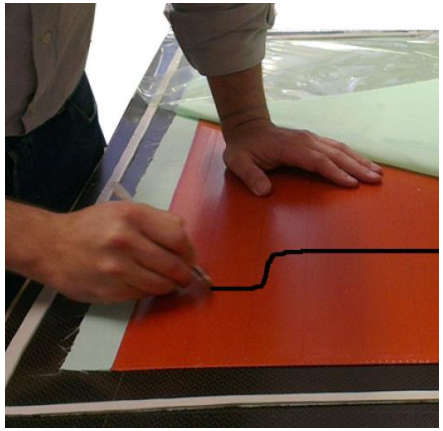
AIRBUS GROUP INNOVATIONS



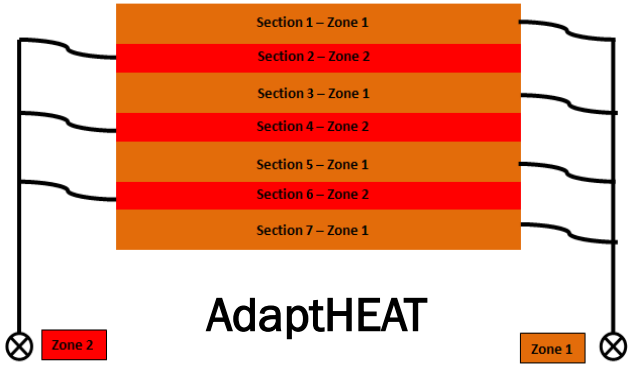
"Cuttable" Blankets

Blankets

Heating Blanket "Cut-to-Measure" **CONDUCTOR**



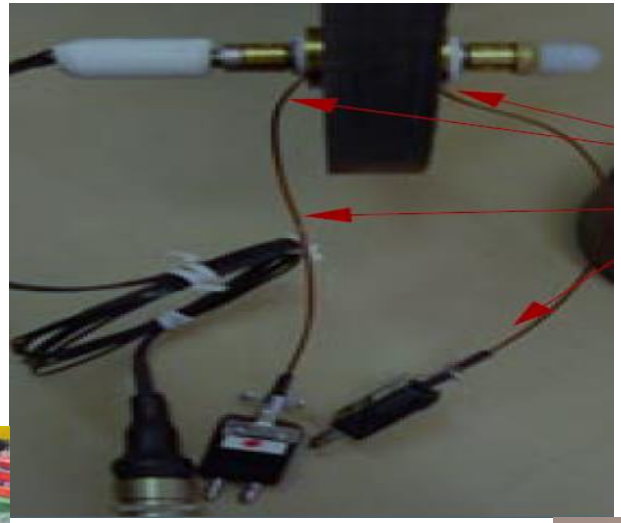
Combined with AdaptHEAT for A350 repairs...

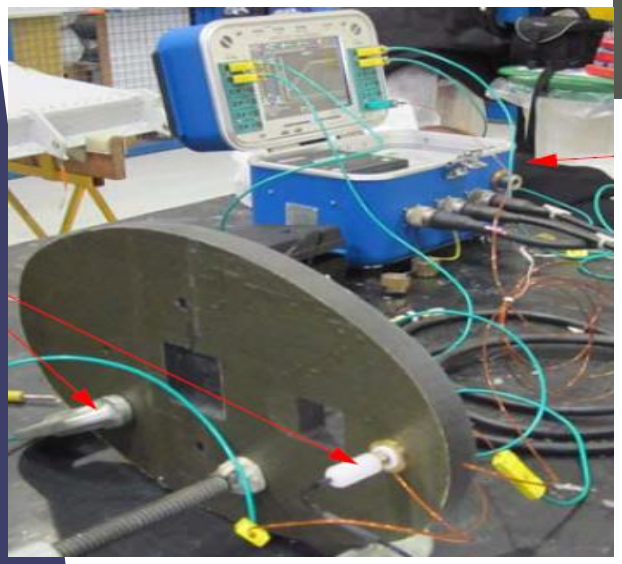


AdaptHEAT

Special Heating Elements

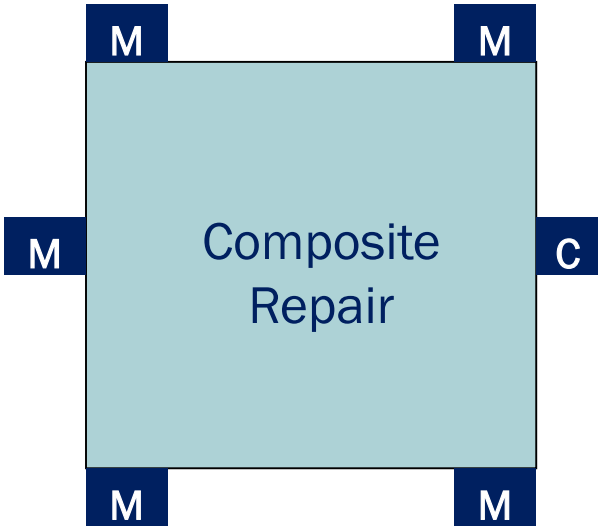
Heating Pins - Heating Bolts for repair inside drilled holes of 3-20mm diameter



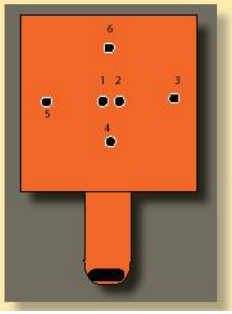


A GMI Innovation : The Sensing Mat

Install the control thermocouple very close to the repair



A Quick Connector is mounted on the mat to connect to the cable in one operation. Only the thermocouples involved in the process, selected by their right position above the patch, are connected to the bonding console.



Typical positioning of sensing points

The picture shows 6 sensing points organised on the surface of this mat .Each point is identified by its number.
According to the repair patch dimension , the operator will decide which are the sensing points to select for the control and monitoring . These points will be connected to the console through its indivual cables .
The large mat will have 12 points embedded , while smaller will have 6 points.

To succeed good control you need to put the control thermocouple “C” at an area of “representative” temperature. As such, a point very close to the edge of the repair is usually proposed. Take care to put the monitoring thermocouples “M” around the repair and definitely at areas with potential heat sinks.

Ideally, use the GMI’s “sensing mat”, in order to be able to get temperature measurements from the center of your repair, without marking your part.

A set is constituted by a Mat and a Cable of 12 couples.

The P/N of the blanket must be selected according to the usual sizes of blankets as used by the operator.

The STSM dimensions must be larger than the blanket’ones. Of course, one given STSM is suitable for all Heating Blankets of smaller sizes.

ANITA COMPATIBILITY

The STSM is manufactured to be fully compatible with ANITA and its thermocouples are thus of type J.

The STSM can be used with all types of ANITA : NG or OT , HE explosion proof models, 4, 6 or 8 zone Models.

The STSM is compatible with 1 or multi-zone GMI heating Blankets.

Select a Mat according to the dimensions and add a Cable .You can select one cable for more than on mat..

DIMENSIONS OF STSM MOST USUALS

You can order according to metric or imperial dimensions . All mats have 12 thermocouple type J embedded , but the smaller one 10 x 10 in (250 x 250 mm) which has 6 .

Dimensions in cm	Approximatives Dimensions inches	P/N	Number of Thermocouples
25 x 25	10 x 10	GMIHBSM025025	6
30 x 30	12 x 12	GMIHBSM030030	6
40 x 40	15 x 15	GMIHBSM040040	6
50 x 50	20 x 20	GMIHBSM050050	12
60 x 60	24 x 24	GMIHBSM060060	12
30 x 50	12 x 20	GMIHBSM030050	6

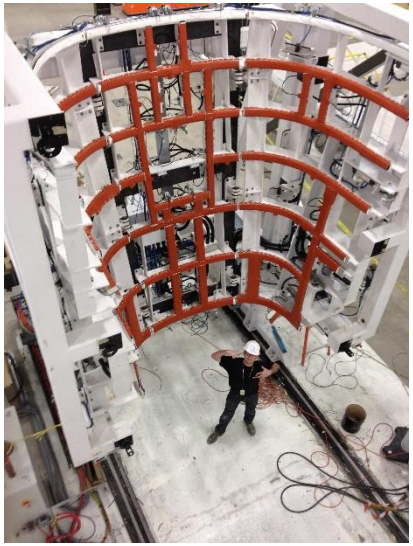
COMPENSATION CABLE

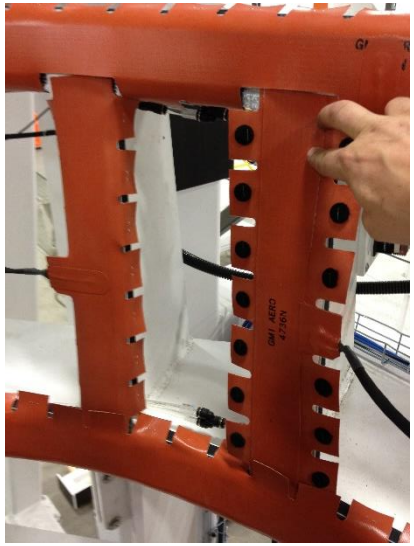
Mating Cable with capacity : 12 Thermocouples type J.
P/N : GMIHBSM-12J.
Mating Cable with capacity : 06 Thermocouples type J.
P/N : GMIHBSM-06J

Autoclaves –OOA

OOA

GMI has developed a solution to attach the complete metallic stringer set to reinforce the rear cone skin on Bombardier C- Series. These blankets are plugged on an Anita 6 zones.





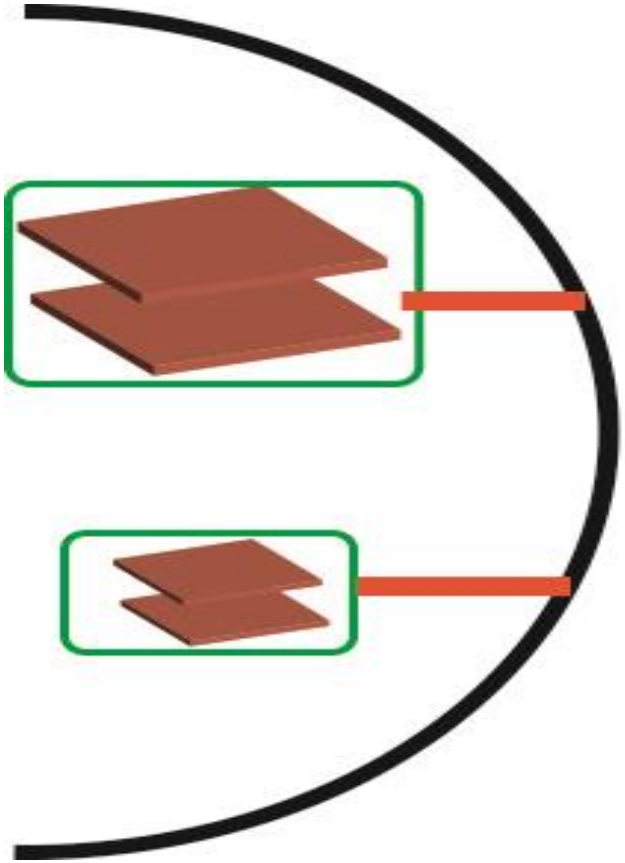

Repair Enhanced Autoclaves

Using flexible blankets as the main source of heating!

- **Addressing repair requirements of complex aeronautical parts**, such as the **A380 engine reverses**, the **B777/B787 engine nacelles** etc.

- Globally heating the parts in "conventional" autoclaves would **immediately distort** them while causing **severe and unrecoverable damage**, due to **variation of thermal expansion coefficients** of involved materials.

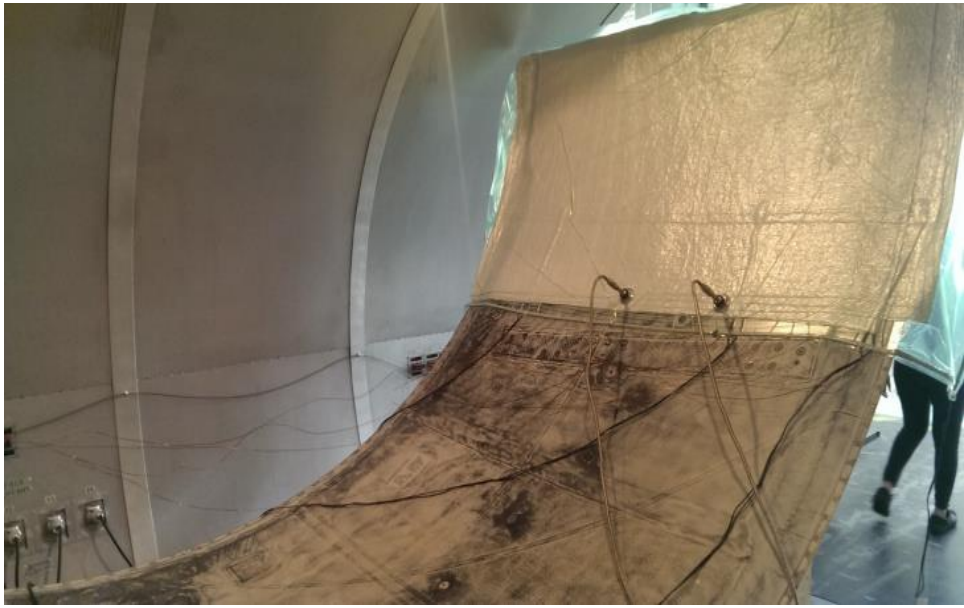
- Even though an autoclave is still used to provide required pressure and slightly elevated ambient temperature (i.e. 50-80°C), **heating at 120-180°C is ensured using specially designed adapted heating blankets**, at the repair area **ONLY**!



Repair Enhanced Autoclaves

Using flexible blankets as the main source of heating!

- **Installation** of power supply plugs, connectors, extension cables.
- Thermal **simulation** and **analysis** of the repair area to ensure Temperature **homogeneity**.
- **Design and manufacturing of adapted heating blankets**, tailored to the specific repair requirements.



GMI – AFI cooperation for B777 GE90 Nacelle

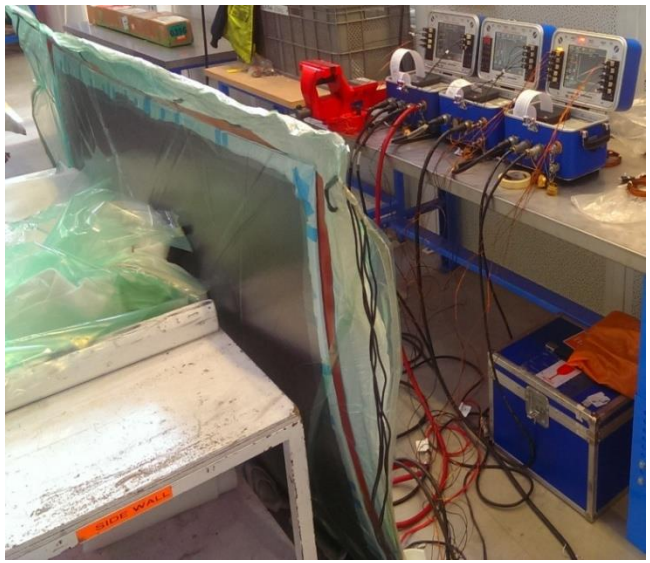
GMI AERO

Commercial in confidence

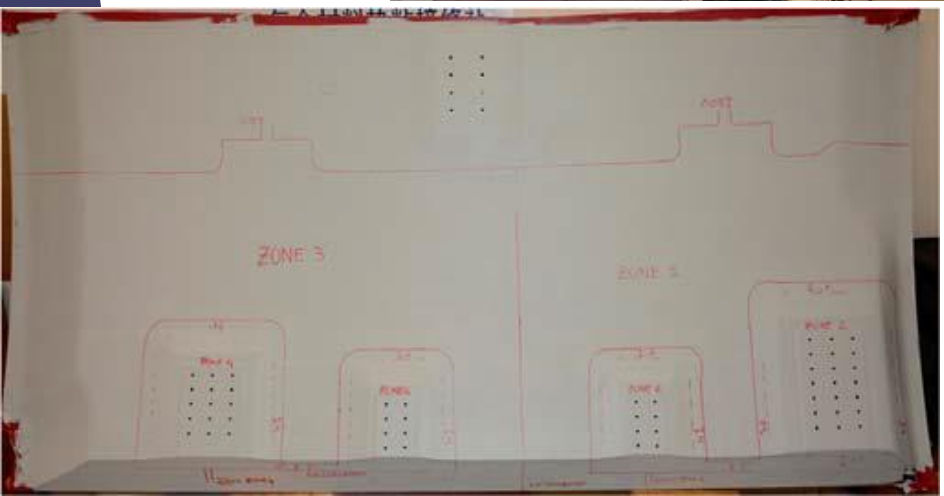
AIRFRANCE INDUSTRIES

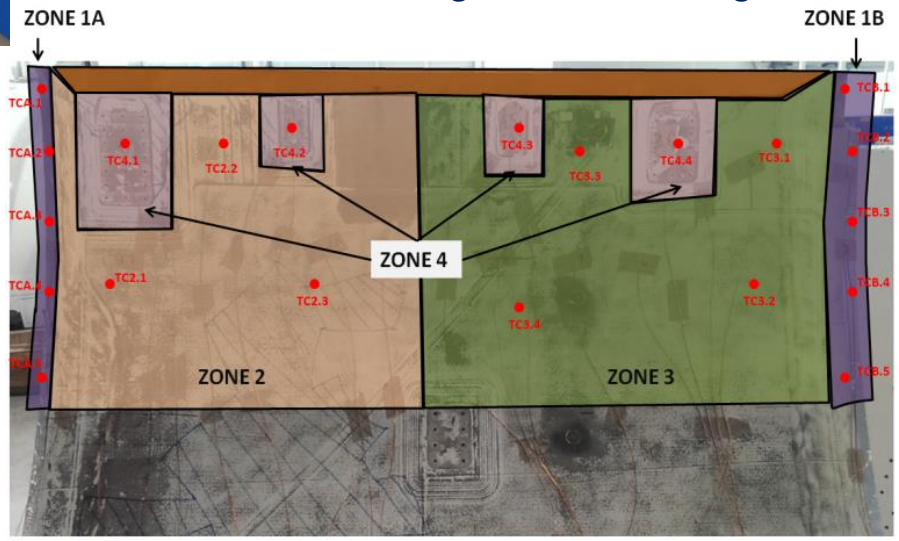
KLM Engineering & Maintenance

Overview of the GE90 area to be repaired, showing variations in construction materials and methodology (sandwich – monolithic)

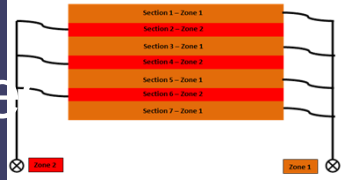


The 8-element / 5-zone adapted heating blanket, designed to cover the upper surface of the right / left cowling

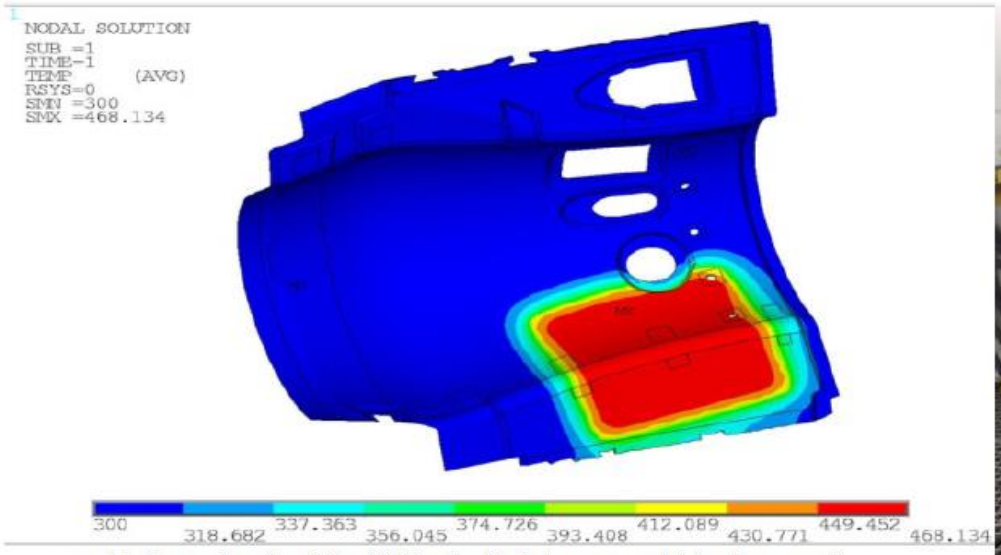




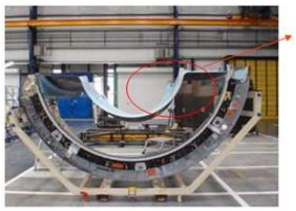
Repair Enhanced Autoclave

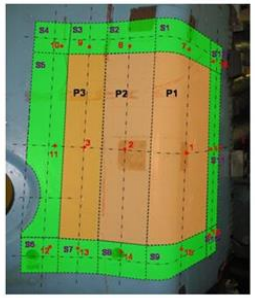


"**ADVANCED**" Out-Of-Autoclave (OOA) Heating Solution for Production and Repair of A380 Thrust Reversers using **18 zones**

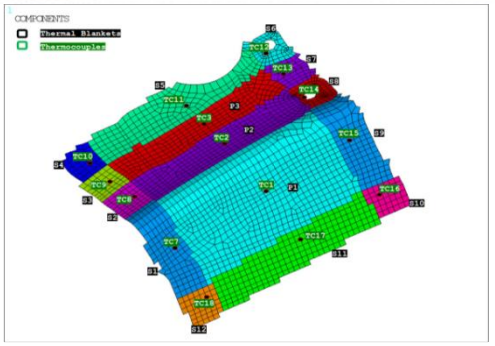


- Heating configuration defined (15 heating blankets on cocured side + 3 on opposite side)





- Up to 72 T/C available for regulation and monitoring
- Some of them could be localized specifically for correlation with Thermal Simulation



Repair Enhanced Autoclaves







“ADVANCED” Out-Of-Autoclave (OOA) Heating Solution for Production and Repair of A380 Thrust Reversers

Answer to Challenges:

a. Adaptive Heating Solutions

b. Integration in 4.0 concept

c. Training & Continuous Professional Development

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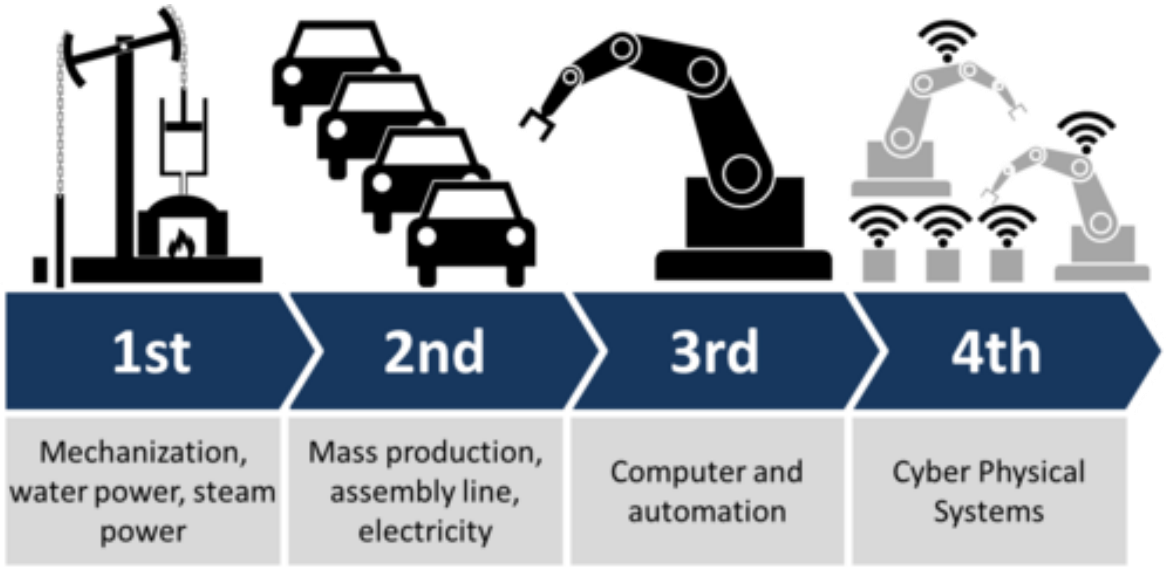
www.gmi-aero.com – gmi@gmi-aero.com

ANITA 4.0 is the application of the **Industry 4.0** concept in the field of bonded composite repairs



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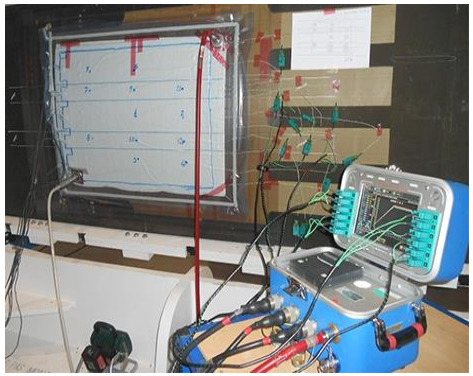
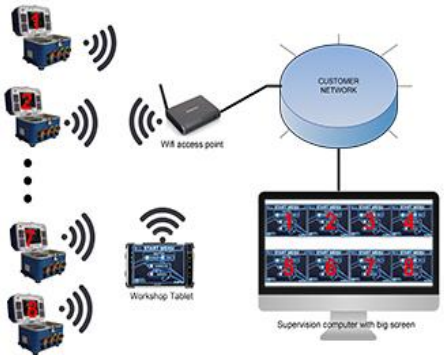
www.gmi-aero.com – gmi@gmi-aero.com

ANITA 4.0 concept Main Steps

Last steps of repair preparation on an A350 fuselage



ANITA EZ with AdaptHEAT ® controlling the curing process



ANITA EZ connections to the company's intranet

On-line inspecting and evaluating the overall process

Proximity WiFi Solution
Remote Monitoring and Control Tablet

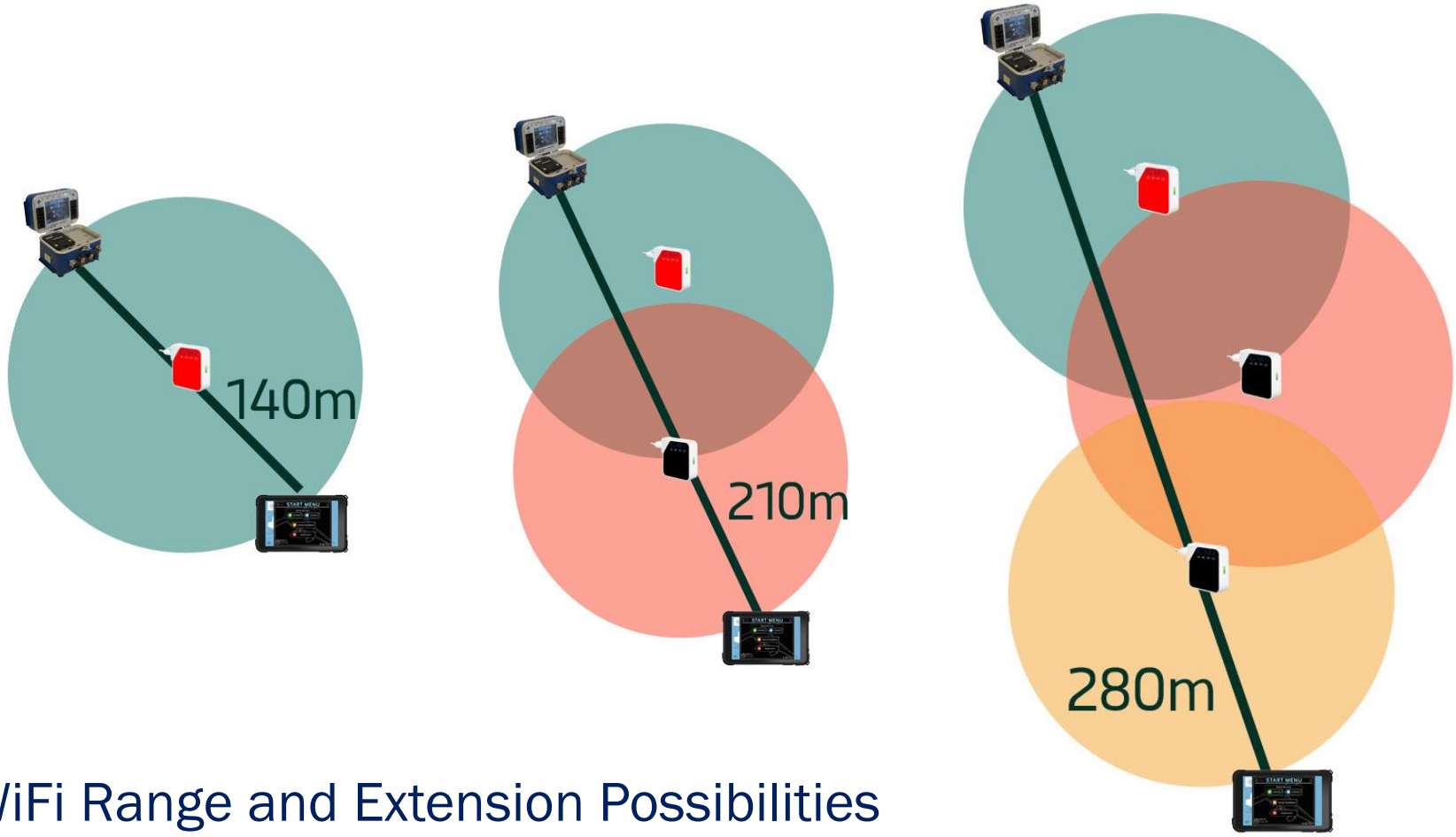
Technicians could be engaged with other activities in their offices or around! → 80% reduction of MH associated with repair…

Remote Control Tablet

→

Surveillance and control of up to four (4) bonding consoles

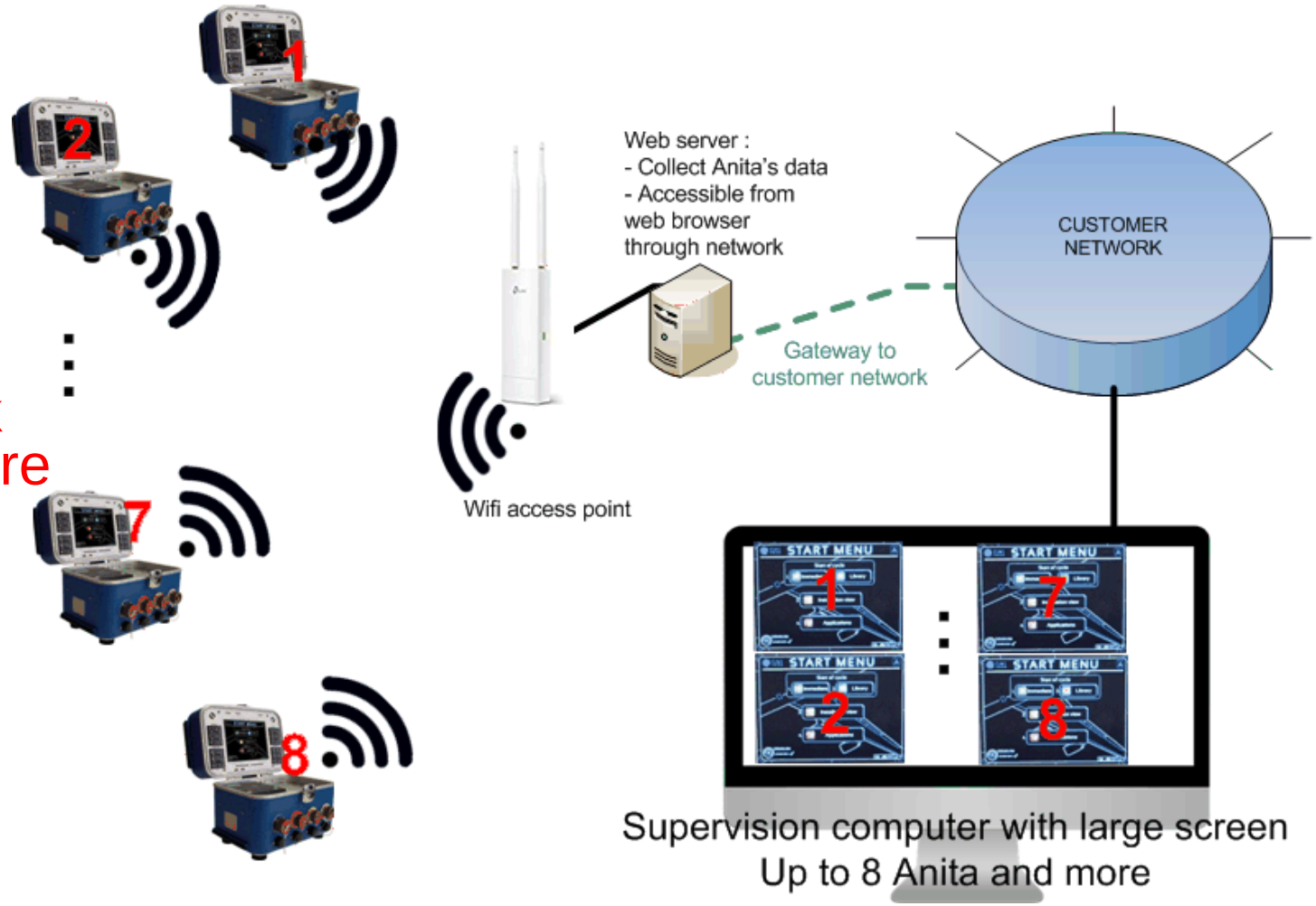
Proximity WiFi Solution
Remote Monitoring and Control Tablet



WiFi Range and Extension Possibilities

Distant IT Solution
PANOPTES

General Network Architecture



Distant IT Solution
PANOPTES

Distant Parallel Monitoring

- Up to **eight (8) ANITAs** connected to end-user's central IT system through WiFi.

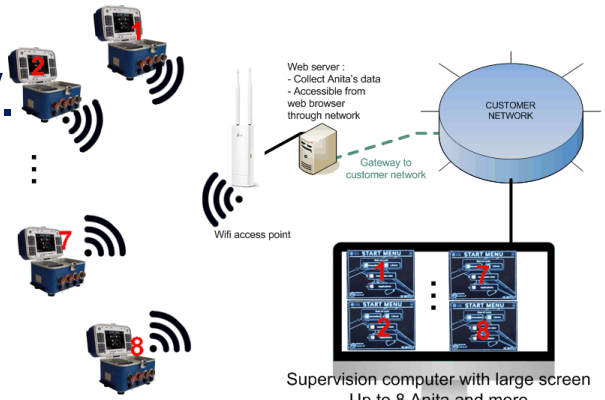
- **Web application**, accessible from main web browser.

- Collects ANITAs information & stores in a **database**.

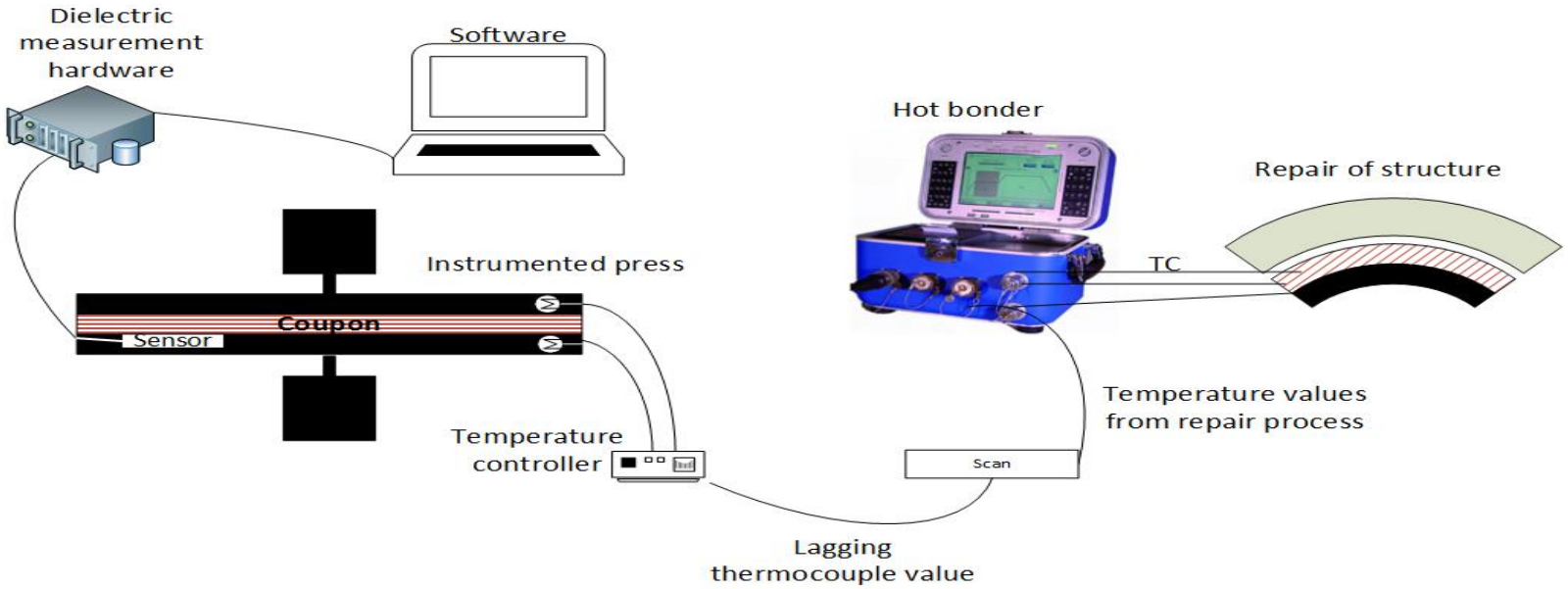
- **Visualizes** summary of all connected ANITAs current status (Zones on cycle, Setpoint, T/C, Vacuum, etc).

- **Data presented** on PC screen or Smart TV.

- Format and variety of presented data **tailorable** to end-user's requirements.



Repair Digital / Physical Twin
On-line Quality Monitoring



- When a **safety critical** structural repair is performed all repair data (temperatures, vacuum level etc.) are **recorded** and **real-time transmitted** to the aircraft manufacturer.
- At the aircraft manufacturer's facilities a **setup using same materials** is prepared and is **simultaneously** to the actual repair **cured**, using **appropriately selected portion of transmitted real time data** (e.g. lagging thermocouple), so as to enable **imminent** destructive or non-destructive **testing** of produced material.
- Within the set-up prepared at the aircraft manufacturer's facilities, **dielectric sensors for curing degree monitoring** are included, thus providing **real time degree of cure data**, equally valid for the remotely performed structural repair on the aircraft.

Aircraft Composite Repair Evolution and Challenges

Answer to Challenges:

a. Adaptive Heating Solutions
b. Integration in 4.0 concept
c. Training & Continuous Professional Development

Aircraft Composite Repair Evolution and Challenges

BUTCHER OR BAKER?

There are some significant challenges for technicians due to the nature of composites - which are very process driven and rely heavily on the composite technician building quality into the finished product. To illustrate this, the Aug/Sep 2012 edition of Aviation Maintenance (AVM-mag) published an article discussing the difference between repairing a metal vs a composite aircraft being akin to the difference between highly skilled butchers and talented bakers. Here's why:

Image source: dreamstime.com

Butchers don't have to create the meat they work with. The raw meat comes into the shop fully formed. The butcher's job is to carve it up into the required cuts. This is similar to mechanics working on a metal aircraft. Whether they are installing a new part, re-shaping and repairing an old one or - in extreme cases - custom measuring, cutting, shaping and custom fitting a new metal part from scratch, mechanics don't have to smelt and cast the metal they are working with. Instead, the metal comes into the shop in workable shapes, sheets and thicknesses, no fundamental manufacturing is required. It's not quite as convenient as working with meat, but it is close.

In contrast, bakers must start with the raw ingredients, condition them to room temperature, and combine them into specific mixtures first. Then they have to transform these mixtures into cakes, pies, breads, etc. and use the right levels of heat for the correct amounts of time. In the same vein, composite repair technicians must follow strict processes to combine and cure ingredients to achieve an optimum result.

GMI Training Activities

- Level 1: **BASIC** BONDED COMPOSITE REPAIR **STANDARD** TRAINING COURSE – **5 DAYS**
- Level 2: **ADVANCED** BONDED COMPOSITE REPAIR **INTENSIVE** TRAINING COURSE – **5 DAYS**
- Level 2: **ADVANCED** BONDED COMPOSITE REPAIR **STANDARD** TRAINING COURSE – **10 DAYS**

Example of 5 days Basic Training Course

Level I – Basic Bonded Composite Repair

Scope: This curriculum is intended to meet the formal training requirement for individuals who intend to become certified as aircraft composite repair technicians. Persons who successfully complete this aircraft structural repair training program are considered to be able to perform **basic** composite bonded repairs to aircraft structures in compliance with the manufacturers' repair documentation or other acceptable or approved repair data.

Applicable documents: GMI Aero proposed Training Courses align with the latest SAE Commercial Aircraft Composite Repair Committee (**CACRC**) and regulatory authorities documents, as follows:

- **AIR4938C** Composite and Bonded Structure Technician/Specialist Training Document
- **AIR4844D** Composites and Metal Bonding Glossary
- **AIR5719B** Teaching Points for an Awareness Class on "Critical Issues in Composite Maintenance and Repair"
- **FAA AC 65-33** Development of Training/Qualification Programs for Composite Maintenance Technicians

Trainee's prerequisites:

- Experience as aircraft maintenance technician or engineer
- Good knowledge of the English language (minimum B2)
- Basic mathematics, physics and chemistry considerations (minimum High School - level or equivalent)

Course Outline: This training course is divided into four (4) main training units, namely:

- Basic Theoretical Considerations
- Bonded Composite Repair Equipment and Toolings for Curing and Machining
- Implementation of actual Bonded Composite Repairs
- Theoretical & Practical Examinations

Continuous Professional Development

Continuous Professional Development

CPD Participants, Organizers and Speakers in action, during the Seminar

"New Aircraft, New Materials, New Repairs"
Guillaume FERRER
Embodiment Industrialisation Manager
Composite Repair Process Development
Airbus Customer Services

"Technical challenges and innovations in bonded aircraft composite repair"
Philippe SERVANT
Responsible for Engineering, Research and Development of Aerostructures,
AFI KLM E&M

Continuous Professional Development

REPUBLIC POLYTECHNIC
DISCOVER. TRANSFORM. ACHIEVE

SINGAPORE AIRSHOW
SINGAPORE AIRSHOW 2020
ASIA'S LARGEST AEROSPACE AND DEFENCE EVENT
11-16 February 2020
Changi Exhibition Centre

GMI AERO

Composite Technology Seminar & Experts Forum Singapore, 10/2/2020

Fraunhofer IFAM

GMI AERO

Composite Repair Seminar & Experts Forum *Berlin, 11-13/5/2020*

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Bonded Composite Repair Methodologies – Latest Advancements and Developments

Questions?