Brussels, 13 November 2018

COST 101/18

DECISION

Subject:	**Memorandum of Understanding for the implementation of the COST Action "Reliable roadmap for certification of bonded primary structures" (CERTBOND) CA18120**

The COST Member Countries and/or the COST Cooperating State will find attached the Memorandum of Understanding for the COST Action Reliable roadmap for certification of bonded primary structures approved by the Committee of Senior Officials through written procedure on 13 November 2018.

MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA18120
RELIABLE ROADMAP FOR CERTIFICATION OF BONDED PRIMARY STRUCTURES (CERTBOND)

The COST Member Countries and/or the COST Cooperating State, accepting the present Memorandum of Understanding (MoU) wish to undertake joint activities of mutual interest and declare their common intention to participate in the COST Action (the Action), referred to above and described in the Technical Annex of this MoU.

The Action will be carried out in accordance with the set of COST Implementation Rules approved by the Committee of Senior Officials (CSO), or any new document amending or replacing them:

a. "Rules for Participation in and Implementation of COST Activities" (COST 132/14 REV2);
b. "COST Action Proposal Submission, Evaluation, Selection and Approval" (COST 133/14 REV);
c. "COST Action Management, Monitoring and Final Assessment" (COST 134/14 REV2);
d. "COST International Cooperation and Specific Organisations Participation" (COST 135/14 REV).

The main aim and objective of the Action is to enable the implementation of composite bonded joints in primary structures (critical-load-bearing strutures). This will be achieved through the specific objectives detailed in the Technical Annex.

The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at EUR 68 million in 2018.

The MoU will enter into force once at least seven (7) COST Member Countries and/or COST Cooperating State have accepted it, and the corresponding Management Committee Members have been appointed, as described in the CSO Decision COST 134/14 REV2.

The COST Action will start from the date of the first Management Committee meeting and shall be implemented for a period of four (4) years, unless an extension is approved by the CSO following the procedure described in the CSO Decision COST 134/14 REV2.

TECHNICAL ANNEX

OVERVIEW

Summary

With the increasing pressure to meet unprecedented levels of eco-efficiency, aircraft industry aims for superlight structures and towards this aim, composites are replacing the conventional Aluminium.The same trend is being followed by civil, automotive, wind energy, naval and offshore industry, in which the combination (or replacement) of steel with composites can increase the strength-to-weight ratio. However, the joining design is not following this transition. Currently, composites are being assembled using fasteners. This represents a huge weight penalty for composites, since holes cut through the load carrying fibres and destroy the load path. Adhesive bonding is the most promising joining technology in terms of weight and performance. However, its lack of acceptance is limiting its application to secondary structures, whose failure is not detrimental for the structural safety. In primary (critical-load-bearing) structures, fasteners are always included along bondlines, as “back-up” in case the bond fails. The main reasons for this lack of acceptance are the limited knowledge of their key manufacturing parameters, non-destructive inspection techniques, damage tolerance methodology and reliable diagnosis and prognosis of their structural integrity. The Action aims to deliver a reliable roadmap for enabling certification of primary bonded composite structures. Despite the motivation being aircraft structures, which is believed to have the most demanding certification, it will directly involve other application fields in which similar needs are required. This Action will tackle the scientific challenges in the different stages of the life-cycle of a bonded structure through the synergy of multi-disciplinary fields and knowledge transfer.

Areas of Expertise Relevant for the Action	Keywords
● Mechanical engineering: Mechanical and manufacturing engineering (shaping, mounting, joining, separation) ● Mechanical engineering: Aerospace engineering ● Civil engineering: Civil engineering ● Materials engineering: Structural properties of materials	● adhesive bonding ● critical load bearing structures ● certification

Specific Objectives

To achieve the main objective described in this MoU, the following specific objectives shall be accomplished:

Research Coordination

● Develop common definitions on the topic, namely:
- Kissing bonds vs. weak bonds;
- Defects vs. Degradation;
- Prognosis of in-service life methodologies vs. design methodologies.

● Collect existing knowledge (state of the art) on the five areas of research: adhesive synthesization and interface bonding, design, manufacturing, in-service life and disassembly.

● Collect the requirements and needs of the stakeholders and certification agencies, in terms of regulations (REACH), materials, inspection techniques, testing, models and manufacturing tools.

● Define the main scientific and industrial challenges to put forward in upcoming Research and Technology activities.

● Coordinate and benchmark different test methodologies and models in each of the five fields.

● Define standard dataset for material data clustered for different application cases (analytical methods, numerical simulations, manufacturing parameters, etc.).

● Collect existing test data and create an open access data base (material properties, standard tests, etc.)

● Disseminate the knowledge to the researchers and stakeholders.

● Define, together with the European industry, researchers, academia and certification bodies, the improvements for the next generation of composite structures.

● Inform general public of the technology developments to alleviate mistrust in adhesive bonding.

Capacity Building

● Stimulate exchange of knowledge and a common research agenda around the topic bonded primary structures within the context of a roadmap to certification.

● Bridge distinct disciplines participating in the topic, such as material science, surface science, structural mechanics, design, physics, big data handling, and automation/robotics.

● Involve early career investigators, under-represented gender and countries less represented in the field of composite bonded structures.

TECHNICAL ANNEX

1. S&T EXCELLENCE

1.1. CHALLENGE

1.1.1. DESCRIPTION OF THE CHALLENGE (MAIN AIM)

The main aim of this Action is to enable the implementation of composite bonded joints in primary structures (critical-load-bearing structures). In order to achieve this, the Action will tackle the challenges related with the five stages of the life-cycle of a bonded structure: (1) Adhesive synthesization and interface bonding, (2) Design, (3) Manufacturing, (4) In-service life and (5) Disassembly. The main scientific challenges in each of the fields are:

(1) Adhesive synthesization and interface bonding:
   a. Develop new eco-friendly adhesives and surface treatments that fulfil the REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) European regulations.

(2) Design:
   a. Develop fail-safe design for bonded structures in aircraft by making use of damage arresting capabilities;
   b. Develop damage tolerance methodology for bonded structures;
   c. Define analytical and/or numerical methods for typical application scenarios of bonded joints – including the set of material properties and related test standards required for the analysis.

(3) Manufacturing:
   a. Define the key manufacturing parameters for ensuring the production quality of the bond strength on a large scale; develop online monitoring methods for control and recording of the manufacturing parameters;
   b. Assess the bond quality by non-destructive inspection; define suitable methods for different defect scenarios;
   c. Develop upscaling scenarios for automated bonding and relevant design adaptions to enable an automated bonding process.

(4) In-service life:
   a. Diagnosis and prognosis of the structural integrity of bonded structures under Environmental and Operational Conditions;
   b. Define guidelines towards bonded repairs application.

(5) Disassembly:
   a. Development of techniques that can efficiently disassemble bonded parts for repair and re-use purpose.

Bonded structures deal with very distinct fields – materials science, surface science, physics and structural mechanics. Moreover in order to achieve industrial progress, more disciplines have to be involved, such as automation and big data management. An inter-disciplinary approach is therefore needed to achieve breakthroughs on this topic.

Funded by the Horizon 2020 Framework Programme of the European Union

1.1.2. RELEVANCE AND TIMELINESS

With the increasing pressure to meet unprecedented levels of eco-efficiency, aircraft industry aims for superlight structures. Towards this aim, composites are replacing conventional Aluminium Alloys as the primary material used in aircraft. In service since January 2015, the Airbus A350 with more than 50% of its structural weight made of composites is the most recent testimony to this trend. There is also an increasing need for reducing weight in civil, automotive, wind energy, naval and offshore industry, in which the combination (or replacement) of steel with composites can increase the structures' strength-to-weight ratio.

However, the joining design is not up to date yet with this transition. Currently, composites are being assembled using bolts and fasteners, joining techniques developed for metals. This represents a huge weight penalty for composites, since holes cut through the load carrying fibres and destroy the load path. This mismatch between the use of new materials and traditional "metal-joining" techniques results in inefficient composite structures and leaves ample room for improvement.

Adhesive bonding is the most promising joining technology in terms of weight and performance. However, the lack of acceptance of adhesive bonding by certification authorities is limiting its application to secondary structures, whose failure is not detrimental for the structural safety. In primary (critical-load-bearing) structures, fasteners are always included along the bond-lines, as "back-up" in case the bond fails. This 'back-up' system deteriorates the joint's efficiency. In addition to this, there is an urgent need facing industry to introduce REACH-compliant pre-treatment processes and adhesive chemistries and eliminate (or replace) chemical components that can represent a hazard to both human health and environment (such as toxic Volatile Organic Compounds, VOCs, and Chromium).

It is estimated that the replacement of the current mechanical fasteners solutions by adhesively bonded joints in, for example, an aircraft such as A350 can reduce up to 10% of its structural weight. This weight reduction will help air transport to achieve its sustainability goals set for 2050: to decrease 75-90% greenhouse gas emissions while responding to traffic increase (45% in 2000-2010). Despite the main motivation being aircraft structures, which is believed to have the most demanding certification, this Action will directly address other application fields in which similar needs are required.

This Action aims to tackle the challenges of bonded structures from the design up to the end-of-life and, at the same time, pave the way to an eco-friendly implementation according to REACH regulations. This will allow a leap forward in the certification of bonded primary structures.

1.2. OBJECTIVES

1.2.1. RESEARCH COORDINATION OBJECTIVES

The research coordination objectives aim to synergize the dissociated groups/knowledge. These objectives are:

1. Develop common definitions on the topic, namely:
    - Kissing bonds vs. weak bonds;
    - Defects vs. Degradation;
    - Prognosis of in-service life methodologies vs. design methodologies.
2. Collect existing knowledge (state of the art) on the five areas of research: adhesive synthesization and interface bonding, design, manufacturing, in-service life and disassembly;
3. Collect the requirements and needs of the stakeholders and certification agencies, in terms of regulations (REACH), materials, inspection techniques, testing, models and manufacturing tools;
4. Define the main scientific and industrial challenges to put forward in upcoming Research and Technology activities;
5. Coordinate and benchmark different test methodologies and models in each of the five fields;
6. Define standard dataset for material data clustered for different application cases (analytical methods, numerical simulations, manufacturing parameters, etc.);
7. Collect existing test data and create an open access data base (material properties, standard tests, etc.);
8. Disseminate the knowledge to the researchers and stakeholders;
9. Define, together with the European industry, researchers, academia and certification bodies, the improvements for the next generation of composite structures;
10. Inform general public of the technology developments to alleviate mistrust in adhesive bonding.

The research coordination objectives will be tackled by the Working Groups (WG), and will be fulfilled by the corresponding deliverables – further described in section 3.

1.2.2. CAPACITY-BUILDING OBJECTIVES

The capacity-building objectives aim to build the critical mass needed to address the scientific challenge. These objectives are:

1. Stimulate exchange of knowledge and a common research agenda around the topic bonded primary structures within the context of a roadmap to certification;
2. Bridge distinct disciplines participating in the topic, such as material science, surface science, structural mechanics, design, physics, big data handling, and automation/robotics;
3. Involve early career investigators, under-represented gender and countries less represented in the field of composite bonded structures.

1.3. PROGRESS BEYOND THE STATE-OF-THE-ART AND INNOVATION POTENTIAL

1.3.1. DESCRIPTION OF THE STATE-OF-THE-ART

Adhesive bonding technology has been present in aircraft history since the late 1940's. Although it has shown its potential for several decades, its application as a joining technology and assembly method has always been limited to secondary parts of the aircraft.
Conventionally in metal aircrafts different parts of aluminium sheets are assembled using fasteners, namely rivets. Riveting is a joining technology that has been streamlined over the past decades. Recent developments in the automatization have made riveting economically attractive.
Nowadays aircraft manufacturers are increasingly using Carbon Fiber Reinforced Polymers as a light and robust replacement of aluminium. Riveting such composite materials has a lot of hazards, such as fibre breaking, stress concentrations, black dust, etc. Adhesive bonding is the most promising joining technology in terms of weight and performance for assembling composite parts. However, bonded joints without additional fasteners are only certified for assembling secondary structures of an aircraft, whose failure is not detrimental for aircraft safety. In comparison with metals, composites bring extra difficulties for bonding since the manufacturing processes use release agents which can lead to reduce adhesion strength that cannot be detected with the conventional non-destructive testing, such as ultrasound. Therefore, the current common practice in primary bonded structures is to include fasteners, which typically can carry the full limit load, along with the bonded systems, as "back-up" in case the bond fails.
This design practice is not limited to aircraft structures. In bridges, ships, oil-platforms, industries where composites are also gaining their share, it is common practice to include fasteners and/or anchorage systems due to lack of confidence in bonded joints.
In addition to this, some chemical components used in the application of adhesive bonding represent a hazard for both human health and environmental. Examples of this are isocyanates (VOCs), which are being used in the adhesive material synthesization, and chromates, used for guaranteeing a durable and effective surface treatment prior to bonding metals. However, both chemical components are among the current chemicals for which industrial users must find substitutes, or request authorisation from EU regulators to continue their use to be compliance with the strict REACH EU regulations.
This state-of-the-art hinders the full potential of bonded systems (uniform distribution and no stress concentration) and moreover, it does not diminish any of the hazards caused by drilling in composites. New alternatives are urgently needed to use the full potential of bonded systems in primary composite structures.

1.3.2. PROGRESS BEYOND THE STATE-OF-THE-ART

The implementation of bonded primary structures is the main driving force for the current research on the topic. This Action will enable a knowledge leap forward on the following areas:

(1) On the adhesive synthesization and interface bonding:
    a. Define material synthesization procedures and surface treatment procedures that fulfil REACH regulations.

(2) On the Design:
   a. Propose alternative design features to replace fasteners that do not hinder the performance of the adherends (no drilling, no stress concentration factors) but guarantee structure integrity in case of local weakbonds;
   b. Develop damage tolerance methodologies for bonded joints.

(3) On the Manufacturing:
   a. Define manufacturing process of adhesive bonding that guarantees its reliability and robustness on an industrial scale;
   b. Identify NDI processes that can detect different adhesion defects and have the potential to guarantee adhesion strength (or predict interfacial failure).

(4) On the In-service life:
   a. Develop methodologies for diagnosis and prognosis of the structural integrity of bonded joints under environmental and operational conditions;
   b. Understand the particularities of bonded repairs and overcome the challenges in service application in terms of contamination risk and variation of surface conditions after years of operation.

(5) On the Disassembly:
   a. Develop disassembly techniques to guarantee repairs and ensure end-of-life disassembly and separation.

The five topics mentioned above will be addressed within the five working groups (WG) of this Action. These WGs will bring together the researchers and stakeholders on each specific topic. One extra WG will be set-up for the certification, aiming to synergize the work of the remaining five WGs. The research being developed will result in meeting the above-mentioned challenges and pave the way for facilitating the certification process of adhesively bonded primary structures.

1.3.3. INNOVATION IN TACKLING THE CHALLENGE

One of the main innovative aspects of this Action is to tackle the challenge by synergising the research groups of different fields, the industry and their certification experts.
Despite the significant amount of research conducted in the field of bonded structures, the research is dispersed throughout different European groups (universities or Research institutes).
Up to now, most of the technology fields addressed in this Action (material science, design, manufacturing, in-service life and disassembly) have been investigated within relatively isolated research activities. However, the dissociated knowledge of those key technologies is not enough. The synergy is crucial for a concrete leap forward on the certification of composite bonded structures.
Moreover, industry often does not have a platform that connects them to the research and the other way around, researchers are often not aware of the specific requirements/limitations of the industry in this topic.
In terms of scientific and technological output, overcoming the addressed research challenges and aligning the European efforts will result in major innovations in the field, such as eco-friendly adhesives and surface treatments, reliable non-destructive inspection (NDI) techniques for different types of defects on the bondline, prediction models for specific applications, definition of realistic monitoring techniques in service and feasible disassembly techniques for repair and end-of-life solutions.
This holistic approach will help defining the set of industry requirements, align the research efforts and address the practical challenges of bonded structures.

1.4. ADDED VALUE OF NETWORKING

1.4.1. IN RELATION TO THE CHALLENGE

The field of adhesive bonding involves several disciplines. At the earlier stage of the technology, it involves the field of chemical and material engineering for development of the adhesive material and the field of surface engineering for the process of interfacial adhesion that allows the parts to join. Towards the implementation, structural engineering is involved for the design, sizing and certification towards the authorities. Finally, industrial engineering is involved for the definition of an industrial process. This process closes the circle to the chemical basics by ensuring the correct parameters in

accordance to the initial lab definition or defining the achievable chemical processes and avoids any critical deviation or contamination.
Often the communities of those disciplines participate in different networking activities (conferences, committee groups), have different peer reviews communities and hardly communicate with each other. This lack of synergy hinders and slows down the developments on this area of research.
For the next breakthrough in the adhesive bonding technology, it is necessary to have a fully integrated research and development, from the basic chemistry up to the final design and manufacturing. Only such a holistic development and suitable product design can provide the required reliability to be demonstrated for certification bodies.
This Action, as a holistic networking tool, is the best approach to tackle the challenge and make the synergy between these different fields possible.
The networking activities of this Action will also ensure the knowledge transfer from senior (expert) generation to future generations – Training schools and Workshops. This will avoid knowledge barriers in generations to come.
The involvement of industry, academia, research institutes and certification bodies will increase the knowledge transfer between these parties and speed up the increase in Technology Readiness Level (TRL) of innovations in this field. This is especially important for bonded structures because the manufacturing process is very specialized. Therefore, the up-scale of the technology has to be very well supported so that the quality is assured. This can only be done by close exchange of knowledge between the complete communities. This will avoid that in the future unexpected lower performance cannot be justified and therefore the acceptance of bonded structures is, again, put into play.
Finally, this Action will establish a platform across industries interested in the benefits of bonded structures (aircraft, automotive, civil, wind energy, naval, offshore, etc.).

1.4.2. IN RELATION TO EXISTING EFFORTS AT EUROPEAN AND/OR INTERNATIONAL LEVEL

The European efforts on the topic of this Action generally focus on one of the described challenges, covering a topic corresponding to one working group of this Action. Examples of this are:

- 2006-2009, Modular Joints for Composite Aircraft Components (MOJO), EC FP7;
- 2006-2009, Advanced Bonding Technologies for Aircraft Structures (ABiTAS), EC FP7;
- 2008-onwards, REACH implementation projects (RIPs);
- 2009-2013, Cost Effective Reinforcement of Fastener Areas in Composites (CERFAC), EC FP7;
- 2009-2013, Extended Non-Destructive Testing of Composite Bonds (ENCOMB), EC FP7;
- 2010-2012, Increase of the passive safety of cars for the protection of pedestrians by Crash Resistant Adhesive Bonding of attachments on Lacquered Surfaces (CRABLacS);
- 2012-2016, Boltless assembling Of Primary Aerospace Composite Structures (BOPCAS), EC FP7;
- 2012-2016, Validation of Large and Light Innovative Nacelle, CORAC EPICE VANILLE, French funding by Council for Civil Aeronautic Research.
- 2013-2017, Development of an innovative manufacturing process for the in-line coating of pultruded composites (COALINE);
- 2015-2018, Quality assurance concepts for adhesive bonding of aircraft composite structures by advanced NDT (ComBoNDT), EC H2020;
- 2015-2019, Non-destuctive evaluation of Bonding by Laser Shock Technology (FUI COMPOCHOC), Frech funding by the Unique Inter-ministerial Fund for applied research.
- 2016-2024, Development of innovative and ECO‐friendly airframe TECHnologies from design to manufacturing to improve aircraft life cycle environmental footprint (Eco-TECH), CleanSky2;
- 2016-2019, Reliable and Autonomous Monitoring system for Maritime Structures (RAMMS);
- 2016-2019, Technology transfer from between the aerospace and the automotive sector of assembling technologies (AEROCAR);
- 2016-2021, MANUNET-III: ERA-NET CO-FUND on Manufacturing technologies, H2020;
- 2017-2019, Titanium Composite Adhesive Joints (TICOAJO), CleanSly2;
- 2017-2020, QUALIFY: Enabling Qualification of Hybrid Structures for Lightweight and Safe Maritime Transport, Interreg.
- 2018-2021, Controlled Damaging by Symmetric Laser Shock Technology for NDT/SHM and Disassembly of Bonded Joint (FUI MONARQUE), Frech funding by the Unique Inter-ministerial Fund for applied research

However, up to now, there is no European network effort that combines those challenges in one single community. So far, no activity is known which covers a holistic approach for integration of the full bonding perimeter. This is the main asset of this Action and it is believed to be the key element to make a major breakthrough on the certification of composite bonded structures.

2. IMPACT

2.1. EXPECTED IMPACT

2.1.1. SHORT-TERM AND LONG-TERM SCIENTIFIC, TECHNOLOGICAL, AND/OR SOCIOECONOMIC IMPACTS

The impact of this Action is the direct consequence of enabling the efficient use of composite materials in large structures across several disciplines (such as aircraft, automotive, railway, civil and renewable energy industries), namely:

1. Technical level: increase the confidence on bonded structures. Improve the efficiency of composite structures, on a structural level and manufacturing level. On the short-term, directly after the certification of bonded joints, it allows the immediate implementation of bonded repairs in the operating (composite) aircraft fleets. On the long-term, it will enable new breakthrough design approaches for the next generation of composite structures;
2. Scientific level: this Action will contribute to bring the high strength-to-weight efficiency of composites from a material level to a fully integrated structural level (different composite parts joined together). On the long-term, this Action will increase the multi-disciplinary scientific knowledge on adhesive bonding technology, from chemistry to the final design and industrialization;
3. Socio-economic level: This Action will contribute to foster the construction of efficient light-weight structures. The expected up to 10% of weight reduction from current joining solutions to the proposed solution, will help to achieve the levels of eco-efficiency established to 2050 by the European Commission (reduce Green House gas emission). The reduction of fuel cost will also help to keep the European industry competitive and, possibly, increase employment in this sector. In addition to this, the development of eco-friendly adhesive materials and surface treatments will minimize the negative impact on human health and environment. The dissemination of the Action’s activities to the public, as for example via our YouTube channel and social media, will increase the awareness on this topic.

2.2. MEASURES TO MAXIMISE IMPACT

2.2.1. PLAN FOR INVOLVING THE MOST RELEVANT STAKEHOLDERS

The main stakeholders that will be involved in this Action are: (1) on an industrial level, the complete supply chain of the large European industry manufacturers, including adhesive material manufacturer, surface treatment companies, composite manufactures, and aircraft manufacturers (not only major industrial stakeholders but also Small Medium Enterprises, which are directly involved in the technology development); (2) on a research level, the universities and research institutes that aim for the application in bonded structures, which includes material science, surface science, structural mechanics and monitoring and across different disciplines (aerospace, civil, naval, offshore and wind energy), (3) and one certification body. Contact will be made with other certification bodies and large naval and civil industries during the Action through invitation for the Action workshops and meetings. The bench marketing of different test methodologies and models in each of the five scientific fields will maximize impact and promote stakeholder’s involvement.
The mentioned stakeholders will have key-roles in this Action, such as WG leaders. Furthermore, the stakeholders, who come from different European countries, will act as ambassadors on their local community by hosting meetings and in-house workshops giving the opportunity to the Action members (researchers, engineers, industry, etc.) to explore local resources and the further applicability of the Action’s outcomes to a higher technology readiness level.

2.2.2. DISSEMINATION AND/OR EXPLOITATION PLAN

The dissemination and exploitation activities will be performed as a continuous process with a timeline right from the beginning of the Action and will involve all partners. The Action will promote the Open Access of the results and outcomes generated by the activities of the Action and the protection of the Intellectual Property when needed. The guidelines to dissemination and exploitation will be agreed upon by the MC and released at the kick-off meeting.
A dissemination plan will be elaborated describing all activities to carry out during the Action, targeting different groups: general public, scientific community, stakeholders and relevant industrial sectors, certification bodies and national authorities.
The dissemination plan will include for the general public:

- A website where general information and activities about the Action will be available;
- Post activities of the Action in Social media, such as Twitter, LinkedIn and Facebook;
- YouTube channel: e-courses and interviews.

For the scientific community:

- Oral and poster presentations at national and international conferences (International Conference on Structural Adhesive Bonding, International/European Conference on Composite Materials, World Conference on Adhesion and Related Phenomena);
- Organisation of specific sessions on major composites and bonding related conferences;
- Joint papers for international peer reviewed journals (e.g. International Journal of Adhesives and Adhesion, Composite Structures, Journal of Materials Science, Surface and Coatings Technology);
- Open access data-base at DataVerse.nl and 4TU.nl (material properties, standard test results, manufacturing processes, NDI);
- Distribution of Action leaflets at national and international conferences.

For the stakeholders and relevant industrial sectors:

- Newsletters and press releases in aerospace/aeronautics and relevant journals and forums (such as Reinforced Plastics);
- Industrial seminars and workshops (such as JEC Composites, SAMPE - Society for the Advancement of Material and Process Engineering).

The open access data base will be hosted by DataVerse.nl, a dynamic online storage for research data during the COST Action and up to 10 years. Every participant will be given access to the data base to upload/download and modify data. Once the data is ready to be published as open access it will be transferred to 4TU.nl, with a respective DOI number. Major stakeholders will support the database and integrate it in their design process.

The MC will be responsible for the elaboration of the preliminary exploitation plans, summarizing the MCs' strategy and exploit the foreground generated by the Action. The plan(s) will schedule and co-ordinate innovation related activities within the respective WGs and will detail how to exploit Action's output in terms of R&D activities via European and national funding schemes.

2.3. POTENTIAL FOR INNOVATION VERSUS RISK LEVEL

2.3.1. POTENTIAL FOR SCIENTIFIC, TECHNOLOGICAL AND/OR SOCIOECONOMIC INNOVATION BREAKTHROUGHS

The development of a roadmap for certification of adhesively bonded primary structures requires the synergy of several scientific fields in a holistic perspective. This Action brings together experts working independently on addressing the challenges of their respective fields. The Action will build a collaborative framework that will benefit all involved parties to holistically view, address and meet the scientific challenges.
Potential scientific breakthroughs include the development of hazard free chemical products without compromising quality, deep understanding of interface bonding process manufacturing. Related to the design, the potential to understand how from a highly efficient material one can design highly efficient structures. Nowadays, composite materials are available and are solely very efficient in term of strength-to-weight ratio. However, when up-scaled to structures, the efficiency is immensely decreased.
In terms of technological breakthrough, the development of NDI techniques that might identify and predict adhesion defects at the interface would be the "holy grail" for the certification of composite

bonded structures. This will allow developing a framework between design models, NDI techniques and remaining useful life prediction models.
In terms of socio-economic breakthroughs, the use of REACH-compliant materials and highly efficient strength-to-weight large structures will increase the sustainability of future composite structures.
The Action is very ambitious, since many key scientific and technological breakthroughs are currently missing. Examples of this are Non-Destructive testing that can assess adhesion strength, damage arresting capabilities that do not hinder joint performance and methodologies for diagnosis and prognosis of the structural integrity of bonded joints. The separate success in each of these technologies would be a breakthrough in their specific field (manufacturing quality, design and in-service life, respectively). Despite the high risk, if the cross-disciplinary breakthroughs are achieved, the Action will achieve an historical milestone in the development of eco-efficient composite structures.

3. IMPLEMENTATION

3.1. DESCRIPTION OF THE WORK PLAN

3.1.1. DESCRIPTION OF WORKING GROUPS

In order to deal with the five main scientific challenges and meet the research coordination and capacity-building objectives, the Action is split into six WG; five WG dedicated to the five main scientific challenges and one WG to synergize the work of the previous five. The last WG is of major importance in order to achieve the certification of the bonded joints.
Common deliverables to all WGs will be the preparation of the state-of-the-art reports and the creation of a data-base containing types of materials and their mechanical properties, mechanical tests, manufacturing process and NDI techniques. It will be available at the website and it will be accessible to all partners, and when ready for publishing, to all public (open access). General IP principles will be discussed in the kick off meeting of this Action. The IP general policy resulting from this meeting will be followed by each partner joining the network. The data-base will be regularly updated during but also after the Action.
Due to the interdisciplinary nature of the Action, common activities to all WGs will be training schools and Short Term Scientific Missions (STSM). Training schools will focus on intensive courses for early stage investigators and students, who work on the same engineering field with the organizers of the school and want to excel in their field. STSMs will focus on the exchange of researchers and engineers between different disciplines in order to gain and synergize interdisciplinary knowledge, different generations to ensure knowledge transfer and different regions of Europe to succeed knowledge dissemination. The attendants of the training schools and STSMs will benefit from the existing knowledge for adhesive bonding technology and ensure the exchange of the 'know-how' between the different scientific groups and the development of a common research agenda. Young researchers, who will attend the training schools and STSMs, will pave the way to create new knowledge for adhesive bonding technology.
The workshops and training schools will be linked to the national and international meetings/conferences (such as, SAMPE, ECCM European Conference on Composite Materials and AB International Conference on Structural Adhesive Bonding), in order to maximize the impact across several industrial sectors. Research associations dealing with the wide spectrum of adhesive bonding will be invited to participate and disseminate the Action activities within their members.
At the end of the Action, an international conference will be organized where the final results will be presented to a broad scientific and technical community. The conference will be the paradigm for future reference.
The Steering Group (SG) and MC will meet at least once per year. The aim of these meetings is to assess the progress of the Action, to ensure that all objectives set are being met and that the activities reported are completed.
The Milestones of the Action will be presented at the end of the description of the WGs, in Table 1.

WG1: Adhesive and interface chemistry
This WG aims to align and cross-correlate the research and development programs of the members to come to REACH-compliant adhesive materials and interfacial bonding designs. This WG will gather experts in the field of material science, chemistry and interface bonding. The objective of this WG is to define material synthesization procedures and surface treatment procedures that fulfil REACH regulations.

This WG will perform the following tasks:

- Task 1.1: Evaluate current common practice in industry: adhesive chemistries and surface treatment processes for bonded joints.
- Task 1.2: Collect the requirements and needs of the stakeholders and certification agencies, in terms of regulations (REACH).
- Task 1.3: Propose novel non-toxic and environmentally friendly surface treatment processes and adhesive chemistries.
- Task 1.4: Evaluate the quality of the new proposed eco-friendly solutions.

Activities: The WG will meet if possible twice a year, for addressing the above-mentioned tasks. The WG will organize two Training Schools in order to provide intensive training on pre-treatment processes, on the physico-chemical surface states and adhesive chemistries. Part of the training will be a series of lectures given by industrial partners (adhesive manufacturers and surface pre-treatments) and academic experts (adhesive chemistry and surface science). The lectures will be recorded and be available as 'e-courses' on the website of the project and the YouTube channel. Invitations for the activities will be published on the website and will be disseminated to Action's peers.

Deliverables: The WG will deliver the content of the Training Schools (e-courses and state-of-the-art) in Year 1. Since the scientific community is highly interested in surface treatments, adhesive chemistries and their effect on interfacial adhesive performance and its degradation upon exposure to wet and aggressive environments, the WG will present the outcomes of the activities in international conferences and open-access publications.

WG2: Design phase

This WG will coordinate research related to the design of adhesively bonded composite structures taking into account geometrical configurations, new design features, fatigue and impact loading, creep phenomena, damage tolerance, imperfect bonding and environmental effects. Although considerable amount of work has been already performed by researchers who developed several design algorithms, there is no generally accepted model yet. The objective of the WG is to propose a universal progressive damage algorithm that incorporates the aforementioned parameters and complies with the engineering allowables and design rules. In order to meet this objective, the WG will perform the following tasks:

- Task 2.1. Explore new design concepts (geometrical configurations and new crack arresting design features).
- Task 2.2. Compare testing procedures for bondline characterization and models validation

(under static, fatigue and impact loading, creep phenomena, imperfect bonding and environmental effects).

- Task 2.3. Evaluate different design methodologies for the structural behaviour and progressive damage analysis of adhesively bonded structures.

Activities: The WG will meet if possible twice a year, for addressing the above-mentioned tasks. The WG will organize two Training Schools in order to provide intensive training on different design methodologies and progressive damage analysis of adhesively bonded composite structures. Part of the training will be a series of lectures by experts. The lectures will be recorded and be available as 'e-courses' on the website of the project and the YouTube channel. Invitations for the activities will be published on the website and will be disseminated to Action's peers.

Deliverables: The WG will deliver the content of the Training Schools (e-courses and state-of-the-art) in the 1st half of Year 1 and open-access publications concerning the tasks. In addition, a trade-off matrix for the different testing procedures and models for the bondline characterization will be delivered.

WG3: Manufacturing phase

This WG will align each member's efforts on establishing an optimal and robust manufacturing process for composite bonded structures. The objectives are to identify key manufacturing parameters and to implement a quality control strategy using destructive and non-destructive testing methods during the process.

The WG will undertake the following tasks:

- Task 3.1. Specify and select the key-parameters that influence the manufacturing process on an industrial scale.
- Task 3.2. Evaluate destructive and non-destructive testing for quality control of manufacturing process.
- Task 3.3. Propose novel embedded sensing solutions for the evaluation of adhesion strength.
- Task 3.4. Evaluate of the effect of different manufacturing defects on the bondline performance.

Activities: The WG will meet if possible twice a year for addressing the above mentioned tasks The WG will organize one Workshop in order to present the manufacturing process of bonded structures. The Workshop will target on Early Career Investigators and Engineers who will be acquainted with the different steps of the manufacturing process. The attendants will benefit by the participation of experienced technicians who will give practical insight of the manufacturing process. The activities of the Workshop will be recorded and will be made available as a training course on the website and the YouTube channel of the Action. STSMs will be promoted and the participants will have the opportunity to learn manufacturing techniques and to operate non-destructive testing instruments that are not available in their own institute/university/company. The WG will prepare guidelines for the applicants, which will be made available within the first 2 months of the Action.

Deliverables: The WG will deliver the content of the Training Schools (e-courses and state-of-the-art). Publications will be available on the key manufacturing parameters for the manufacturing process. A data-base of recommended tests for guaranteeing a robust manufacturing process will also be delivered – data base access will follow the general IP policy of this Action. Finally, this WG will deliver guidelines for the manufacturing process of adhesively bonded composite structures.

WG4: In-service life phase

This WG will coordinate research related to the in-service life monitoring of bonded structures, including bonded repairs. This WG will gather experts from the field of non-destructive testing (NDT) and structural health monitoring (SHM). The WG objective is to assist the development of a holistic approach that incorporates diagnostic and prognostic tools for the structural integrity and the remaining useful life of the structure, respectively. WG3 will work closely with WG1 and WG2 and will benefit from the outcomes that these two WG will produce. The WG3 will perform the following tasks:

- Task 4.1. Propose diagnostic tools for the structural integrity assessment of the bonded structure.
- Task 4.2. Propose prognostic tools for the remaining useful life of the bonded structure.
- Task 4.3. Develop guidelines towards bonded repairs application.

Activities: The WG will meet if possible twice a year, for addressing the above mentioned tasks. The WG will organize an event, as a continuous learning process, which will consist of two Training Schools and STSMs. In the first Training School, the fundamentals of the diagnostic process will be presented (non-destructive evaluation and structural health monitoring). After that, STSMs will follow and the attendants will develop, with the guidance of experts, case studies for bonded composite structures on how to develop prognostic methods integrating the diagnostic tools with the design methodologies. The second Training School will be divided in two modules. In the first module, the STSM participants will present their cases studies, as peer-to-peer learning process. In the second module, the particularities of the bonded repair application will be presented. The WG will organize the Training Schools and STSMs.

Deliverables: The WG will deliver the content of the Training Schools (e-courses and state-of-the-art) and STSMs (report of case studies). Guidelines on the tools about diagnostics and prognostics and bonded repairs will be delivered. As the interest from the scientific community about health monitoring of bonded structures is very high, the WG will present the outcomes of the activities in international conferences and open-access publications.

WG5: Disassembly phase

This WG will be concerned with the research related to the joint disassembly procedure for repair and re-use purposes. The objective is to identify and propose a technology that efficiently disassembles bonded parts without damaging them. This technology will be introduced in the case of flaws detection in the manufacturing phase, in case of damage that can be repaired in the in-service phase and in order to re-use parts in the end-life of the product. The WG will perform the following tasks:

- Task 5.1. Description of the state-of-the-art about disassembly technologies.
- Task 5.2. Evaluation of the technologies and selection of the most promising technology.

Activities: The WG will meet if possible twice a year, for addressing the above mentioned tasks The WG will organize a Training School in which the disassembly technologies will be explored. In parallel, as the disassembly procedure of adhesively bonded parts is not well-known, emphasis will be given to STSMs where the participants will have the opportunity to gain deep knowledge on that field and disseminate the 'know-how' on the scientific community.

Deliverables: The output of the WGs will be reported by participating in international conferences and publication in peer-reviewed journals. In addition to this, the WG will deliver the program of the Training School and will prepare the descriptions of the STSMs.

WG6: Certification

This WG will focus on the certification process of bonded primary aircraft structures. Stakeholders will guide the efforts and together with the rest of the MC and WG leaders will determine the steps towards obtaining the certification. The objective of this WG is to ensure the collaboration between the WG1-5 and integrate their outcomes so as to facilitate the certification process.

- Task 6.1: Define common nomenclature for all WG's activities and deliverables.
- Task 6.2. Integrate the outcomes and build the roadmap.
- Task 6.3. Establish contact with relevant certification bodies and large industry manufacturers in naval, civil, offshore, automotive and wind energy and disseminate the progress of the Action and the roadmap.

Activities: The WG will organize a series of meetings with the certification agencies and between the WG leaders. The aim is to inform and update the activities of the WG and the progress of the Action, and at the same time to receive feedback from the certification agencies on those activities.

Deliverables: List of common nomenclature for all WG's activities and deliverables.
During the Action the WG will deliver the minutes of the meetings to the rest of partners. At the end of the Action the WG will deliver a publication with the proposal roadmap towards certification of composite bonded structures.

Table 1. Summary of the Action's milestones

Milestones		YEAR1				YEAR2				YEAR3				YEAR4			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Common Milestones	Kick-off meeting	M															
	Data base			M													
	International Conference																M
	MC & WG meetings			M		M		M		M		M		M		M	
WG1	Evaluation of common practices				M												
	Requirements for REACH regulations						M										
	Eco-friendly adhesives & surface treatment												M				
	Training School					M						M					
WG2	New desing concepts							M									
	Comparison of testing procedures										M						
	Evaluation of design methodologies												M				
	Training School					M						M					
WG3	Key-manufacturing parameters				M												
	Quality control of manufacturing process								M								
	Novel embedded solutions										M						
	Effect of defects												M				
	Workshop					M						M					
	STSM					M						M					
WG4	Diagnosis								M								
	Prognosis								M								
	Proposition of a hollistic approach												M				
	Training School					M							M				
	STSM						M			M			M				
WG5	State-of-the-art				M												
	Evaluation of the Dissasemply technology												M				
	Training School					M											
	STSM						M			M			M				
WG6	Definition of nomenclature	M															
	Roadmap														M		
	Presentation of roadmap																M

3.1.2. GANTT DIAGRAM

The GANTT Diagram of the Action is presented below.

Roadmap		YEAR1				YEAR2				YEAR3				YEAR4			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Common Activities & Deliverables	State-of-the-art				D												
	Data base			D				D				D				D	
	(Inter)national Conference					C						C					C
	MC & WG meetings	M		M		M		M		M		M		M		M	
WG1	Task 1.1																
	Task 1.2																
	Task 1.3																
	Task 1.4																
	Activities						T1					T2					
	Deliverables				D1												
WG2	Task 2.1																
	Task 2.2																
	Task 2.3																
	Activities					T1						T2					
	Deliverables		D1										D2				
WG3	Task 3.1																
	Task 3.2																
	Task 3.3																
	Task 3.4																
	Activities					W1/S1		S2		S3		W2/S4					
	Deliverables		D1							D2			D3				
WG4	Task 4.1																
	Task 4.2																
	Task 4.3																
	Activities					T1		S1			S2		T2				
	Deliverables		D1		D2								D3				
WG5	Task 5.1																
	Task 5.2																
	Activities					T1	S1		S2		S3		S4				
	Deliverables				D1								D2				
WG6	Task 6.1																
	Task 6.2																
	Task 6.3																
	Activities																
	Deliverables		D1		D2		D3		D4		D5		D6		D7		D8

Legend	
C	Conference
D	Deliverable
M	Meetings of MC, WGs & SG
S	STSM
T	Training Schools
W	Workshop

3.1.3. PERT CHART (OPTIONAL)

3.1.4. RISK AND CONTINGENCY PLANS

The main risk related to the Work Plan is the insufficient interaction and limited exchange of knowledge between the WGs. In order to mitigate this risk, the MC and SG will oversee the progress of each WG activities and ensure the highest interaction by organizing the regular WGs meeting at the same time and location with MC and SG and creating a forum in the website where the partners can exchange information and pose question during the entire duration of the Action.

Training schools and STSMs are core activities and play an important role in the implementation of the Work Plan. Another risk is the low attendance in these activities. For example, in the STSMs of the WG4, attendees will develop case studies on how to design structural health monitoring strategies and will present them in a follow-up Training School. In case few attendees will participate in these STSMs and few (or no) case studies will be developed, the WG4 partners will propose the case studies for the follow-up Training School.

On the technical level, the risk is related with high challenging tasks of this Action, such as, REACH-compliant materials, NDI to assess adhesion strength, damage arresting capabilities and

methodologies for diagnosis and prognosis of structural integrity of bonded joints. In case the technology leap is not achieved, alternative ways to enable the certification of bonded joints will be studied. For example, if full bonded joints are not certifiable, existing and new disbond stopping features will be studied. Possible alternatives on a technical level are topology optimization of rivets (minimizing the number of rivets instead of removing all from the bondline), surface modification of the composite adherend (thermoplastic inserts can decrease the crack growth in the bondline), micro pin connection or nano-reinforced adhesives with damage arresting capabilities. In terms of REACH implementation, the major challenge is to maintain the quality of the materials and surfaces without using the toxic components. In the case this is not reached, a balance will have to be achieved between the quality requirements and the components allowed to be in use.
In parallel, to address scientific challenges that might not be achieved during this Action, the network will stimulate these topics in the research agenda of main subsidiary agencies in European and national level.

3.2. MANAGEMENT STRUCTURES AND PROCEDURES

The organization of the Action will follow a structure as outlined in the 'Rules and Procedures for Implementing COST Actions'. The working plan is for four years and is designed in such a way in order to meet the scientific objectives of the Action and at the same time to disseminate the activities and present the results across Europe to several target groups.
The activities of this Action will be monitored by the Management Committee (MC). The Chair and the Vice-Chair of the MC and the WGs leaders will be elected at the kick-off meeting. A project manager will be appointed for supporting the Chair and Vice-Chair on the administrative tasks. Chair, Vice-Chair and WGs leaders' nominations of early stage researchers will be encouraged and balanced between research institutions and industry. This core team will form the Steering Group (SG) which will oversee the activities of the Action, review the progress of the WGs and report the results to the MC. The Vice-Chair will serve also as Communication Manager within the SG and will ensure the flow of information between the participants of the Action to ensure the timely and successful achievement of the objectives. Training schools and STSMs coordinators will be elected also at the kick off meeting.

The MC and SG will meet if possible twice a year in order to assess the progress of the Action, ensure that the Action objectives are met and that the activities are completed. In addition, the SG can have e-meetings in order to deal with urgent issues. The meetings of the MC, SG, WGs will take place in a different place among the COST Member Countries and when possible alongside major events such as scientific conferences. Emphasis will be given to strategic places, i.e. close to stakeholders' business locations and certification agencies, and to the inclusiveness target countries that participate in this Action.
A Collaboration Coordinator will be selected from the MC to foster collaboration between different working groups in cooperation with WG leaders and manage knowledge transfer and homogenization. The Collaboration between different groups will be supported by common data base which is accessible by all partners and common dates for WG's meetings.
A Database Coordinator will be selected from the MC to continuously report the content of the data base (topics, themes, etc.) and evaluate the shortcoming and further requirements during the Action.

3.3. NETWORK AS A WHOLE

At the proposal stage, the Action has been able to gather many experts from universities, research institutes, major industrial stakeholders and SMEs across 18 European countries, including 7 inclusiveness target countries. Due to the interdisciplinary nature of the Action, the dissemination plan, as it is stated in section 2.2.2, will promote the activities to a broader scientific platform in order to attract experts from several disciplines who will strengthen the synergy (47% Mechanical Engineering, 27% Material Engineering, 8% Chemical Engineering, 5% Civil Engineering and 13% others). Finally, the network of proposers consists of:

- 70% male and 30% female;
- 55% early career investigators;
- 66% Academia, 17% Industry, 13% Governmental Organisations including certification bodies and 4% of Non-profit institutions