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1 EXECUTIVE SUMMARY

The aim of this project is to develop innovative Non-Destructive Testing (NDT) techniques to on-line monitor CFRP damages during structural tests execution. The demonstrator has included one NDT technique. NDT instrumentation performs automatically and hugely reducing human intervention. Data acquisition and analysis can be accessed through network in real-time.

Up to now, ultrasonic conventional manual inspection is carried out. For safety reasons, facilities are stopped before. One of the first steps of the project has consisted of demonstrating the feasibility of novel NDT techniques. Among others, non-contact advanced ultrasonic inspection was proposed (laser ultrasonics, air-coupled UT) as well as other imaging techniques, such as infrared thermography and laser shearography. All these approaches were postulated with the aim of:

- avoiding/reducing human intervention
- reducing inspection time
- improving inspection quality by providing NDT data positioning and recording
- simplifying system automation, and
- providing processed data by means of image processing and data fusion, extracting automatically relevant information to support structural test follow up and associated decision making procedures.

A NDT demonstrator has been validated at subcomponent level (flat panels) and in a more realistic scenario (full scale cockpit mock-up).

2 SUMMARY DESCRIPTION OF THE PROJECT CONTEXT AND THE MAIN OBJECTIVES

Below, an exhaustive description of objectives within the project context is presented, as well as the achievements during the project related with them.

<u>Total test time reduction and saving in hours of human presence (NDT tests could run in the evening or whenever they are required):</u>

The system developed allows monitoring even during a whole weekend, as validated during the validation tests.

<u>Possibility of a very early detection:</u>

During the project different monitoring tasks have been performed successfully during structural tests over different specimens. In all of them there have been registers of failures of the specimen of different nature before the final failure. One of the Consortium proposals for industrialization in the future is to introduce an alarm during the precise moment when the indication appears. Management of these alarms could be a big improvement and need a precise specification of needs.

NDT Technologies for Composites:

There has been a huge amount of tests using different NDT techniques to inspect different composite specimens, in order to assess their pros and cons to be chosen for the implementation on the final system (around 172 inspections).

Principle of automation: automatic control of signals and sensors:

Remote control of NDT data acquisition systems

Data acquisition Hardware is setup, launching the inspection process as required and storing inspection data.

NDT records will be available through web.

The NDT system can be managed and controlled in a remote way, recording the data and being available through an IP network in a remote way.

Principle of automation: Autonomous scanning at concerned areas:

A compromise between total area inspected and achieved defect resolution is needed. It is recommended to avoid scanning because in general this is more time consuming that techniques directly based on imaging.

The NDT technique chosen to be integrated in the system is based on imaging, traditional scanning (as it is in UT NDT techniques) is avoided.

Principle of automation: Scan comparison with reference:

Passive IRT tests are continuously running. With regard to active IRT, the complete sequence of heating-cooling will be automatically launched and analysed, comparing between sequences from test to test. It is intended to process the NDT data.

The system developed has a tool that compares NDT registers based on imaging. The tool allows to compare two different images that can correspond to different NDT methods.

Principle of automation: Recording functionality in buffer storage capacity for at least 24 hours.

Recording functionality will be optimized for each NDT technique. Data processing will reduce the information of interest to the minimum for defect evolution follow-up. It is possible to generate rules in order to save only the thermograms that are giving useful information. If during IRT inspection from passive IRT is detected, the SW is capable of selecting the proper info to be sent to the control room.

An specific test during the Final Validation tests has been carried out consisting in monitoring during a whole weekend, and it has been successful.

It has to be remarked that after a proper assessment, it has been concluded that a Computer based device with the capabilities of real time processing and storing at the same time and in parallel would be out of the economic scope of the project.

In that sense, the possibility to store everything it is just dependable of the capabilities of an specific Workstation (it would be a matter of cost). Because of that, it has been validated the real-time monitoring, storing only the data corresponding to moments where relevant events have happened, and not storing all the information, but validating the real-time monitoring capability.

Principle of automation: interface through standard computer and commercial operative systems

An in service oriented application will be developed to build a 24 hours service where the data can be accessed through any network capable device with the adequate hardware and application.

This principle has been completely achieved, as the Server Side Software applications can be running 24 hours as a service. Any capable device, properly configured and with the Client Side applications installed, can access through an IP network to the services provided by the Server Side software.

All the software is running in standard computer and commercial operative systems.

Principle of automation: Portability and management by one person

The management of the integrated system is completely possible by one single person, once installed. The system is portable, it could be moved to a second structure with the same dimensions than the first structure. It will take time and cost (if specific devices for the second structure are demanded). The mechanical system is more complex that initially required in the proposal, and makes the final inspection system able to perform automated movements. The system is more complex, with many different devices and subsystems embedded, so the portability is possible, but needed to be performed by several people.

Applied to Structural Testing

This objective has been taken into account from the beginning of the project as one of the main objectives and as a prerequisite for the system to develop. It has been fully accomplished and validated during several tests.

On Line Results Transmission: service-oriented arquitecture (SOA) will be used in order to transmit results on real-time.

The integrated solution developed during the project is based on a client-server configuration, having the possibility to control and manage the system from a capable Hardware device connected to the same IP network than all the Server Side of the System, properly configured. It is possible as well to visualize and perform evaluations of the data being recorded from this remote device.

3 MAIN SCIENTIFIC AND TECNOLOGICAL RESULTS AND FOREGROUNDS

3.1 DEFINITION OF A SUITABLE NDT TECHNIQUE

During the first stage of the project, different NDT testing techniques were assessed, selecting the most suitable ones to be tested for the project targets. There was a deliverable intended for the purpose of presenting all the fundamentals of each technique, followed by different applications of them in the aerospace and other industrial sectors. The main advantages and constraints of each one were assessed as well.

The NDT techniques assessed as a first approach was as follows:

1. Infrared Thermography (IRT)
2. Laser Shearography (LS)
3. Ultrasound (UT)
    - Conventional Ultrasound
    - Phased Array Ultrasound
4. Air Coupled Ultrasound (AUT)
5. Laser Ultrasound (LUS)

The following tables gives an overview of the characteristics of the different NDT methods assessed, with ponderation factors from 1 (worst performance) to 3 (best performance).

	Non-contact	Inspection Speed	Not sensible to vibrations	Applicability to scheduled inspections	Cost of equipment	Set-up preparation
IRT	✓	3	3	✓	3	3
LS	✓	3	1	✓	2	3
UT		1	1	✓	2	1
AUT	✓	1	1	✓	2	1
LUS	✓	2	2	✓	1	1

Table 1. *Techniques characteristics as NDT method.*

	Delaminations/debondings	Level of porosity	Impact damage	Cracks	Flaw position along thickness	Monoli-thic	Sand-wich
IRT	✓		✓	✓		✓	✓
LS	✓		✓	✓			✓
UT	✓	✓	✓	✓	✓	✓	✓
AUT	✓	✓	✓	✓		✓	✓
LUS	✓	✓	✓	✓	✓	✓	✓

Table 2. *Defects detectability for the NDT methods considered*

	Defect positioning (depth)	Defect characterization (type of defect)	Defect sizing (area)	Defect sizing (thickness)
IRT	1,5	2	3	1
LS	1	2	2,5	1
UT	3	2	3	2
AUT	1	2	2	1
LUS	3	2	3	2

Table 3. *Defects positioning, characterization and sizing capabilities for the NDT methods considered*

After having a global vision of all the characteristics of the different techniques applicable to monitoring of structural test, some of them show a better combination of properties for industrialization of the monitoring process, having into account defects detectability, on-line and in-live measurements (inspection speed) and influence of environmental or test-related interference such as vibrations.

3.2 TRIALS WITH DIFFERENT NDT TECHNIQUES

Along with the previous theoretical assessment, based on the state of the art of different NDT techniques, there was an exhaustive tests battery over different small coupons making use of the most appropriate NDT techniques. The total amount of inspections was 172, and it could be summarize in the following table.

PART		CONCLUSIONS
CFRP CATEC woven composite plate (150x100 mm^2)		**Passive IRT**: Suitable method for monitoring mechanical tests as it is not affected by environmental vibrations. Damage (cracks and delaminations) evolution control and data post-processing available (damage cuantification) **Active (reflection mode) & UT**: complementary methods for defects characterization when structural tests are not running
EADS-CASA Impacted Panels	P3 P4 P7	**Active IRT (reflection mode)**: mechanical test has not been monitorized. Active IRT allows identify defects like impacts, delaminations and superficial elements
FIDAMC Panels	D01 D02 D03 D04 D05	**Active IRT (reflection and transmission modes)**: the configuration of this material and the technique applied allow identify defects such as wrinkles, gaps between fibers and abrupt superficial curvatures
MT-1 GRA cockpit Demonstrator		**Active IRT (reflection mode)**: These techniques applied to an actual aircraft structures shown the ability to detect the typical defects usually found after manufacturing and during mechanical tests. The defects are: gap between fibers, gap between tape lay-ups, lack of resin, delaminations, internal wrinkles in the laminate.

		UT: results are affected by surface roughness (difficult coupling) and shows high attenuation due to SMAC layers.
MT-1 GRA cockpit Demonstrator parts	(a) Door (b) Window (c) Section from nose top (d) Section from cabin bottom (e) Windshield (f) Section from landing gear zone (g) Section from nose bottom	**Active IRT** (reflection, transmission on selected parts): As the structures are similar to the previous part tested, the applicability is the same **Laser Shearography**: results similar to IRT but with influence of environmental vibrations so it can not be used for monitoring mechanical tests. **UT and AIR UT** on selected regions: Less sensible to detection of lack of resin and fiber gap (influence of surface finishing and attenuation due to SMAC). Also affected by external conditions.
Rigidized flat panels	2014-36-P02 FLHYB06	**Active IRT** (reflection mode) and **UT**: similar defects are found with both techniques but with more detail in the IRT inspection with these pameters.

Table 4: *Summary analysis of techniques applicability*

In view of these results the conclusion is, for the materials configurations and parts under study, that typical defects are detected in all cases by the majority of the methods. Air coupled ultrasonics might be a little behind in detectability for some types of defects. Other techniques characteristics to take into account are the sensibility, applicability, cost and difficulty of set up preparation. They are summarized in the next table:

	Detectability	Sensibility to external conditions (e.g. vibrations)	Applicability during monitoring (i.e. non contact)	Cost	Set up preparation
IRT	High	Low	✓	Low	Low
LS	High	High	✓	Medium	Low
UT	High	Medium		Medium	High
AUT	Medium	High		Medium	High

Table 5: *Techniques principal characteristics*

According with the initial theoretical assessment and related to the obtained results from the different inspected parts, infrared thermography complies with most of the detectability requirements. The technique is capable of identifying different types of indications like delaminations, macro voids, fibre gaps, lack of resin and induced damage, but limited for micro-porosity. On the other hand, the foreseen inspection system of the DiAAMond project is targeted to the monitoring and detection of damage evolution during mechanical testing. Micro-porosity is a consequence of the manufacturing process and analyzed previously by certified inspection protocols, and not appearing during static or fatigue testing, and its detection it is out of scope in the current project.

Other technologies such as ultrasonic methods and laser shearography depend more heavily on environmental conditions like vibrations during mechanical test. For this reason they are not the more convenient technique for monitoring operations.

Due to the possibility of performing easy inspection set-ups, the advantage of non-contact and reduced inspection times, infrared thermography makes possible the evaluation of large areas in very short processing times. Also this technique could perform live monitoring inspections in a wide range of materials configurations and structures like the available in the MT-1 cockpit demonstrator, as presented in this report, unfeasible for other NDT techniques under evaluation, and suitable for the detection of damage apparition and evaluation of its evolution. A wide variety of infrared cameras are available, and with different sensitivity to cost ratios. This last parameter can be adjusted for finding the most cost effective solution.

3.3 DESIGN AND DEVELOPENT OF THE SYSTEM

The following diagrams represents schematically the integrated system developed.

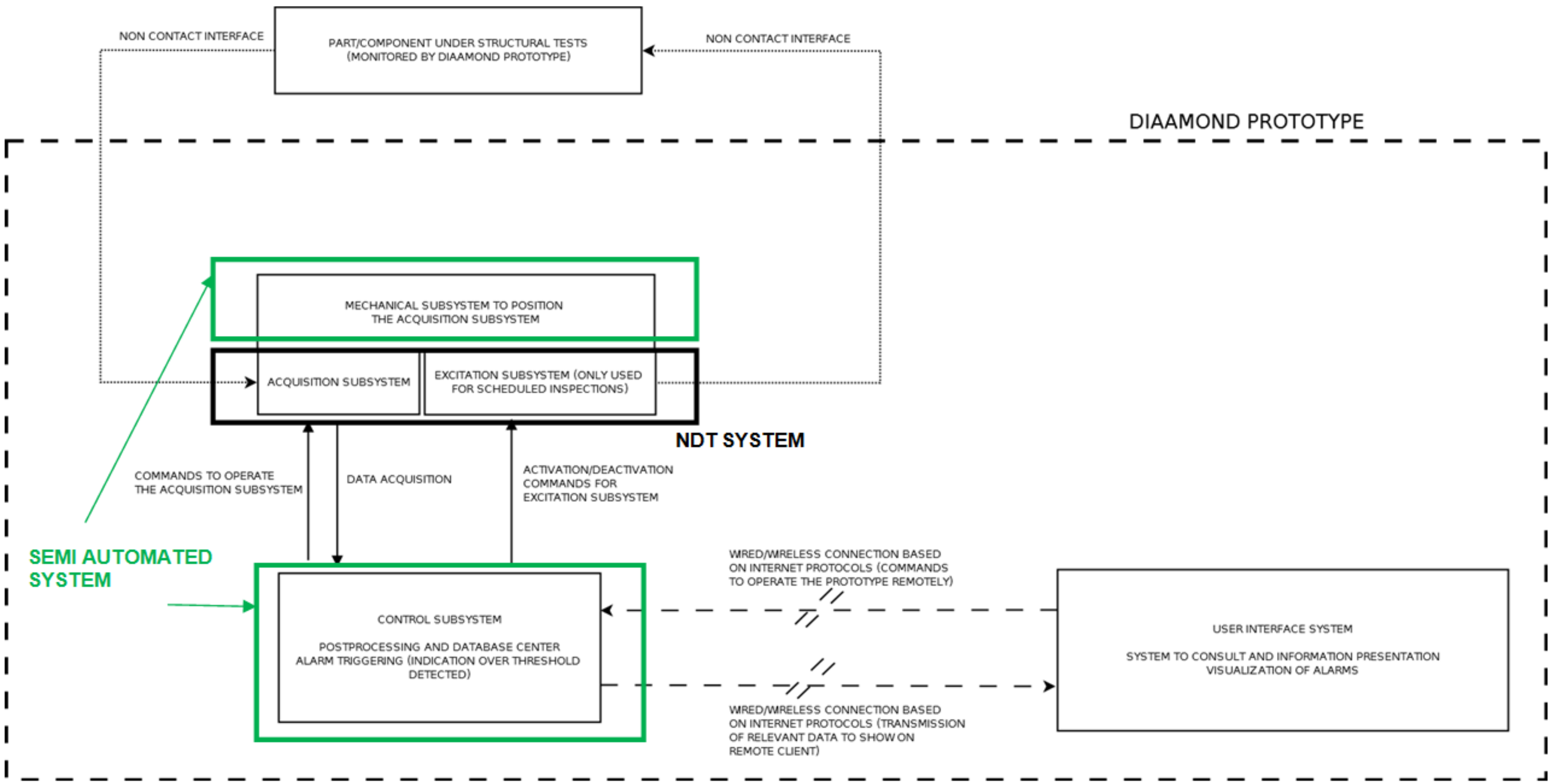


Figure 1: *Schematic Box Diagram of the DiAAMond Demonstrator*

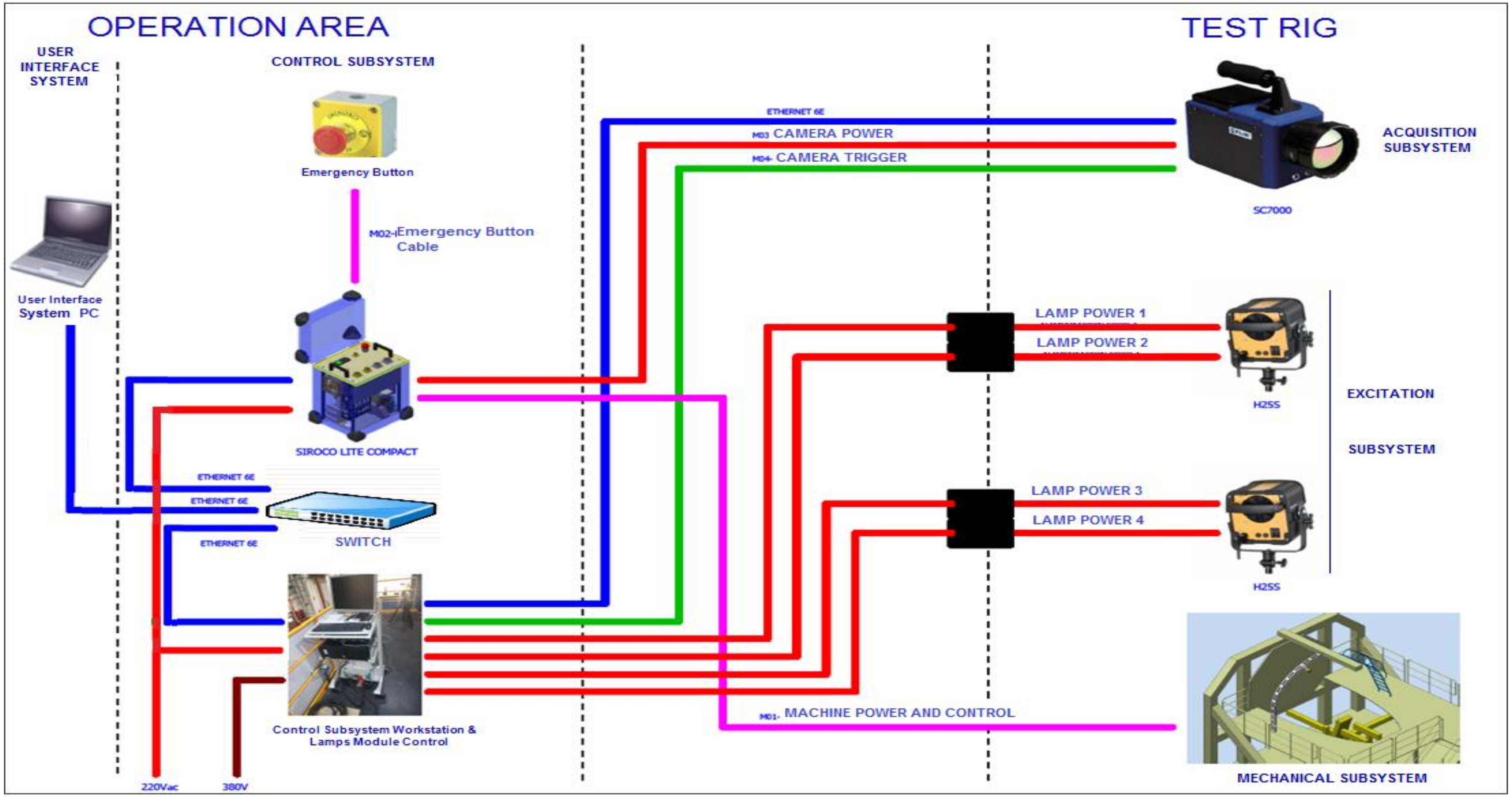


***Figure 2:** Wiring Diagram of the DiAAMond Prototype*

As it is showed in the images above, the Final Demonstrator is composed by the following subsystems:

3.3.1 NDT SYSTEM

Acquisition Subsystem:

The acquisition Subsystem will be based on a thermographic camera, specifically the model SC7600 of FLIR.

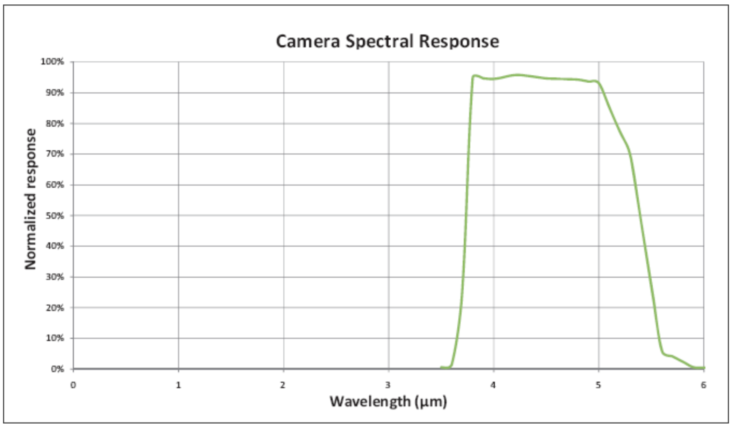


Figure 3: *FLIR Infrarred Camera*

Excitation Subsystem:

The excitation subsystem will be based on two halogen lamps used to stimulate thermally the specimen to test.

Figure 4: *Hedler H25s halogen lamps that forms the Excitation Subsystem*

3.3.2 SEMI AUTOMATED SYSTEM

<u>Mechanical Subsystem:</u>

It consists of an arc-shaped support along the perimeter of half of the cross-section of the cockpit.

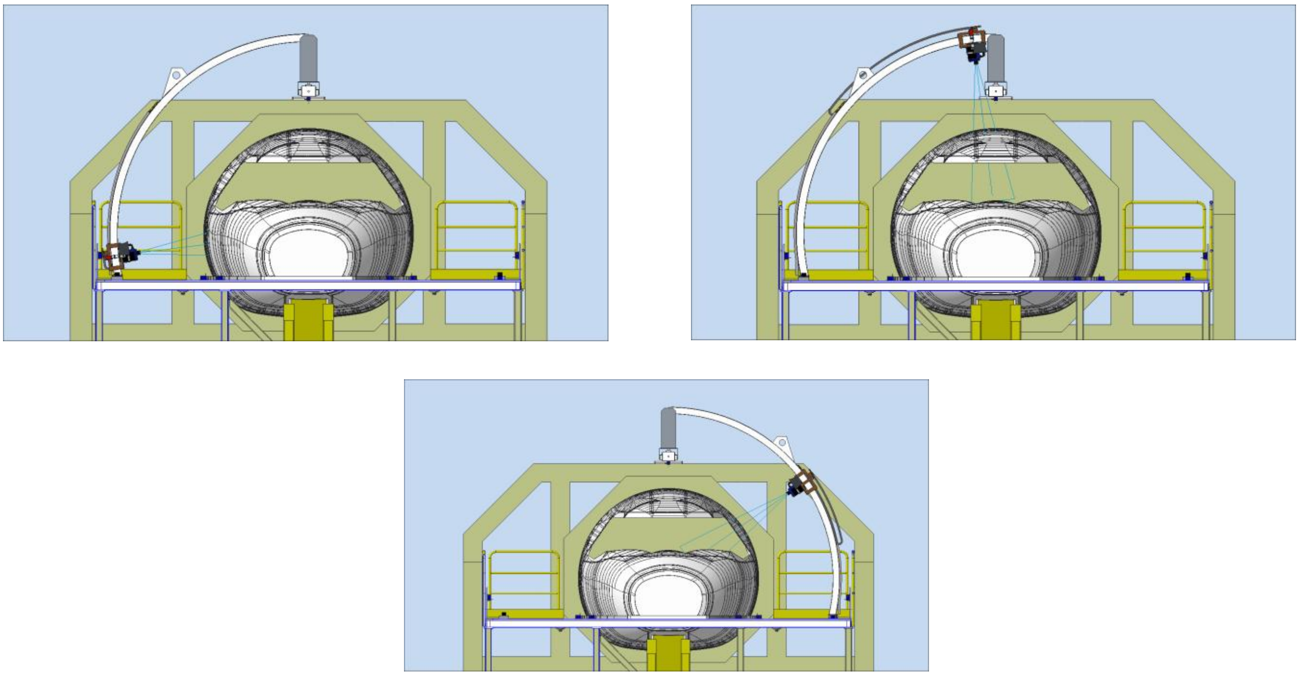


Figure 5: *Mechanical Subsystem installed at Test Rig*

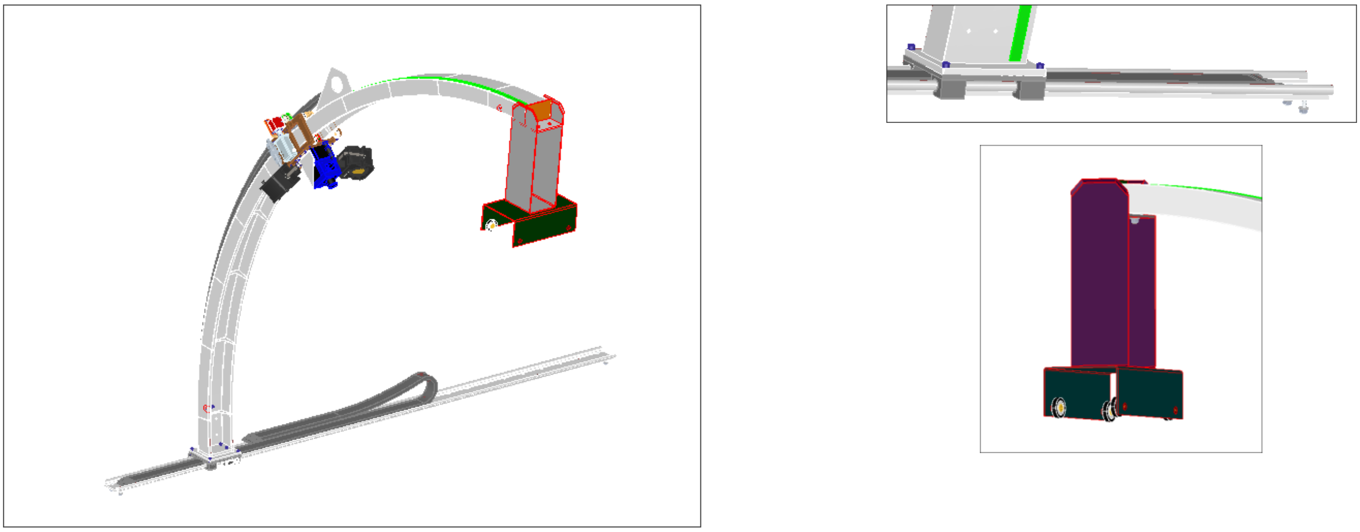


Figure 6: *Details of the Mechanical Subsystem: whole Subsystem (left), detail of the lower rail (up,)attachment to upper bar (down)*

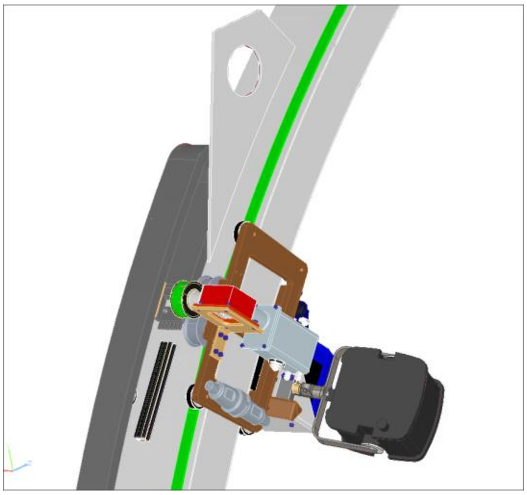


Figure 7: *Motor Box, Cable Guidance and Handle to be used with a Crane*

Control Subsystem:

This system is based in a Workstation (PC) running all the processing and server side software needed and a specific Hardware element in charge of the automated movements of the Mechanical Subsystem. This HW element is called Siroco Lite, and is the one in charge of command to the mechanical subsystem to move to a determined position, being controlled by specific software running on the Workstation.

The workstation will be running multiple softwares, dealing with:

- Recorded frames processing
- Specific Hardware responsible of the automated movements of the Mechanical Subsystem.

  In this context, the HW element would become responsible of command to the mechanical subsystem to move to a determined position, being controlled by specific software running on the Workstation.

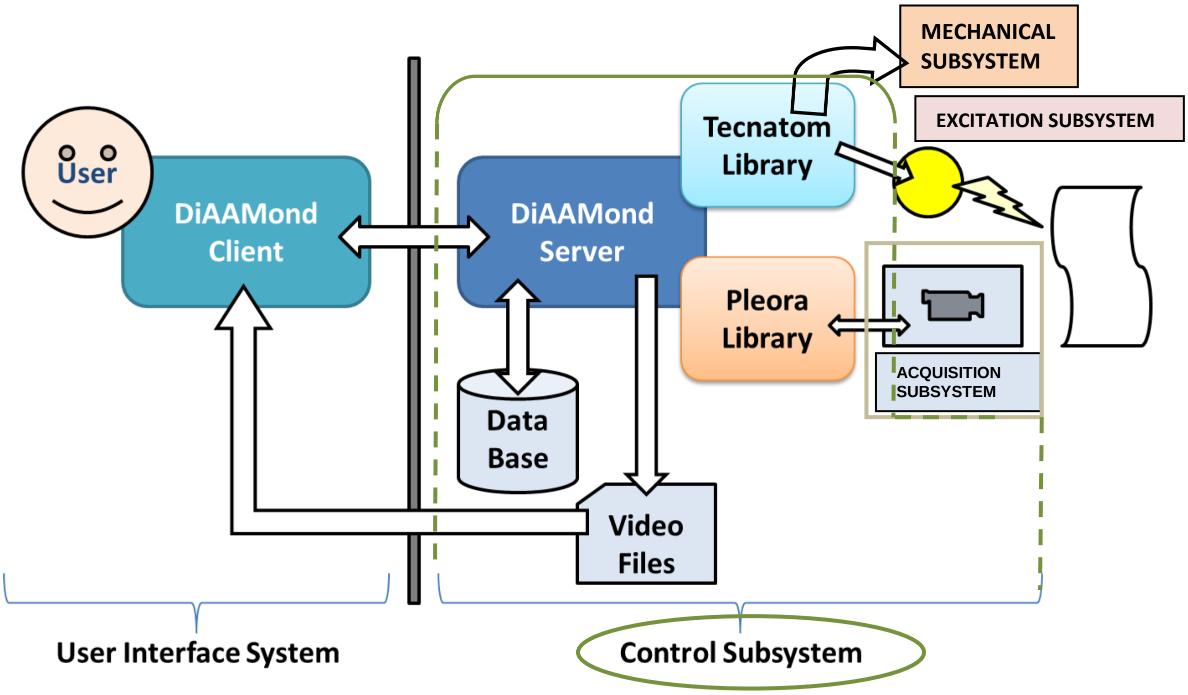


Figure 8: *Control Subsystem flow chart*

These two elements that form the Control Subsystem will be connected to each other through standard IP protocol, sharing a properly configured network. The connection will be performed through standard Gigabit Ethernet wiring and with the use of a Switch.

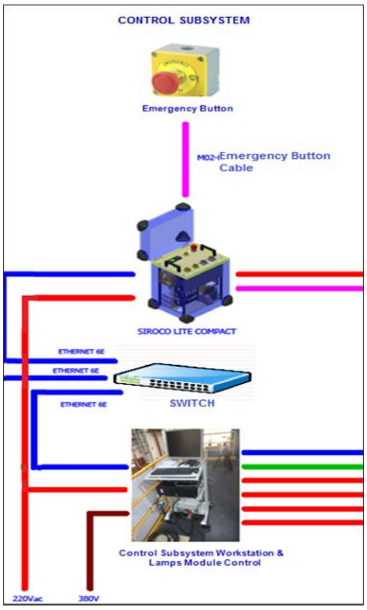


Figure 9: *Elements that forms the Control Subsystem and their wiring*

The software running in this Workstation will be in charge of the following algorithms:

- For damage on-line monitoring (Passive Inspections). In charge of getting and recording the most relevant events during the monitoring.
- For Active Thermography inspections, three algorithms are available to post-process the frames sequences acquired:
    - First Derivative
    - Second Derivative
    - Residue

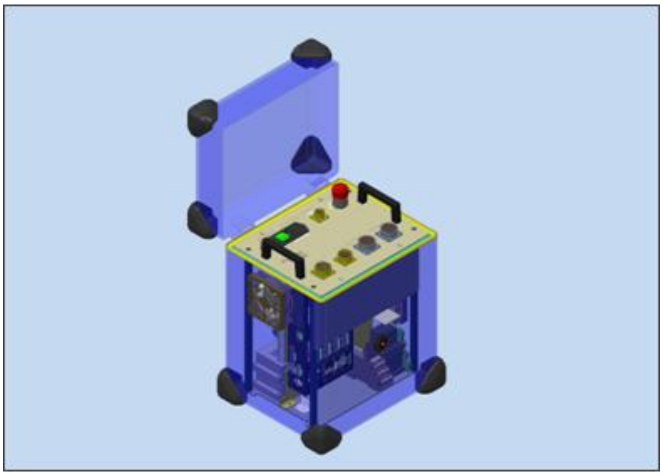
This Workstation running the processing and server side software applications will be connected as well with a standard USB cable to a module that is connected to a Power Source. This module will be lately the element activating/deactivating the Excitation Subsystem (lamps), controlled by the software running in the Workstation. This module can be seen at Figure 10.

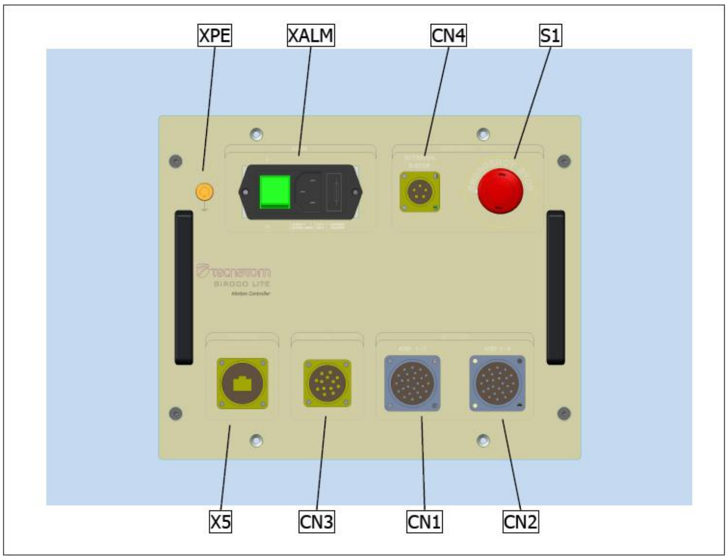
Figure 10: *Lamp module control (the unit in black)*

<u>Siroco Lite:</u>

This is the HW element that will be connected to the Mechanical Subsystem, and is in charge as well of their low level management, commanded by the server software running at the Workstation.

An overview of this element as well of their interfaces is shown at Figure 11.





- ***CN1***: machine power and control
- ***CN2***: FLIR camera power
- ***CN3***: Not used
- ***CN4***: remote emergency STOP
- ***S1***: emergency STOP
- ***XALM***: power inlet (220 Vac)
- ***XPE***: access to device ground
- ***X5***: Ethernet interface to connect to the Workstation

Figure 11: *Siroco Lite and their Interfaces*

This HW element has embedded an STOP Emergency button.

3.3.3 USER INTERFACE SYSTEM

The User Interface System is conceived as the set of elements modules and interfaces devoted to provide remotely required information in corresponding formats: video, pictures, graphics, text… of the elements being monitored.

It should account for specific software and hardware to carry out foreseen functionalities milking information being used remotely, also providing control commands into the different software modules of different subsystems to alter nominal monitoring procedures.

It will be the element in charge of running all the client side software, including all the user interfaces for remote operating the system, querying and evaluating data. The system should be based in all the software that is running from the client side. This software should be installed in a personal computer able to be connected to the same IP network than the Control Subsystem.The System should be located far from the area where the structural tests are performed, with the purpose of giving all the security measures to the human operator during the execution of the tests providing the operator the interface needed to schedule the tests and querying the results obtained.

Eventually for the final prototype, a personal computer should be used to run all these software and should be connected through wired Gigabit Ethernet connection to the Control Subsystem. A wired connection will be more robust and free of interferences. Such connection should be based in a standard IP connection that can be implemented in a wireless flavor as well.

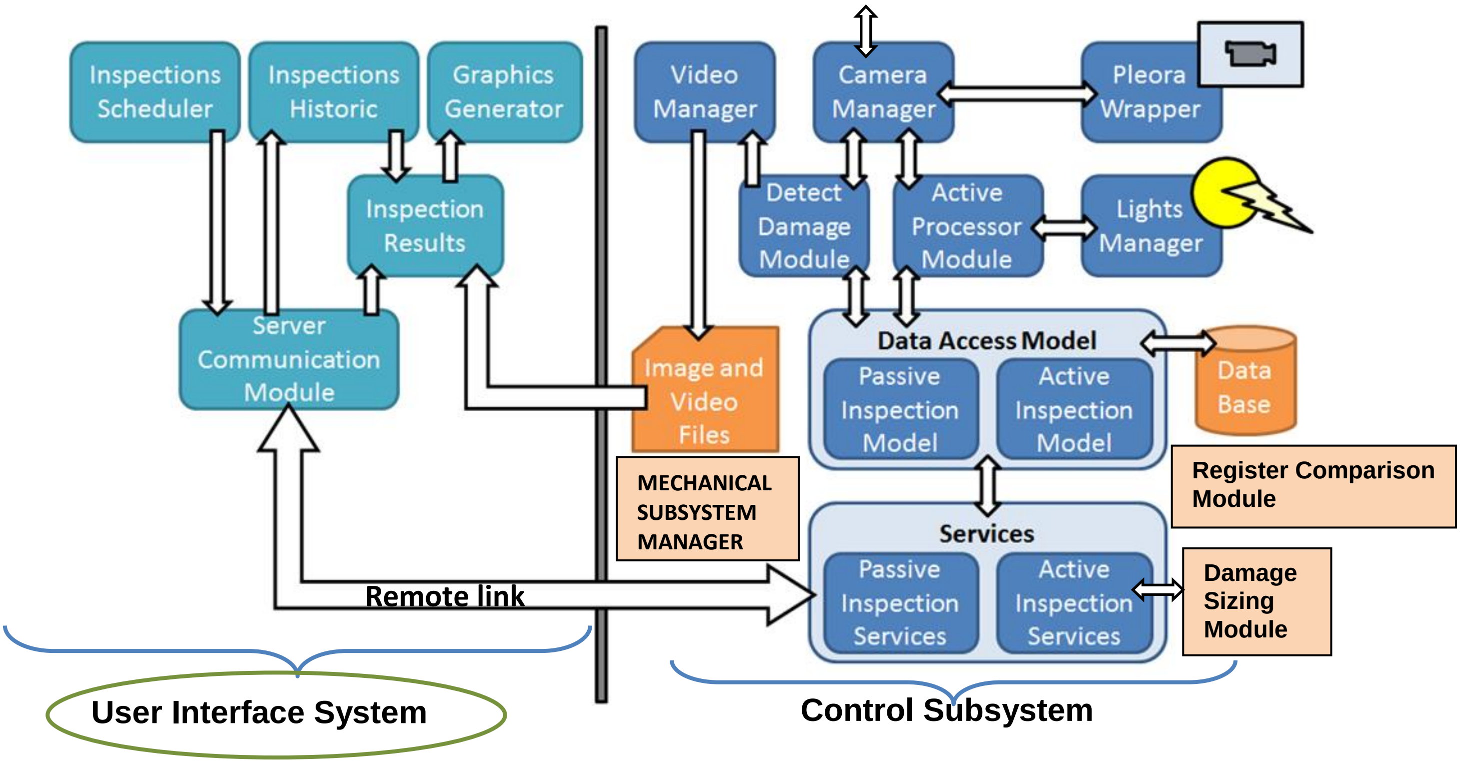


Figure 12: *User interface system flow chart*

Multiple types of functionalities should be considered implemented in this module as inherent result of the accessibility to the core of Control Subsystem services:

- Parameters of inspection control
- Scale-up images to real size
- Inspection data
- Damage comparison functionalities
- Compilation of a damage/defect set of data

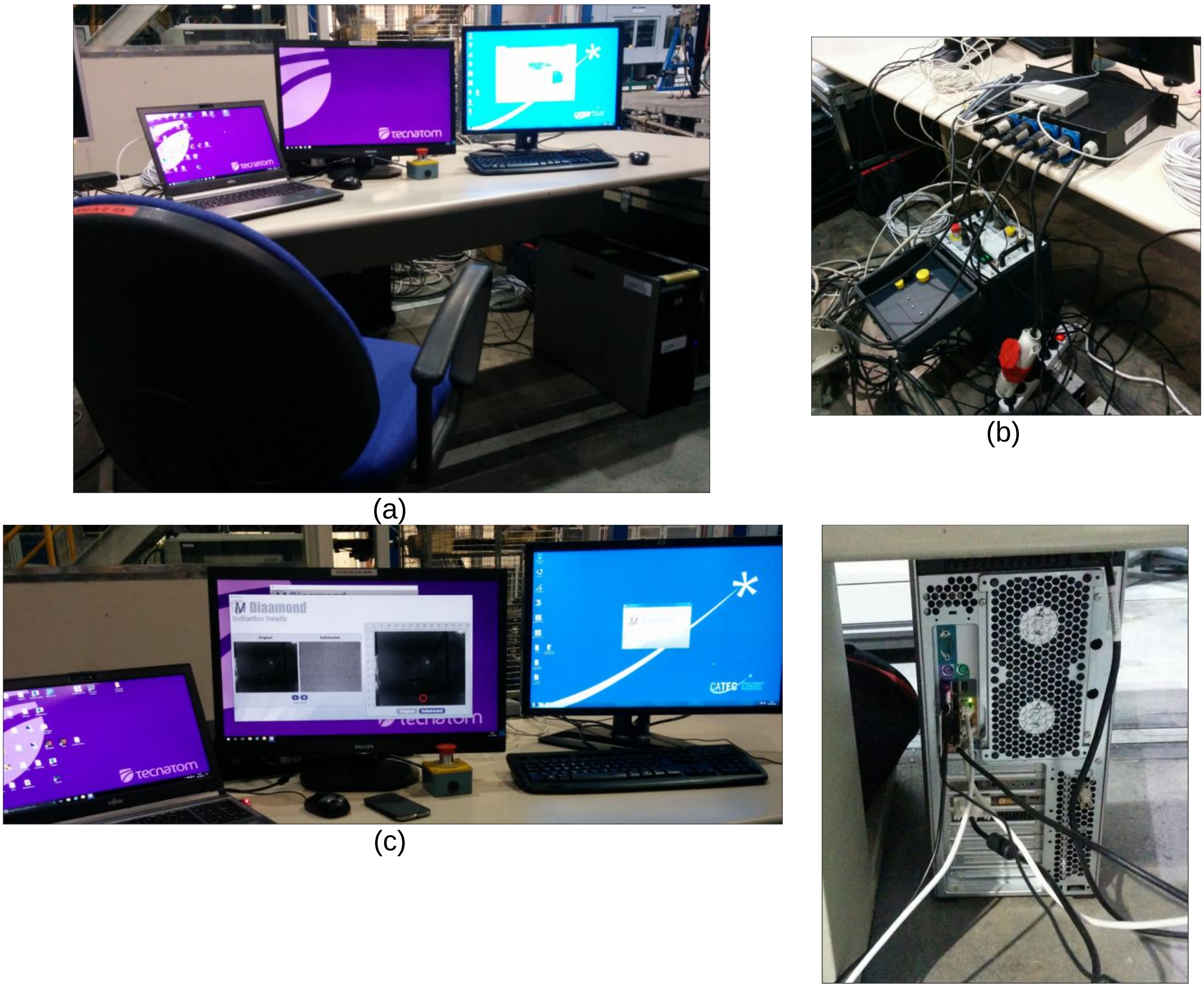
3.4 FINAL VALIDATION TESTS

At the last stage of the project, the Final Demonstrator described above was installed and validated at Topic Manager facilities during structural tests over a full scale cockpit mock-up.

At the following figures the Final Demonstrator it is shown installed there.

Figure 13. *Different views of the Mechanical Subsystem (supporting the NDT System) integrated with the test rig at Topic Manager facilities*

Figure 14. *Overall view of the test rig with the Mechanical Subsystem integrated on it, and the Operation Site where the different equipments to operate remotely the system are set.*



(a) (b) (c) (d)

Figure 15. *Different elements of the system at Operation Site: (a) Server Side and Client Side units to run the SW; (b) HW elements in charge of the automation of the NDT System and Mechanical Subsystem; (c) Visualization of IRT registers from client SW side (through IP network); (d) Workstation running the Server Side SW application*

3.5 SUMMARY OF FUNCTIONALITIES VALIDATION

As a result of the validations tests performed along the development of the Preliminary Prototype and Final Demonstrator, the following table is shown.

Functionality	Validated	Comments
NDT Monitoring during structural tests	Yes	It has been probed during various tests that when a damage it has been clearly produced, the system has detected it.
Real time monitoring of defects	Yes	When damage appears during a structural test, the system is able to detect it in the precise moment is appearing.
Remote Controlling of Acquisition Subsystem	Yes	The activation, working time, deactivation and framerate can be controlled remotely.
Heat source in order to thermally stimulate the specimen to perform Active Thermography Inspections	Yes	The excitation system has worked properly, and able to be controlled remotely.
Remote Controlling of Excitation Subsystem	Yes	Lamp power is fixed, the activation and excitation time can be controlled remotely.
Minor corrections of the Mechanical Subsystem (Manual)	Yes	A fully automated structure for the NDT system it was out of the scope and budget of the project. As a solution of compromise it was agreed to have an electromechanical device partially automated, partially manual. The manual movements have worked properly, as well as the minor corrections in the orientation of the lamps (excitation subsystem). The focusing of the camera it´s manually adjusted as well, as it´s a functionality that depends of the specific camera used. The use of a camera with the same characteristics of the one used with automatic focusing added, was out of the scope of the project, and would be a further improvement in the future.
Remote Controlling of the Mechanical Subsystem	Yes	A fully automated structure for the NDT system it was out of the scope and budget of the project. As a solution of compromise it was agreed to have an electromechanical device partially automated, partially manual. The automated movements have been worked properly, remote controlled and with variable speed (configured by the user).

Handling and processing of the Data	Yes	The system handles and processes correctly all the data acquired.
Validation of algorithms	Yes	Algorithms for monitoring have been validated, as the system is able to get only relevant information from the monitoring process, and it effectively gets the information when a clear damage has been produced. Indications produced during the monitoring process can be visualized and checked the moment of their apparition. Algorithms for postprocessing recordings using Active Thermography are easily accessibile from User Interface System and works properly.
Remote access to all the functionalities (except manual mechanical adjustments)	Yes	During the Final Validation Tests everything was managed and controlled from a computer running the User Interface System SW (Client Side of the SW architecture), with no problem. This computer was connected to the same IP network than the Workstation running the Control Subsystem SW (Server Side of the SW architecture).
Damage Information Accessibility	Yes	The user can access to all the previous passive and active inspections already performed, as well as create new inspections and schedule passive inspections (monitoring cycles) for the future. When monitoring, if there is an indication that is higher than a threshold, the system generates a video and generates a sequence of frames when performing active inspections. These functionalities work properly. During monitoring the system build cumulated damage charts that can be accessed and checked, and the user can perform the NDT evaluation (marking an indication), using the tools provided when performing Active Thermography. These functionalities work properly.
Mapping of the Inspection Area	Partially	The user has views of defect position according to cockpit plots that are integrated in software screen in order to track key position related with defect ID. The user associate the damage to be monitored/inspected at the moment of schedule/perform the inspection. The information is integrated in the software after the information provided by Topic Manager related with the impacts performed over the cockpit. After an Active Thermography is performed, the user will be able to able to use the scale-up tools to adapt the image to the real size of the element being inspected. After this calibration process, the user can use the tools provided to quantify a damaged area. This damaged area will be associated to a defect ID. Future lines of development would improve these tools and would ease the process to the user for uploading to the system

		new defect IDs information, as well as geometry specific information.
Data Visualization from User Interface	Yes	The user can access remotely to the videos generated when monitoring (passive thermography) and to the sequence of frames generated during active thermography.
Comparison of Defects with reference	Yes	There is a specific tool to perform comparison between NDT registers. The tool allows to the user to qualitatively compare two different image based registers. Tools to optimize and quantify the comparison can be improved and developed in the future.
Data Loading of Images for comparison	Yes	There is a specific tool to perform comparison between NDT registers. The tool allows to the user to qualitatively compare two different image based registers. Tools to optimize and quantify the comparison can be improved and developed in the future.
Definition of threshold values for damage index	Partially	At the moment, the system make use of thresholds to define when to get information during the monitoring process. A threshold at Active Thermography to decide the severity of a damage could be defined in further steps of development.
Evolution curves of Damage Index	Yes	The user has the possibility to check the evolution of a specific damage, and check useful information related with the structural test. The user fills this information at the moment of performing the active thermography. After a proper evaluation from the user at different moments, the user can check the evolution of this damage, and can export the information to a proper format to build evolution curves. Tools to optimize this functionality and to have it more integrated with the system can be developed in the future.

Table 6: *Validation results*

3.6 ENHANCEMENT FOR INDUSTRIALIZATION

Based on the final validation tests to check the functionalities of the Final Demonstrator and their limitations, an assessment for the improvement and industrialization of the system and technology has been performed.

4 DESCRIPTION OF THE POTENTIAL IMPACT

4.1 SOCIO-ECONOMIC IMPACT

The following lines detail the expected impacts stated at Description of Work of the proposal, as well as the results achieved at the end of the project.

Substitution of manual NDT inspection by an automatic process:

With the system developed, the Inspection process is launched and executed in a remote way, defining the parameters needed for the inspection and the time it will last.

The system provides the user to perform monitoring related inspections (during structural tests and in parallel with them) based on passive thermography, as well as scheduled inspections based in active thermography during stops of the structural tests.

Data storage optimization has been taken into account during the monitoring allowing to store only relevant information to the user.

Automated inspection with positioning recording:

The system is able to record and manage the acquired data. There are manual positioning tools integrated in the system that allows the user to position in a manual way. The automation of this process can be carried out in a further stage of development in the future.

There are as well tools to compare the NDT registers acquired with UT inspections with damage marked directly on the test article, in a qualitative way. More sophisticated tools in this sense can be developed in the future in a further stage of development.

Test time reduction:

The test time can be reduced in a high degree by the use of the system developed.

Early damage detection by menas of a larger number of NDT inspections and on-line access to processed data:

On line diagnosis is performed completely in automatic mode, giving to the user the possibility to analyze relevant data, because the system has embedded specific algorithms for filtering and lighting up data to be evaluated. The defect position and dimensioning are provided through different specific tools developed and integrated in the final system. These tools require user interaction to be performed completely. Other tools included in the software provide as well a comparison of NDT records. A complete set of software tools have been developed.

Tools to process NDT information (automatic evaluation) and decision making tools will be taken into account for further and future developments, where a very precise specification about customer requirements and tolerances has to be provided in advance.

Dimensions of the monitored area versus resolution:

The Final Demonstrator includes a solution of compromise in terms of mechanical devices to perform sensors displacements. This solution of compromise has a high level of automation taking into account the budget and the scope of the project.

Recommendations to improve the automation of the system and different possibilities for industrialization of the system are included in a specific report.

Application to aircraft production programmes:

The system is perfectly able to be used in aircraft production programmes.

Application to other industries that make an intensive use of composite materials:

The system is perfectly able to be used in industries related with composite materials.

4.2 MAIN DISSEMINATION ACTIVITIES

Two papers describing the work performed in the project were presented at AEND conference (Spanish Asociation of Non Destructive Testing National Congress) and NDT for Aerospace 2015 , Germany (organized by the German Asociation of NDT). This international congresses oriented to the international NDT industry and scientific comunity, were held in Seville-Spain during May 2015 and in Bremen-Germany during November 2015, respectively. There were oral presentations as well showing the tasks described at the papers.

4.3 EXPLOITATION OF RESULTS

Also, CATEC and TECNATOM have been participating on several talks with current/future customers within the aerospace industry, where results on DiAAMond project have been introduced for further exploitation. There have been as well general difussion notes on the web (CATEC/TECNATOM diffusion general routes but also external).