COST
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Brussels, 27 May 2022

COST 069/22

DECISION

Subject:	Memorandum of Understanding for the implementation of the COST Action “Advanced Composites under HIgh STRAin raTEs loading: a route to certification-by-analysis” (HISTRATE) CA21155

The COST Member Countries will find attached the Memorandum of Understanding for the COST Action Advanced Composites under HIgh STRAin raTEs loading: a route to certification-by-analysis approved by the Committee of Senior Officials through written procedure on 27 May 2022.

MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA21155
ADVANCED COMPOSITES UNDER HIGH STRAIN RATES LOADING: A ROUTE TO CERTIFICATION-BY-ANALYSIS (HISTRATE)

The COST Members through 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, 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 document amending or replacing them.

The main aim and objective of the Action is to establish the scientific and technological (S&T) foundations for the creation and implementation of a reliable and robust framework for the certification by analysis of advanced composite load-bearing structures subject to high strain rate loading. This will be achieved through the specific objectives detailed in the Technical Annex.

The present MoU enters into force on the date of the approval of the COST Action by the CSO.

OVERVIEW

Summary

Climate change challenges have driven an ever-increasing use of composite materials, including hybrid and metamaterials, in structures prone to extreme dynamic events. HISTRATE aims to lay the scientific and technological foundations for the creation and implementation of a robust framework for the certification-by-analysis of advanced composite structures subject to high strain rate loading, e.g., impact and blast. A paradigm shift in simulation comprehensiveness, high strain rate testing protocols and smart sensing tools is needed to replace the complex, laborious building block approach for validation and product certification with approaches based on simulations which require less tests. In this way, composition and performance adjustments should be allowed without recertification.

Realisation of this aim heavily relies on knowledge available within the HISTRATE network, which now gathers 80 European and non-European, academic and industrial experts active in the wide field of composites. HISTRATE will strongly encourage interaction between the partners by stimulating the exchange and cross-fertilisation of knowledge both across industrial sectors and expertise fields, including material and component testing, measurement and monitoring techniques, modelling methodologies, standardisation and certification. By combining the available knowledge on high strain rate response at different length scales, i.e., from the material constituents to the structure, HISTRATE will radically transform the way we discover, develop, and design ultra-high-performance, durable, safe, sustainable, and novel advanced composites for use in real high strain rate loading applications.

The participation of leading actors in the field provides the basis and impetus for the adaptation of this new approach in industry.

Areas of Expertise Relevant for the Action	Keywords
● Materials engineering: Characterization methods of materials for material engineering applications ● Materials engineering: Structural properties of materials ● Materials engineering: New materials: oxides, alloys, composite, organic-inorganic hybrid	● composites ● high strain rate loading ● certification ● testing ● modeling

Specific Objectives

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

Research Coordination

● 1. Establish and improve semantic interoperability to develop a common “language” between various technologies/tools/methods adopted in the different industrial fields involved in HISTRATE.

● 2. Gather the state-of-the-art in the following science and technology fields for the design of safety-critical structures under high dynamic loading and composite/hybrid structures: dynamic testing, full-field and discrete measurements, in-situ NDT, data extrapolation, advanced simulation tools, certification and standardisation.

● 3. Identify challenges, limitations and issues currently faced in designing lightweight composites, including safety structures undergoing extreme loading conditions. Establish the best practice for design which also includes environmental impact.

● 4. Analyse representative cases across the various industrial fields to address the needs of the stakeholders and the requirements of certification agencies, in terms of materials, inspection, testing,

modelling and regulations. Start activities towards the development of new guidelines for certification.
● 5. Identify short term and long-term challenges of composite structures related to new concepts, advanced material systems or other non-standard systems and approaches.
● 6. Define the main scientific, technological and industrial priorities to be addressed in the Research and Technology activities.
● 7. Organise and coordinate benchmarking of different specific industry-related methodologies against current standards to create a more coherent approach for design, testing and modelling of high-performance structures.
● 8. Produce a compilation of the main research outcomes useful for standardisation and make further steps towards certification by analysis of composite structures, including safety-critical structures.
● 9. Initiate and coordinate activities across the academic, industrial and certification sectors to adopt the state-of-the-art framework for the design of critical structures subject to extreme dynamic loading.
● 10. Establish an open data repository to provide access to all HISTRATE partners to the information needed to realise the objectives listed above.

Capacity Building
● 1. Create and coordinate activities in a collaborative network of experts and facilities from broad backgrounds. This will build a critical mass of partners to drive S&T progress in certification by analysis of high-strain rate loaded structures across various industrial fields.
● 2. Promote geographical, age and gender balance throughout the network activities.
● 3. Generate and promote new opportunities, and create new networks especially for Early Career Investigators (ECIs). ECIs will be actively involved in all activities of the Action. ECIs will be strongly encouraged to participate and take leading roles in the WG, and to go for Short Term Scientific Missions.
● 4. Train graduate students and ECIs on relevant crucial topics such as advanced modelling, multiaxial testing, certification issues, full-field capturing devices.
● 5. Establish strong links between scientists, stakeholders, certification bodies and policymakers.
● 6. Disseminate knowledge and experience from the network by publications (reports and papers), workshops, seminars, periodic conferences, public awareness days, the Action's and the participants' websites and social media presence.
● 7. Incorporate the Action's outcomes in the syllabus of the PhD programmes across the network.

TECHNICAL ANNEX

1. S&T EXCELLENCE

1.1. SOUNDNESS OF THE CHALLENGE

1.1.1. DESCRIPTION OF THE STATE OF THE ART

Composite materials, including hybrid and metamaterials, will play a key role in meeting the challenges posed by the *European Green Deal*. Indeed, these materials are not only intrinsically lightweight, though recent advances made in understanding their anisotropic nature and in how to tailor their properties to specific applications, but allow for an extremely resource-efficient design, by the development of *materials and structures with new and unique combinations of properties*. As a result, these materials are increasingly used as primary load-bearing structures in marine, aerospace, automotive and energy generation applications.

The performance and strength of composite structures, including safety-critical structures, are currently established incrementally through analysis and experimental tests conducted using specimens of different sizes and complexity. This process utilises the so-called 'building block' or 'testing pyramid' approach shown in Figure 1 with tests at different scales: (i) Coupon, (ii) Structural detail, (iii) Component, and (iv-v) Sub-structure or full structure. The 'building block' approach is a systematic methodology and constitutes the backbone of certification processes, especially for composite aero, wind and car structures. The vast majority of certification tests are conducted at the coupon level, whereas far fewer certification tests are conducted at the subsequent higher pyramid levels. The complexity, cost and time of each test escalate up through the testing pyramid. The building block approach has been validated and is widely used for certification of primary structures made of metals and composites subject to static and dynamic loading.

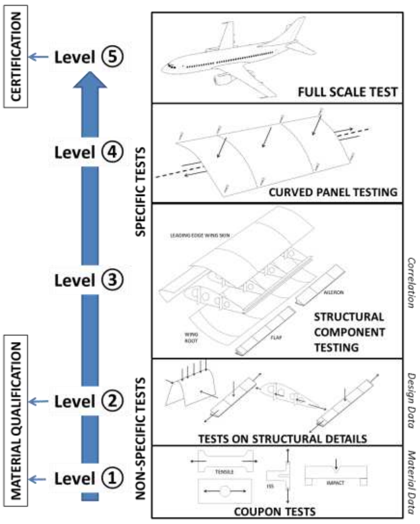


Figure 1. Illustration of building block approach used to assess the performance of composite structures

In many practical situations, *safety-critical structures are subjected to loading at high to very high strain rates*. These extreme loading conditions are often the result of undesirable events such as bird strike, blast, impact, crash, lightning strike. Surprisingly, although the *material and structural response under extreme loading differs significantly from its response to quasi-static loading, extreme loading is outside the scope of standard design approaches*. Additionally, knowledge of the material behaviour under extreme conditions is still limited.

Current test standards used by industry for determining the mechanical properties of composite materials are provided by either the American Society for Testing & Materials (ASTM) International or the former Suppliers of Advanced Composite Materials Association standards. The standard procedures are based on quasi-static loading and do not provide a complete characterisation of the materials, especially in the medium to high strain rate regimes. Additionally, for large parts using heavy fabrics, the ASTM testing protocol is inappropriate as addressed in the next paragraph.

At best, ignoring the often-observed increased strength at higher strain rates, leads to an overly conservative design and, therefore an inefficient use of resources. However, also cases *exist for which the standard leads to unsafe designs where combinations of weakening events cascade into premature* *failure resulting in the loss of human lives*. Consequently, it is necessary **to characterise composites in a reliable and accurate manner under high strain rate loading** and **to develop testing protocols** allowing empirical measurements of global and local strain and strain-rate dependence of the material properties including failure. However, today's analytical and numerical methods used for designing critical load-bearing composite structures *lack the capability of properly capturing the strain rate sensitivities and nonlinearities, failure modes and thermal effects* that are present in the material response under high dynamic loading.

Novel products, technologies and advanced composite materials, such as those used, for example, in fuel tanks for hydrogen storage, electrical batteries casing protection, crash-resistant structures, aircraft engines and structures and ship hulls, pose even bigger threats in the case of non-existent dynamic testing and modelling standards. A **paradigm shift** in *simulation comprehensiveness* and high strain rate testing protocols could significantly simplify or replace the existing experiment-based building block approach with *simulations and tests for validation and product certification in a manner that allows for composition and performance to be adjusted without recertification*. This will be the initial step towards the application of **certification by analysis of high strain rate loaded structures**.

The overarching goal of the HISTRATE Action research network is to contribute to the fundamental understanding of the non-linear dynamic response of composite, including hybrid, materials and structures. While classical engineering applications mainly use stiff materials, there is a growing interest in materials capable of undergoing large deformations with enhanced specific characteristics, such as mechanical metamaterials. This represents an exciting additional development in composite materials and will result in the design of a new class of structures with a wide range of applications.

Structures incorporating metamaterials may significantly change their architecture in response to diverse loading. They may be designed to become unstable when undergoing large deformation. Beyond the instability threshold, the structure rapidly reconfigures, i.e., it changes its structural geometry, into a new configuration with desirable properties. In other words, the instability-induced, geometric rearrangements rapidly tune the functionalities and/or the macroscopic structure response. Examples of applications include structures with adaptive wave propagation characteristics used in energy harvesting, noise control and structural health monitoring, morphing structures used in aerospace and robotics and materials with negative Poisson's ratio in impact protection.

Within this Action, we have extensive knowledge and capabilities to investigate composite materials using a combination of numerical modelling and experiments. Numerical analyses allow for a precise design of experiments and a deep understanding of the experimental results. The experiments are used for characterisation of materials and structures, and support the development of improved simulation tools. In the network, we work on proof-of-concepts as well as the design of a new class of structures.

1.1.2. DESCRIPTION OF THE CHALLENGE (MAIN AIM)

The main aim of this Action proposal is *to lay the scientific and technological (S&T) foundations for the creation and implementation of a* ***reliable and robust framework*** *for the certification by analysis of advanced composite load-bearing structures subject to high strain rate loading*. The framework has to be validated against the existing experimental protocols and be robust enough to allow for development of the new class of composite materials and structures. The improvements in the simulation tools and experimental methods enable the design of lighter, safer and more energy efficient structures. Significant challenges and hurdles must be overcome to achieve the proposed aim in several areas:

Material Testing: the test standards (e.g., EN, ASTM) to measure stiffness, strain, and failure onset of high strain rate loaded composites are limited. Therefore, a comprehensive empirical and analytical protocol is required to characterise the mechanical response of advanced composites in the high strain loading regime pertinent to critical structural applications. Experiments are needed imposing deformation conditions that approach those encountered in real applications. Additionally, test samples should be chosen to reveal possible, critical damage and failure phenomena of the real components. In this regard, interlaminar fracture toughness characterisation under high strain rate conditions must also be elucidated. *A clear understanding of the high strain rate material response, all the way up to failure, is needed with the ultimate goal of developing a standardised testing protocol that includes rigorous mechanics principles and standardised laboratory instrumentation*. Optimised and new test protocols will allow for more efficient model validation with a significantly reduced number of tests.

Full Field and Discrete measurements. High strain rate loading requires real-time, in-situ characterisation of impact events involving volumetric wave phenomena. The capabilities of full-field experimental techniques are limited by the speed performance at the sub-microsecond resolution and the ability to characterise the surface state. The availability of powerful 3D deformation measurement systems allows the use of advanced schemes for the identification of material model parameters. In these schemes, the parameters are iteratively updated by comparing measured full-field strain maps with modelled maps. Full-field monitoring can be coupled with faster (embedded) local sensing. This will allow the development of 1) benchmark performance tests, standards, 2) test methodologies to validate models and, 3) material characterisation by using a range of sample geometries under various loading.

Accurate and reliable in-situ and post-impact damage characterisation provides the basis for the validation of new damage material models and modelling technologies. The variety of modern embedded and external non-destructive testing (NDT) techniques, inspection protocols and standards bring significant disparity when the results are directly numerically compared. The urgent challenge is to develop a common approach and framework for multi-modal inspection based on different physical principles. This common ground will provide both the inspection and modelling sectors with reliable and accurate characterisation tools for post-impact damage needed for modelling validations.

Design across the scales: Significant challenges still exist in tools and methodologies for designing structures with different scale features. It is fundamental *to develop and implement multiscale composite models* able to predict composite response to high dynamic loading. This will involve physics-based models to describe the multiscale damage phenomena due to the complex nature of high impact dynamics coupled with the composite architectural/constituent complications at different scales. On the other hand, *computational methods to overcome the mesh distortion and interpenetration problems associated with failure evolution in a multi-phase environment, and remeshing as required for the FEM and other Lagrangian based methods, need to be addressed*. A multiscale model-based simulation procedure is paramount and should be verified and improved with available experimental data.

Digital roadmap: For analysis and modelling of advanced composite load-bearing structures subject to high strain rate loading *there is a lack of an adaptive virtual certification strategy* to be implemented into today's engineering certification processes starting from the level of a representative volume element (RVE), going, for composite laminates for instance, to the lamina scale, then to the meso-scale laminate level and finally to the component level. Significant challenges include the standardisation of input and output values for seamless interlinking of workflows and the assessment of the quality of the prediction.

To meet these **foreseen challenges**, a **robust structured approach is proposed** where researchers from the industrial partners and academia contribute actively. The areas of research advocated by the HISTRATE Action rely on these cross- and multidisciplinary approaches with a strong wish to integrate also other areas of research to enable cross-fertilisation in different fields. This is only achievable through focused activities. *The roadmap suggests research actions to radically transform the way we discover, develop, and design ultra-high-performance, durable, safe, sustainable, and affordable advanced composites for use in real high strain rate loading applications*. *The targeted applications are lightweight design in the automotive, marine and aeronautical industries, the production and use of renewable energy and the protection of structures against shock and impact.*

1.2. PROGRESS BEYOND THE STATE OF THE ART

1.2.1. APPROACH TO THE CHALLENGE AND PROGRESS BEYOND THE STATE OF THE ART

The proposed digital roadmap strategy for the certification by analysis of safety-critical structures is the backbone of this Action. Several, parallel approaches will be adopted to tackle the challenges described in the previous section leading to significant advances beyond the state-of-the-art:

Development and introduction of novel test methodologies to capture dynamic phenomena. Recently, dynamic tests have been developed which deliberately violate the sample constraints imposed by traditional material testing. Indeed, high- and ultrahigh-speed imaging combined with image processing software allows us to accurately capture highly transient phenomena, such as propagating waves, and local strain peaks. For this reason, strain inhomogeneities and more complex, multi-axial strain paths, will no longer be avoided. New specimen geometries will be developed that are suitable for the characterisation of the new materials under high dynamic loading. Using advanced direct measurement methodologies will allow a significant reduction of tests to identify constitutive material parameters. By spreading these methodologies, HISTRATE will lead to significant efficiency gains.

Virtual design and certification by analysis are achieved by ***developing a holistic, robust, multiscale and multiphysics approach validated with novel sensing and measuring techniques.*** The new simulation tools will feature a theoretical framework of configurational continuum mechanics, nonlocal continua and irreversible thermodynamics. The models for the new materials must be able to capture highly complex and localised phenomena, including damage initiation, progression and failure, under multiaxial loading. A consistent, physically-based multiscale simulation strategy informed by the dynamic properties of the constituents, i.e., fibre, matrix and fiber/matrix interface, measured with novel testing and sensing methodologies will reduce extensive testing across the design scales. In addition, **novel methods for treatment of damage and fracture will be explored**. HISTRATE will focus here on coupled finite element analysis and smoothed-particle hydrodynamics. Mesh-free continuum mechanics provides a theoretical basis to seamlessly model fracture and defects in a continuum solid which is able to handle discontinuities, and large deformations and damage without costly remeshing.

Novel products: the development of future transport and energy structures subjected to high dynamic strain rate loading is in part limited by the development and implementation of advanced materials. HISTRATE will accelerate the maturation and insertion times of advanced materials to support the delivery of technically advanced systems. The precise modelling of these advanced materials and structures is only possible with accurate measurements of their real dynamic response. High-strain-rate testing of these advanced materials is limited by existing methods. *HISTRATE is assembled to include broad abilities to measure the high-strain-rate material properties reducing the limitations on materials, geometries and environments, producing better material data and providing a virtual suite for certification by analysis for the advancement of novel products*. HISTRATE is a cornerstone to the further development of these advanced materials for future composite structures, including safety-critical applications.

1.2.2. OBJECTIVES

1.2.2.1 Research Coordination Objectives

HISTRATE Cost Action will enable:

1. Improvement of the research capabilities of individual partners and the network as an integral entity.
2. Development of procedures for structured and efficient collaboration between the partners.

3. Development and improvement of channels of communication between universities and industrial partners, research institutes, regulatory bodies and funding organisations.
4. Implementation of the existing state-of-the-art across the target groups to allow meeting the reduced carbon footprint requirements through lighweighting, more efficient use of material resources and the development of high-performance, hybrid structures.
5. Establishment of a data repository to allow the use of data-driven approaches for all participants.

Consequently, HISTRATE's contribution towards standards and procedures for designing modern structures under extreme dynamic loading in aerospace, automotive, marine, energy, security and bioengineering will be secured.

Practical and theoretical knowledge is not commonly shared across disciplinary boundaries and therefore theoretical and conceptual leaps remain contained. HISTRATE aims *to tackle and transform this scattered knowledge into an open, coherent and structured network*. As such, it will enable collaborations between researchers, engineers, scholars and other stakeholders and business across a variety of engineering fields by providing a platform to create projects, training activities, workgroups. HISTRATE proposes ways to share interdisciplinary knowledge, to embed the acquired knowledge in the design of future resilient structures, to improve our research systems and practices, and to work jointly to identify and fill genuine knowledge gaps. Ultimately, *the **primary Action objective** is to maximise the integration of novel material characterisation methods, in-situ sensing technologies and advanced modelling frameworks for the "right-at-first time" design of high-performance structures subject to dynamic loadings*. This Action will consolidate currently emerging trends in "certification by analysis" of high-performance structures undergoing dynamic loading. It will directly contribute to more efficient use of materials and improvements in lightweight designs. The latter will result in reduced fuel consumption and, in turn, lower emissions of air pollutants and greenhouse gases.

The specific research coordination objectives are to:

1. Establish and improve semantic interoperability to develop a common "language" between various technologies/tools/methods adopted in the different industrial fields involved in HISTRATE.
2. Gather the state-of-the-art in the following science and technology (S&T) fields for the design of safety-critical structures under high dynamic loading and composite/hybrid structures in general. More specifically:
   a) **Generation of high strain rate loading**. New experimental facilities that couple high intensity and multi-axis capabilities with impact drivers (e.g., lasers, gas guns, etc.), offer exciting opportunities for directly probing material deformation mechanisms under extreme loading conditions.
   b) **Full-field and discrete measurements**. Detection capabilities to provide complete mapping of the temporal evolution of complex materials under dynamic loading. Full-field technologies at real-time rates for immediate visualisation of the deformation fields and potential control of portions of the experiments. Providing measurement input for numerical models for predictive modelling.
   c) **In-Situ NDT**. Technologies and tools for measuring and creating 3D imaging for evaluating post-mortem complex failure modes in highly attenuating materials.
   d) **Data extrapolation**. Suitable collaborative approaches are needed to extrapolate behaviour at high strain rates using mathematical models for materials where experimental difficulties arise. This is motivated by the fact that the measurement of data characterising rate-dependent behaviour needed for impact analyses is laborious, prone to errors unless the necessary precautions are taken.
   e) **Advanced simulation tools**. Novel material models to capture complex failure phenomena coupled with spatial discretisation techniques to correctly model large material deformations validated by full-field and discrete measurements.
   f) **Certification and standardisation**. Promote and prepare the necessary steps for the adoption and standardisation of a digital twin for the certification of safety-critical structures.
3. Identify challenges, limitations and issues currently faced in designing lightweight composites, including safety structures undergoing extreme loading conditions. Establish the best practice for design which also includes environmental impact.

4. Analyse representative cases across the various industrial fields to address the needs of the stakeholders and the requirements of certification agencies, in terms of materials, inspection, testing, modelling and regulations. Start activities towards the development of new guidelines for certification.
5. Identify short term and long-term challenges of composite structures related to new concepts, advanced material systems or other non-standard systems and approaches.
6. Define the main scientific, technological and industrial priorities to be addressed in the Research and Technology activities.
7. Organise and coordinate benchmarking of different specific industry-related methodologies against current standards to create a more coherent approach for design, testing and modelling of high-performance structures.
8. Produce a compilation of the main research outcomes useful for standardisation and make further steps towards certification by analysis of composite structures, including safety-critical structures.
9. Disseminate and inform the academic, research and industrial relevant communities about relevant knowledge and capabilities within the network.
10. Initiate and coordinate activities across the academic, industrial and certification sectors to adopt the state-of-the-art framework for the design of critical structures subject to extreme dynamic loading.
11. Establish an **open data** repository to provide access to all HISTRATE partners to the information needed to realise the objectives listed above.

1.2.2.2 Capacity-building Objectives

The main aim of the capacity-building activities is to create, enhance and develop the capacity and critical mass to address the challenges elaborated in previous sections. The specific objectives are to:

1. Create and coordinate activities in a collaborative network of experts and facilities from broad backgrounds. This will build a **critical mass of partners** to drive S&T progress in certification by analysis of high-strain rate loaded structures across various industrial fields.
2. Promote geographical, age and gender **balance** throughout the network activities.
3. Generate and promote **new opportunities**, and create new networks especially for Early Career Investigators (ECIs). ECIs will be actively involved in all activities of the Action. ECIs will be strongly encouraged to participate and take leading roles in the WG, and to go for Short Term Scientific Missions.
4. **Train** graduate students and ECIs on relevant crucial topics such as advanced modelling, multiaxial testing, certification issues, full-field capturing devices.
5. Establish **strong links** between scientists, stakeholders, certification bodies and policymakers.
6. **Disseminate** knowledge and experience from the network by publications (reports and papers), workshops, seminars, periodic conferences, public awareness days, the Action's and the participants' websites and social media presence.
7. Incorporate the Action's outcomes in the syllabus of the **PhD programmes** across the network.

2. NETWORKING EXCELLENCE

2.1. ADDED VALUE OF NETWORKING IN S&T EXCELLENCE

2.1.1. ADDED VALUE IN RELATION TO EXISTING EFFORTS AT EUROPEAN AND/OR INTERNATIONAL LEVEL

HISTRATE directly strengthens European **excellence** in advanced composite solutions by bridging distinct scientific and engineering fields from material sciences, physics and chemistry with novel solutions on composites, followed by material testing and characterisation. Efficient numerical modelling of the composites' behaviour plays a critical role in the design phase for a more cost-efficient certification process. Metrology and NDT support and validate material design and the modelling at different scales. Currently, individual researchers can collaborate in individual projects which have a limited scale, synergy and international coverage. HISTRATE aims to build such a **synergetic network** and expand cross-border and cross-discipline collaboration to tackle the joint challenge of **certification by analysis**. The most relevant projects that HISTRATE will benefit from are listed below, the key results and expertise of interest are highlighted (sorted by year):

2019-22 European Partnership for Improved Composites (EPIC, M-ERA.NET; **hybrid composites**)
2018-22 Multifunctional polymer composites doped with novel 2D nanoparticles for advanced applications (NANO2DAY, H2020; **multifunctional composites and up-scaling**)
2018-21 Advanced polymer composites filled with novel 2D nanoparticles (NANO2COM, M-ERA.NET; **high-performance composites**)
2017-21 Realisation and demonstration of advanced material solutions for sustainable and efficient ships (RAMSSES, H2020; **large scale composites**)
2017-21 Enabling qualification of hybrid structures for lightweight and safe maritime transport (QUALIFY, Interreg; **metal/composite structures**)
2017-20 Modified cost-effective fibre-based structures with improved multi-functionality and performance (MODCOMP, H2020; **multifunctional material at extreme conditions**)
2015-19 EXTREME Dynamic loading pushing the boundaries of aerospace composite material structures (EXTREME, H2020; **material characterisation methods and impact models**)
2008-20 Clean Sky 1&2 (multiple projects on **manufacturing, eco/green, sustainability**)

HISTRATE will start with a joint workshop (deliverable D1.2) to which, next to the proposers, the key partners from EU projects and COST Actions listed below will be invited. In this way, we join the scattered research communities, gather relevant input and inform the wider society about our objectives.

2020-24 High-performance carbon-based composites with smart properties for advanced sensing applications (COST CA19118)
2019-23 Reliable roadmap for certification of bonded primary structures (COST CA18120)
2019-23 Optimising design for inspection (Ultrasonic NDE, COST CA18203)
2016-20 Solutions for critical raw materials under extreme conditions (CRM-EXTREME, COST CA15102)
2016-20 Multi-functional nano-carbon composite materials network (MULTICOMP, COST CA15107)
2014-19 Quantifying the value of structural health monitoring (COST TU1402)
2013-17 Next generation design guidelines for composites in construction (COST TU1207)
2008-12 Composites with novel functional and structural properties by nanoscale materials (COST MP0701)
ongoing Carbon Fibres & Advanced High Performance Composites Cluster (CFPC)
ongoing European Technology Platform for Advanced Engineering Materials and Technologies (EuMAT)
ongoing European network for lightweight applications at sea (E-LASS)

These projects demonstrate large-scale research on composites in the EU. Despite the advances, the **industrial uptake and real change of certification/qualification procedures are limited**. This is mainly due to the need to adopt new digital tools requiring training, and slow acceptance of novel developments by certification bodies. HISTRATE will provide interactive workshops and seminars along with an online “interactive composites community hub” to disseminate available research results. In this way, we aim at **closing the gap** between research and technology transfer by focusing on innovations, IP generation and personnel mobility and training with a significant industrial involvement.

Therefore, our **ultimate objective** is to efficiently use the results of the previous and ongoing projects. The **value** of HISTRATE is in the new synergetic network which joins multidisciplinary researchers and industrial partners in Europe from multiple EU programs to enable the advances in the certification by analysis of advanced composite structures by coordinated research and innovation efforts.

2.2. ADDED VALUE OF NETWORKING IN IMPACT

2.2.1. SECURING THE CRITICAL MASS AND EXPERTISE

The HISTRATE network includes **80 individual** proposers from **33** countries, including **18** Inclusiveness Target Countries (ITC) and **4** Near Neighbour Countries (NNC) and **1** European Research, Technology and Development Organisation. The proposer's expertise is summarised in the list below and Table 1:

☐ **Industrial** proposers (overall **21, 26%**): **complete cross-sector supply chains** of small and medium-sized enterprises (SME) and large European/world corporations including tier-1 material and equipment suppliers (incl. biocomposites), research and technology organisations, regional and world-leading composite manufacturers, aircraft manufacturers (part- and full-scale), automobile manufacturers (components and full scale in Europe), a manufacturer of wind turbines, world-scale shipbuilder. **Specific input: materials**, **manufacturing capabilities, upscaling**.

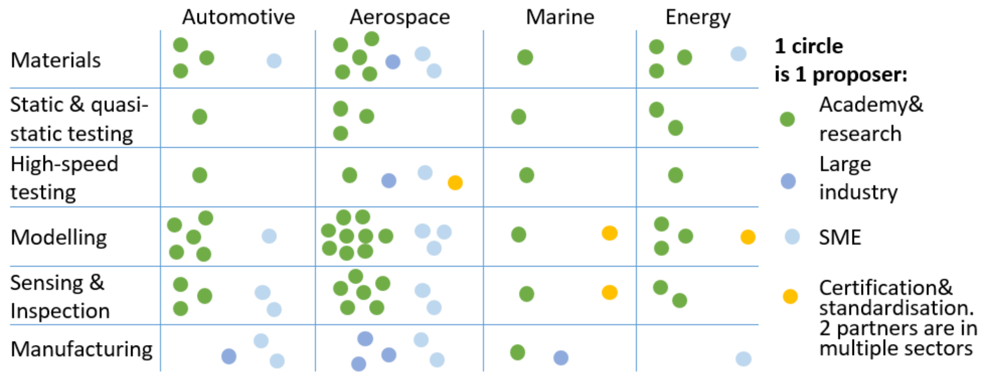
- It is important to highlight **Industrial-modelling and sensing** proposers (**11, 13%; included in the industrial** group) – developers of multiphysics simulation solutions, business experts at micro-meso-macro scales modelling, virtual modelling of operation environment. **Specific input: novel models, efficient computing, software and packages, high-performance clusters.**

☐ **Academic and research** proposers (**57, 73%**) from material sciences, physics and chemistry are the national and European leaders in new composite materials, numerical modelling, dynamic material characterisation, smart embedded sensors and NDT. **Specific input: quasi-static and dynamic material testing, scientific potential, innovative ideas.**

☐ **2** standardisation and certification proposers and multiple proposers directly contributing to the European standards associations. **Specific input: real-life standardisation expertise**

☐ Certification bodies such as EASA, DIN, ISO, NQA Global, TÜV will be invited in the first Action year to be actively involved in the HISTRATE Action to jointly address the certification by analysis challenges.

Table 1. Distribution of the proposer's **main** expertise over the application sectors (approximate plot)



The overall expertise of the network proposers, the cross-sector distribution and the complete supply chain structure in the HISTRATE Action sectors (Table 1) ensures **the critical mass and expertise** to achieve the HISTRATE objectives and to address the identified challenges. The critical personnel and driving force for the innovation are ECI (see HISTRATE Mission and Policies for specific actions). In addition, previous and existing European and national efforts will be directly used by joining and fusing small research and collaboration groups in the proposing open HISTRATE network.

2.2.2. INVOLVEMENT OF STAKEHOLDERS

The HISTRATE open network has raised **significant interest** among the relevant **stakeholders** across a range of the disciplines and sectors, which is reflected in the expertise and scale of the Action. The

HISTRATE Action members have the mandate and obligation to identify and engage focus groups of stakeholders from outside the network and involve them in the Action based on an **open database** that will be created by WG2. These activities are tailored to generate synergies for the joint benefit of academic and industrial partners. Specifically, the following groups from each country are involved:

- Scientists, scientific institutions, organisations, scientific academies and societies
- Industrial organisations and associations
- Decision-makers at governments and societies for research funding, public organisations

The anticipated activities **to involve the stakeholders** fall into four categories:

- Open access publication of topics and results to achieve and gain visibility and involvement across potential stakeholders from direct and adjacent sectors.
- Consultancy and expertise transfer activities from stakeholders to ECI in training events.
- Establishing targeted links with stakeholders from ITC, NNC for cross-border interactions.
- Dissemination activities in the form of an **online interactive composites community hub**, workshops and joint forums aiming at a broad technology and knowledge transfer.

The HISTRATE Action stakeholders will lead relevant tasks being leaders of WGs to advance the **Action impact**. They will also provide feedback to the network through the relevant workgroups, especially WG2 (see section 4). The available extensive expertise of the industrial proposers will ensure the actual application of the HISTRATE Action results and outcomes in their business processes which will **increase the technology readiness level (TRL) of the Action's results**.

2.2.3. MUTUAL BENEFITS OF THE INVOLVEMENT OF SECONDARY PROPOSERS FROM NEAR NEIGHBOUR OR INTERNATIONAL PARTNER COUNTRIES OR INTERNATIONAL ORGANISATIONS

HISTRATE **addresses challenges and objectives at a world-scale**, therefore it is critical for the Action to identify and involve NNC and ITC based on their expertise and contribution. Another objective is to raise awareness in NNC and ITC by providing a direct link to the solutions beyond the state-of-the-art. As an example, our NNC partners from Ukraine and Belarus have extensive experience in the theoretical and analytical analyses of composites behaviour. In HISTRATE, these partners gain unique access to pre-market modelling resources, advanced experimental and material databases, which provides a ground-breaking opportunity for them to directly boost their performance. All partners get into contact with motivated collaborators with a strongly research-oriented mindset. This will have a direct impact on ECI from NNC and ITC which is of high importance as they will shape the future in these countries.

The overall Action's **synergy** of multi-cultural approaches, cross-border and -sector expertise **ensures valuable knowledge transfer and social capital building**. The wide geographical spread will provide keys to the local markets for the Action's new business-related outcomes and support of existing ones.

3. IMPACT

3.1. IMPACT TO SCIENCE, SOCIETY AND COMPETITIVENESS, AND POTENTIAL FOR INNOVATION/BREAKTHROUGHS

3.1.1. SCIENTIFIC, TECHNOLOGICAL, AND/OR SOCIOECONOMIC IMPACTS (INCLUDING POTENTIAL INNOVATIONS AND/OR BREAKTHROUGHS)

The HISTRATE Action is expected to have a significant impact at different levels, more specifically:

The scientific impact will be generated by presenting the research outcomes in high impact peer-review journals, at HISTRATE Action conferences and workshops, in the Action's reports and periodic newsletters, and by the creation of open-access datasets. The key S&T achievement within the HISTRATE Action will be the integration of computer methods, measurement instrumentation and data processing into a coherent and robust methodology for the virtual analysis of composite structures undergoing extreme, dynamic loading. This will be achieved using a multidisciplinary approach, including machine learning and artificial intelligence, through accelerated knowledge transfers among the experts within the network, mobility of the research students and young researchers within the network, and, most important, direct access to unique and specialised equipment for dynamic characterisation testing, including impact and shock loading.

The network established in this Action has the capabilities and a proven track-record in the **development of new technology and know-how**, including the development and introduction of new composite materials tailored to the specific applications. Consequently, it is an ideal vehicle to move the technology from the fundamental laboratory-scale levels up to the higher TRL level including commercialisation. Good examples of TRL evolution are the material models which have been developed, validated and implemented in commercial codes within the network.

The available state-of-the-art **technology** has enabled the design and development of larger, lighter and more energy- and resource-efficient structures and has pushed the design envelopes to their limits, extending the service life and fulfilling a number of societal requirements.

The **main socio-economic** impact is twofold. **Firstly**, the presence of composite materials in daily life is ever-increasing due to their excellent technical characteristics and, if used appropriately, positive environmental impact. A good example of the environmental impact can be found in transport applications. The transport sector's greenhouse gas emissions have increased over time and represent now as much as one-quarter of the EU's total. Reaching the ambitious goal set by the European Green Deal of reducing the emission of greenhouse gases by -55% by 2030 (relative to 1990) and reaching climate neutrality by 2050, requires, inter alia, reconsideration of the materials used. Since composite materials are intrinsically lightweight, they will be playing a crucial role. Also in the energy sector, the **use of composites** can boost the production and use of **renewable green and blue energy**. Lower fossil-fuel-related emissions go hand-in-hand with an overall reduction of air pollutants which will improve air quality and result in broader environmental and health benefits. It will contribute to meeting the strict EU environmental and international targets, e.g. the latest reports by the Intergovernmental Panel on Climate Change (IPCC) AR6 WGI (2021) and the European Environment Agency (EEA) on Air Quality in Europe (2020).

The HISTRATE Action will enable coordination and enhancement of existing research capabilities and facilitate certification of new lighter and safer composite materials that will naturally fit in the circular and green economy requirements of the modern structures used in transport and energy applications. There is a range of ongoing activities within the network related to the use of hydrogen and electrical vehicles fully in line with these objectives.

Second, the HISTRATE Action will provide an agile framework and capabilities with the ability to respond to challenges of the rapidly changing world and the new normality, marked by undesirable extreme events and growing climate changes, including earthquakes, tsunami waves and hurricane winds. This Action aims to establish the First European Composite HISTRATE team in order to provide a framework with integrated capability based on the technology developments in the aerospace, automotive, structural integrity, health monitoring and energy sectors. Our mission is to coordinate and enhance our capabilities, and transfer best practices to other sectors, such as civil and environmental engineering which can be included in the HISTRATE Action in the second Phase of the impact plan. These objectives will be achieved in close collaboration with SMEs by organising collaborative open events, which will increase the visibility of our research across the application sectors and beyond the proposed network. Our industrial partners range from SMEs up to the largest global players in the field. The broad list of the participating countries (**33**) is supported by an additional dimension – the wide geographical presence of the **5** Action's **large industrial partners** which have extensive **European and world coverage**: e.g., composite materials providers present in **9** ITC and **3** NNC; aerospace tier-1 suppliers with research and manufacturing in **1** ITC and **3** NNC; world-scale shipbuilder has yards in 2 ITC and 1 NNC. This dimension will have a far-reaching impact, as these partners will transfer the benefits from the activities and capabilities existing within the HISTRATE Action to the local societies.

The number of women active in the fields of the HISTRATE Action is limited within the EU and is even lower in ITC countries, including Croatia, Serbia, Hungary, Turkey. HISTRATE will therefore contribute to the wider aim of increasing the female involvement in the sector at the EU level.

The main innovations and breakthrough of the HISTRATE Action will be the synthesis of the state-of-the-art simulation tools, including computing big data with machine learning, as well as the instrumentation tools, towards the development of a validated, reliable and robust virtual/synthetic design environment. For instance, the integration of numerical and full-field measurement methods allows for accurate measurement of physical constitutive model parameters for damage and failure. This will pave the way for reliable certification by analysis and allow for significant lead time and design change cost reductions. These results will bring the ITC partners to higher standards and will directly benefit Europe's competitiveness in the international markets across a wide range of industries.

3.2. MEASURES TO MAXIMISE IMPACT

3.2.1. KNOWLEDGE CREATION, TRANSFER OF KNOWLEDGE AND CAREER DEVELOPMENT

HISTRATE aims to foster an **open environment** for skills and knowledge sharing in the area of composites under extreme loading environments. The involvement of industry and academia in sharing knowledge is essential for achieving innovative solutions for safer, lighter and greener structures. The network consists of **scientists with a broad background** and industrial partners. All partners together **have the required expertise and facilities needed to reach the HISTRATE Action objectives**. With the engagement of all partners, new and existing knowledge will close the gaps identified from industrial use cases. This synergy guarantees the Action's success and spans across several industrial sectors. The expertise and facilities available will introduce new researchers to a multi-disciplinary knowledge transfer, adoption of new educational and training methods (e-learning, online education). Special attention will be paid to ECIs, especially to those coming from ITC and border EU members. At the end of the Action, the outcomes can be exploited for expanding Europe's business and market activities.

To maximise impact, a well-developed plan for monitoring and maintenance of a high level of impact is required from the very start. Measures to maximise impact will be developed in three phases:

- Phase 1 (Y1) – identify and include the certification bodies and draw up a road map for a successful and high level of impact with SME's and other industrial stakeholders.
- Phase 2 (Y2 & Y3) – open type conferences, where we actively approach young researchers to get on board and to form a European Composite HISTRATE society. The conferences will be opportunities for presentation of the developments to date. A clear objective is to have impact at an international level and, especially, to attract interests from the USA and other global contributors.
- Phase 3 (Y4) – long-term impact plan for a HISTRATE conference series.
- We estimate **5** new research proposals and over **100** reviewed papers to come out of the Action.

As the balance between countries, junior and senior, male and female, industry and academia is very explicitly pursued in the Action, a fertile environment is created fostering the careers of the involved engineers and researchers. Special attention will be paid to the development of the careers of the young members of the network by giving them a prominent role in HISTRATE. There are over 100 postgraduate researchers and early career professionals directly affiliated with the Action. Involving them in the management of HISTRATE will be an essential part of this and will allow them to improve their organisational skills in terms of work planning, networking, administration and resource management. In addition, by allowing and encouraging their participation in conferences and workshops they will get greater visibility outside the network.

To develop the skills and expertise of young researchers and engineers, coaching programs will be offered including:

- *Talent Management Programs:* giving young researchers and engineers the possibility to attend courses on leadership, time management and planning, career management and technology transfer.
- *In-depth technical **training (WG8)**:* an extensive amount of S&T knowledge and experience is present in the network. Dedicated courses will be organised within the activities to transfer this knowledge to the young researchers and engineers.
- ***Exchange** program academia-industry (WG8):* As we believe that strong interaction, cooperation and knowledge transfer between industry and academia are crucial, exchange programmes for young researchers and employees will be offered, including postgraduate programmes with industry-based projects. Therefore, short exchange stays in companies and research institutes involved in HISTRATE will encourage the early career researchers.

3.2.2. PLAN FOR DISSEMINATION AND/OR EXPLOITATION AND DIALOGUE WITH THE GENERAL PUBLIC OR POLICY

The dissemination and exploitation activities will be a constant process with a specific timeline and will involve all partners. To achieve the dissemination objectives, a dedicated steering committee will be formed at the kick-off meeting, which will be led by a dissemination manager and the HISTRATE Action chair. They will plan and coordinate the steering committee meetings, management committee meetings and work group meetings. The first item on the committee agenda is identification of the target groups in Phase 1 (see section 3.2.1) of the impact, including: scientific community, stakeholders and relevant industrial sectors, standardisation and certification bodies, national authorities and general public. It is important that each target group receives the most relevant information, tailored to its needs and experience.

A successful exploitation strategy will create more acceptance amongst stakeholders maintaining the EU industrial leadership in the addressed sectors. During the Action, a set of specific actions will be undertaken to ensure comprehensive and effective exploitation of the Action's outcomes and will take the specific demands of all partners involved, including industry, SMEs, academia and research, agencies and institutions into account. In particular:

- An elaborated exploitation plan to serve as a clear guideline for market exploitation of the results.
- An exploitation workshop at the Action start. This will enable all partners to share the exploitation strategy and vision as well as to discuss and agree on the best ways forward.
- Tailored activities to involve relevant external stakeholders in the exploitation (expert interviews and focus groups). Exploitation activities will start early in the Action and will follow an exploitation path that will evolve with the evolution of the project.

The HISTRATE Action framework and capabilities will be made available and presented to a mixed industrial and academic audience via:

- publications in open-access peer-reviewed journals (we estimate that over a hundred publications will be generated during the Action) and by presenting at technical conferences;
- interactive annual workshops with stakeholders from each target group;

- inclusion of the results of the project in short university and PhD courses;
- participation in international and local exhibitions, workshops, webinars and seminars;
- developing training WG8 dedicated to capacity-building; via the Actions and partners webpages as well as the social media streams (LinkedIn, Twitter and Youtube).

The dissemination of the results from the HISTRATE Action will be done in a structured way and around a unified strategy, leveraging the members' strong relationships with a range of audiences – academic, industrial, operational and governmental. The dissemination plan will engage with the range of stakeholders in the relevant domains that have the most to gain in the near-term from the results of the Action, as well as the research communities that could build upon more fundamental findings. The project dissemination plan will identify the most appropriate means for each stakeholder's category to ensure that activities are:

- effective i.e. suited to achieving the Action's communication goals;
- proportionate to the scale of the Action;
- address audiences beyond the Action's community, including the media and the public.

Special attention will be given to **knowledge management** and data-protection issues from the beginning, and during the whole lifetime of the project. The open-access database will be hosted by well-established academic research and data repository (at least 15 years), open and available for society. All specific details regarding data management and protection of knowledge created within the project will be specified in the Consortium Agreement (CA; data management plan), following well-known models, such as the DESCA Horizon 2020 document.

4. IMPLEMENTATION

4.1. COHERENCE AND EFFECTIVENESS OF THE WORKPLAN

4.1.1. DESCRIPTION OF WORKING GROUPS, TASKS AND ACTIVITIES

HISTRATE is comprised of **nine** working groups (WG, Figure 2) to effectively deal with the challenges. WG1 will steer the coordination of the network. WG2, led by one of the industrial partners, is dedicated to market analysis and new business models. Four WG (3-6) focus on scientific excellence. Based on the assessments in WG3-6, WG7 will focus on certification and standardisation. Training of young researchers is done in the topical WG3-6, coordinated by WG8. WG9 addresses our impact.

WG1 – Coordination & Networking Activities. WG1 will coordinate activities to promote communication, knowledge exchange and access to the Action tools. A Steering Group (SG) will be established to ensure collaboration between the WGs, to mitigate risks (see 4.1.3) and to monitor the performance at **bi-annual meetings**. The SG will be comprised of a representative from **each partner**. SG will outline a **roadmap** for networking activities (Task 1.1). The roadmap will also guide the activities within the scope of WG8-9. Within WG1, S&T core groups will be established for all following WGs. Additionally, WG1 will manage Task 1.2 to promote **involvement** of ITC members, women, and ECI.

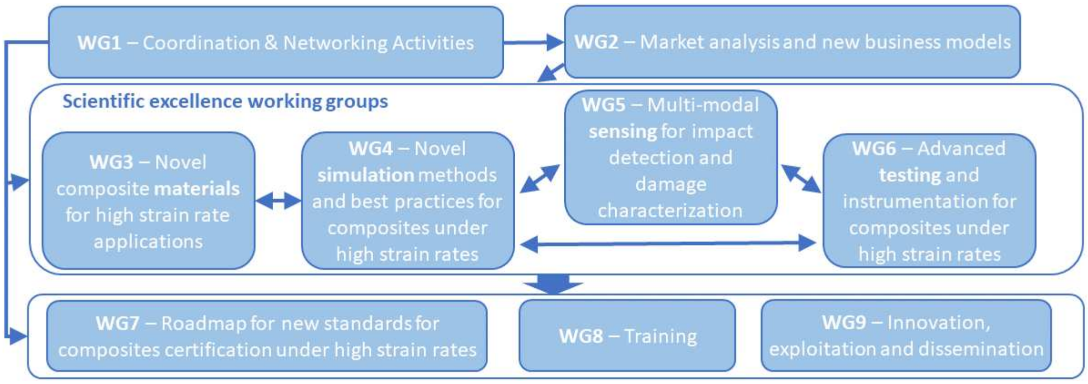


Figure 2: Interaction of working groups in the HISTRATE Action

WG2 – **Market analysis and new business models. WG2** will collect data from end-users on industrial needs and will identify barriers, commercial opportunities and policy changes, especially for certification. Task 2.1 will identify **gaps and barriers** for the application of high-performance composites for crash and safety applications. Additionally, relevant challenges of industrial partners will be identified at the "industry meets academia" workshops (Task 2.2). This information will pave the road for S&T activities. Validation of the S&T strategy will be performed based on new business models and identification of new value chains in the relevant industrial sectors. For this, industrial partners will interact with academia to find reliable and cost-effective design routes for structures under extreme dynamic loading (Task 2.3).

WG3 – **Novel composite materials for high strain rate applications. WG3** will investigate novel materials for high strain rate loading applications. Most of the time, industrial uptake (Task 3.1) of advanced composite materials involves the contradictory goals of meeting safety requirements, but also decreasing overall structure weight while reducing manufacturing cost. WG3 will overcome these issues by organizing **information exchange** between academia and industry regarding industrial use cases and benefit analyses for materials selection (Task 3.2). The focus will be on potential benefits arising from weight reduction, emissions reductions or meeting future business and regulatory needs.

WG4 – **Novel simulation methods and best practices for composites under high strain rates. WG4** will investigate the numerical techniques for simulating high strain rate phenomena in composites including complex failure mechanisms. Key issues to be addressed are the development of suitable constitutive laws for the mechanical behaviour of composites to failure and the implementation of the materials models into commercial codes (Task 4.1). WG4 will stimulate the development and use of "**standard**" or widely accepted **modelling protocols**, particularly used to characterise high-performance composite materials to build the **open access database** with material models and numerical best practices (Task 4.2). Emphasis will be given to digital tools enhancing the industrial uptake of numerical tools and accelerating the time to market/certification, such as big data processing and machine learning. WG4 will also disseminate the design practices (Task 4.3), assess their applicability in industrial environments and develop educational and training tools for wider society.

WG5 – **Multi-modal sensing for impact detection and damage characterisation. WG5** will explore sensing & smart sensors platforms and algorithms for in-situ impact and damage detection and post-loading volumetric damage characterisation to increase structural reliability and prolong useful lifetime. The focus is on new developments in embedded sensing elements, wireless technologies and IoT devices, which offer new opportunities for research and commercial exploitation of sensing high-performance composites (Task 5.1). Through WG5, knowledge will be **exchanged** between partners engaged in developing sensors and manufacturers/OEMs to develop SHM and NDT technologies for optimal sensitivity, robustness and added value (Task 5.2).

WG6 – **Advanced testing and instrumentation for composites under high strain rates. WG6** will focus on the characterisation of wave propagation, shock loading and damage initiation in composite materials, also evolution and failure under multi-axial and high-speed loading. This will include specimen design, the use of advanced optical measurement techniques, embedded sensors and NDT tools. **WG6**

brings together academic partners to collaborate on the coupling of techniques to advance real-time monitoring (Task 6.1). Expertise from industrial partners will direct the developments with a prospect of **joint proof-of-concept experiments** to demonstrate the potential usefulness of coupled characterisation tools for the benefit of WG3-5 and standardisation of testing (Task 6.2).

WG7 – **Roadmap for new standards for composites certification under high strain rates. WG7** will provide a general description of the developed methodologies and measurement procedures, requirements (including safety), system calibration and certifications, required training and qualifications raised in WGs 3-6 (Task 7.1). In this WG7, industrial partners will provide input to prepare preliminary standard recommendations adapted for the industrial sectors involved in the Action (Task 7.2).

WG8 – Training. WG8 will join training activities organised by each technical WG3-6 to contribute to the professional development of young researchers, students and potential users of the HISTRATE Action results (Task 8.1). The proposing training routes address the learners at various levels. All events will be in a **hybrid format** to ensure cost-effective and COVID-19 compatible networking.

- **Workshops** for **ECI** on materials, sensing, analysis, characterisation under impact and crash to provide the opportunity to create contacts and establish partnerships with experts across the world.
- **Training schools** for **students and ECI** from academia and industry (Task 8.2):
  - Novel composite materials for impact and crash safety applications (WG3,4; M6)
  - Simulation methods and best practices for composites under high strain rates (WG4; M18)
  - Multi-modal sensing for impact detection and damage characterisation (WG5; M30)
  - Advanced testing and instrumentation for composites under high strain rates (WG6; M42)
- A prospect of Massive Open Online Course for professional development based on the schools results.
- **Thematic Seminars/Webinars** driven by WG3-6 for **industry** to disseminate the HISTRATE Action results will be aligned with existing events, conferences and EU funded projects.
- **Short Term Scientific Missions** (STSM) for **ECI** will enable the multidisciplinary exchange of expertise between partners and will bring coherence in the Action implementation and dissemination.

WG9 – **Innovation, exploitation and dissemination. WG9** is in charge of accumulating the innovation and outreach activities of the network. It is responsible for developing and maintaining the website of HISTRATE and the **online interactive composites community hub** (Task 9.1), collection and processing of information from the scientific WG3-6 (Task 9.2). WG9 will produce targeted information to convey clear, simple and straightforward messages to ensure the dissemination of the results at local, EU and international levels (Task 9.3) via:

- **Online interactive composites community hub**: a live platform for the HISTRATE Action members to communicate, share developments, arrange collaborative initiatives;
- Meetings/events: International Conferences and workshops will be attended by all partners in order to ensure wider dissemination of the outcomes. Dedicated Workshops will also be organized in the framework of relevant events at the end of HISTRATE;
- **Open access** publications: scientific publications, conference contributions (invited, oral, posters), technical magazines, general audience articles;
- Special sessions at existing conferences;
- Media activities: constant presence in Linkedin and Twitter, HISTRATE website, newsletters.

4.1.2. DESCRIPTION OF DELIVERABLES AND TIMEFRAME

WG1	D1.1 – Continuous coordination and roadmap for networking activities, S&T groups (M48)
	D1.2 – Workshop with participants from other EU projects and COST Actions (M9)
WG2	D2.1 – Report on industrial needs and barriers (M9)
	D2.2 – “Industry meets academia” workshops (M12, M24, M36, M48)
	D2.3 – Industrial uptake and market report on activities realised within the Action (M48)
WG3	D3.1 – Industrial uptake of composite materials for impact, crash and safety applications (M12)
	D3.2 – Business plan and manufacturing upscale (M36)

WG4 D4.1 – Report on simulation methodologies and predictive capabilities (M12)
D4.2 – Open access database with material models and numerical best practices (M24)
D4.3 – Joint papers in simulations for composites under high strain rates (M12, M24, M36, M48)
WG5 D5.1 – Selection, state-of-the-art of sensors for multi-modal sensing for impact detection (M6)
D5.2 – Joint papers sensing capabilities for impact damage (M12, M24, M36, M48)
WG6 D6.1 – Selection and state-of-the-art of high strain rate testing (M6)
D6.2 – Roadmap for standardisation of high strain rate testing (M24)
WG7 D7.1 – Standards survey for certification (M12)
D7.2 – Standards recommendations for composites under crash and impact (M36)
WG8 D8.1 – Workshops for materials, sensing, analysis, characterisation under impact (M12, 24, 36, 48)
D8.2 – Training schools for students and ECI (M6, M18, M30, M42)
WG9 D9.1 – Online interactive composites community hub (M3)
D9.2 – Website with public access content and regular update (M3)
D9.3 – Data management plan (M9)
D9.4 – Dissemination plan with training schools, workshops, conferences, online training (M6)
D9.5 – Conference grants for researchers from ITC (M3, M12, M24, M36)

MILESTONES:

M1 – Dissemination plan with training schools, workshops, conferences, online training (M6)
M2 – Identification of industrial needs and barriers (M9)
M3 – Industrial uptake of composite materials for impact, crash and safety applications (M12)
M4 – Roadmap for standardisation of high strain rate testing (M24)
M5 – Standards recommendations for composites under crash and impact (M36)
M6 – Industrial uptake and market report on activities realised within the HISTRATE Action (M48)

4.1.3. RISK ANALYSIS AND CONTINGENCY PLANS

HISTRATE aims at creating a **robust network** towards certification by analysis of the identified challenges (see 1.1.2). The main risks identified for the HISTRATE Action, together with their consequences and likelihood, are reported in the following table. *The main risks lay in a limited collaboration and involvement of the partner, complemented by the* ***COVID-19*** *situation*. These risks are enhanced because of the geographical spread of the HISTRATE partners and their specific focus, e.g., industrial, economical development. To mitigate **technical** risks and **limited progress** by the partners, the value of the HISTRATE objectives will be highlighted, together with prospects for future funding. Additionally, a project health and progress monitoring system will be implemented to identify threats and and take the necessary proactive actions.

Risks [WG | consequence | likelihood]	**Mitigation actions**
Lack of collaboration and knowledge transfer Limited cross-discipline collaboration [**all** | **major** | likely]	Work-groups are built 'bottom-up', i.e., driven by partners interested in certain topics to ensure their active participation. Cross-discipline groups will be formed to meet the objectives. Provisional coordination will be implemented to track WGs performance and react if needed.
Low involvement of companies due to IP issues and/or economical factors [WG 2, 7 | **major** | possible]	Motivate industrial partners to cooperate by providing early scientific results and developing new business cases. Industrial partners may provide review and evaluation of the scientific results.
Technical risks: challenging use-cases, material compositions, etc. delaying their implementation [WG 3-6 | moderate | possible]	Identification of realistic use cases from the partners with a search for efficient and rational modelling solutions. Scaling the models down to smaller representative cases to ensure reliable model validation.
Limited certification perspectives [WG7 | moderate | possible]	Search for alternative ways towards certification by adjusting the scale, complexity and structure to realistic specifications.

Lack of local funding for research activities [WG 4-6 | **major** | possible]	In advance, partners arranged sufficient funding from national and international projects. Redistribution of the tasks within the network in case of unforeseen funding issues.
Low involvement of target participants (ECI, women, ITC) [WG 3-9 | **major** | possible]	Efforts will be spent dedicated to involve target participants. A dedicated taskforce will be established to motivate participation of target participants.
Low attendance of the meetings, workshops. Travel and meeting restrictions due to **COVID-19** [all | **major** | **certain**]	During lockdowns – shift towards on-line and blended meetings. Partners located close to each other are encouraged to meet in person, if possible. Multiple on-line sessions can potentially compensate the lack of the live interaction.
Wellbeing of the partners, including **COVID-19** issues [all | **major** | possible]	Network has ample experience with the COVID pandemic. Tasks will be redistribution between partners and within their organisations.

4.1.4. GANTT DIAGRAM

HISTRATE has parallel tasks in the technical WG3-6 to minimise the effect of risks in a certain WG delay on the overall Action performance. Therefore, the parallel WG will be managed according to a project portfolio methodology, i.e., active and standby phases are planned together with revision actions.

WG, tasks (aligned with deliverables, in short)	Year 1				Year 2				Year 3				Year 4			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
WG1 Coordination & Networking																
T1.1 Coordination and roadmap for networking																D1.1
T1.2 Workshop with other EU projects / COST			D1.2													
WG2 Market analysis and new business model																
T2.1 Industrial daps, needs and barriers			M2													R
T2.2 “Industry meets academia” workshops				D2.2				D2.2				D2.2				D2.2
T2.3 Industrial uptake and market activities report																M6
WG3 Novel composite materials																
T3.1 Industrial uptake of composite material				M3										R		
T3.2 Business plan and manufacturing upscale												D3.2		R		
WG4 Novel simulation methods																
T4.1 Simulation methodologies, predictive capab.				D4.1										R		
T4.2 Open access database								D4.2						R		
T4.3 Joint papers in simulations				D4.3				D4.3				D4.3				R

WG5 Multi-modal sensing for impact/damage																
T5.1 Selection of sensors: sensing		D5.1												R		
T5.2 Joint papers on composites with sensing				D5.2				D5.2				D5.2				R
WG6 Testing under high strain rates																
T6.1 Selection of high strain rate testing		D6.1												R		
T6.2 Roadmap for standardization of testing								M4						R		
WG7 Roadmap for new standards for certification																
T7.1 Standards survey				D7.1										R		
T7.2 Standards recommendations												M5		R		
WG8 Training																
T8.1 Conferences, workshops, seminars			W	C|W				C				C				C
T8.2 Training schools		M1				M3				M3				M3		
WG9 Exploitation and dissemination																
T9.1 Website, online composites community hub	D9.1															R
T9.2 Dissemination plan		D9.2		R				R				R		R		
T9.3 Data management plan			D9.3	R				R				R		R		
T9.4 Conf. grants for researchers from ITC	D9.4			D9.4				D9.4				D9.4				

Active main task
Active subtask
Technical task

Or Standby phase: data acquisition, analysis

C – conference
W – workshop
R – revision