

Brussels, 19 May 2026

COST 058/26

DECISION

Subject: Memorandum of Understanding for the implementation of the COST Action “Inertial fusion energy: supply Chain of laser-targets from Exploration to Delivery” (ICED) CA25144

The COST Member Countries will find attached the Memorandum of Understanding for the COST Action Inertial fusion energy: supply Chain of laser-targets from Exploration to Delivery approved by the Committee of Senior Officials at its 227th meeting held in Brussels on 19 May 2026.

MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA25144

INERTIAL FUSION ENERGY: SUPPLY CHAIN OF LASER-TARGETS FROM EXPLORATION TO DELIVERY (ICED)

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 create a sustainable laser-target supply chain to tackle: (i) production of large batches of targets and production standards towards a sufficient supply for Inertial Fusion Energy, (ii) development of targets for parametric studies that advance the understanding of laser-plasma interactions and burning plasmas, and (iii) interdisciplinarity all across the chain. 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

Recent experiments with high-energy lasers have established for the first time a burning plasma delivering more energy than was consumed for its creation. Large scale fabrication and delivery of efficient burn material is an essential pillar of Inertial Fusion Energy (IFE). These targets are currently manufactured on a small scale, and at great expense, individually or in small batches across multiple separate facilities in Europe, largely Universities or national laboratories. This Action aims at building permanent bonds between different actors in the field to

- (I) study IFE based on available target technology with the potential to discover synergies,
- (II) develop new simulation tools following up on available technology, i.e. for porous media,
- (III) create first target supply chains drawing on available expertise,
- (IV) outline a roadmap from small-scale manufacturing to large-scale fabrication,
- (V) build novel target inserter technology compatible with reactor environments,
- (VI) found working groups for different avenues towards laser-fusion, e.g. cryogenic wetted foams for direct-drive IFE and boronated targets for pB-fusion,
- (VII) strengthen the community with an early involvement of graduate students and training of young researchers.

Purpose of ICED will be to establish a network of stakeholders for the design, fabrication and supply of targets for inertial fusion energy, promoting the delivery of new technology and an advanced theoretical understanding. The action aims to facilitate access to large-scale science infrastructures for experimental and numerical studies, supporting the career growth of young scientists with training activities, and boost the production of new knowledge and innovations by breakthrough discoveries.

Areas of Expertise Relevant for the Action - Physical Sciences: Lasers, ultra-short lasers and laser physics - Physical Sciences: Gas and plasma physics (theory) - Physical Sciences: Nuclear physics (theory) - Physical Sciences: General physics - Materials engineering: Fluid dynamics (physics) for materials engineering applications	Keywords - inertial confinement fusion - inertial fusion energy production - fuel supply chain - targetry for laser-plasma experiments - additive manufacturing
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Specific Objectives

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

Research Coordination

- sharing and acquisition of new scientific knowledge and technical know-how, especially by the creation of synergies among Action participants from different backgrounds (theory / experiment) and fields (physics,

material science, additive manufacturing, chemistry, nuclear engineering)

- development of breakthroughs needs international coordination, due to the fragmented nature of the current research landscape, with strong specializations that divide groups, even with the same background and field
- development of a common understanding of essential elements of a target supply chain for Inertial Fusion Energy and a common terminology
- coordination of information seeking in experiments and for theoretical studies, comprising the benchmarking of numerical codes through the dialogue between theory and experiment, and improved confidence levels through the comparative analysis of data
- coordination of metrology and diagnostics procedures, including cross-calibration of methods
- consolidation of knowledge in a new international interdisciplinary community by creating open spaces for the free circulation of ideas and the mobility of researchers, enabling fundamental research and subsequent societal applications
- conception of safety related strategies (ionizing radiation, EMP, non-proliferation)

Capacity Building

- broadening and facilitating access to research infrastructures in Europe and outside
- fostering the knowledge exchange between scientists of different backgrounds in different fields
- bridging the fields of physics, chemistry, material science and additive manufacturing
- developing joint research agendas in the field of IFE targetry with an interdisciplinary approach
- disseminating new ideas and research concepts to promote scientific breakthroughs, and to advance knowledge and innovation
- involving emerging researchers focusing on specific target groups such as underrepresented groups, gender, Early Career Investigators, newly established teams/facilities, and researchers from countries/regions with less capacity or support in the field to increase plurality
- growing the number of participating young researchers and early career scientists, to build the foundation of the future workforce, and growing the community of collaborators by identifying new stakeholders for the network and emerging scientific topics
- enabling focused collaboration of a joint community with industry actors
- acting as a driving force for the conception of a roadmap towards a sustainable target supply chain relevant for IFE studies, with a clear perspective towards reactor-ready technology
- acting as a stakeholder in planning and supporting future capabilities and extensions of existing large-scale user facilities

TECHNICAL ANNEX

1. EXCELLENCE IN S&T AND NETWORKING

A. Main challenge

Working in the field of laser-driven fusion energy, we seek to unite existing small-scale initiatives across Europe into a cohesive community, with the aim of building a sustainable laser-target supply chain for inertial fusion power generation. In parallel, we intend to broaden the knowledge base on the design, synthesis, and fabrication of targets by engaging new expertise through industrial collaboration and interdisciplinary academic partnerships.

Ensuring a global energy sustainability is one of the greatest challenges of our age. Energy independence on all levels, from communities to nation states, enables a secure future in which technology serves the advancement of humanity. Recent breakthroughs at the National Ignition Facility (NIF) in the US, where energy gain was demonstrated for the first time, have transformed Inertial Fusion Energy (IFE) into a priority mid-term goal for the laser and plasma physics communities. IFE research from Inertial Confinement Fusion (ICF) is now actively pursued by large and diverse networks in laser physics, plasma physics, chemistry, and material science, involving industry, national laboratories, and universities alike.

Four key priorities have been identified by the high-power laser energy research roadmap [1] for progress in the field: (1) advancing the physics of laser-plasma interactions and burning plasmas; (2) developing high-energy high-repetition-rate laser technology; (3) innovating in fusion reactor materials and target systems; and (4) strengthening community building for secure carbon-free energy sources with effective methods for innovation transfer. While several of these aspects are already progressing in consolidated communities, other areas still require network development. This action is therefore designed to establish and build a community focussed on fusion-relevant target design, materials, characterization and fabrication.

The principal challenge in creating a laser-target supply chain can be divided into three interrelated strands: (i) Producing large batches of near-identical targets with exacting standards on surface roughness, shape, and chemical purity, (ii) Developing targets with controlled variations in design to enable parametric studies in IFE-relevant experiments, as well as more complex targets for interdisciplinary collaborations, and (iii) Establishing strong interconnections across all elements of the supply chain, which may necessitate distributed fabrication processes coordinated among specialised laboratories. Expanding on these three strands:

- (i) Although pioneering exploratory experiments at major laser facilities such as NIF, OMEGA and LMJ currently operate at only several shots per week, future fusion reactors intended for energy production will need to operate at shot rates of 5 to 10 Hz [1], [2]. This makes the capability for mass production of targets indispensable. While the development of reactors remains a task for the next years and decades, the recent commissioning of European laser facilities, including the three pillars of ELI (Czech Republic, Hungary and Romania), CLPU (Spain), and APOLLON (France), has already achieved shot rates of ten or more shots per hour, through the deployment of advanced high-power, high-repetition-rate laser systems. This shift in technological capability creates an immediate challenge: the demand for large batches of novel target designs, coupled with advanced metrology techniques to guarantee quality at scale.
- (ii) New approaches to ICF target fabrication need to be developed to build the increasingly complex targets necessary to take full advantage of the unique laboratory environment created by ICF experiments. Parametric studies aimed at optimising target configurations will require hundreds of thousands of tailor-made test-targets. Moreover, studies planned by various consortia [1-4] already anticipate the need for tens of thousands of targets based on existing designs. The exploration of different avenues towards efficient laser-fusion requires a vast range of different technologies, from chemical doping of materials, to depositing foam layers over cryogenically-cooled bulk material, 3D printing and nano-structured surfaces. Production of efficient targets is a challenge that demands interdisciplinary work involving experts in plasma physics, nuclear physics, two-photon polymerization, cryogenics, laser-micro-machining, chemistry, and material science.
- (iii) Implementation of target supply in the fusion reactor environment will require the incorporation of new links to fields with acceleration potential, like robotics or ballistic injection. It will be the

important challenge for the new consolidated community around IFE targetry to reach out and identify interdisciplinary research and development opportunities.

Tackling Research and Development (R&D) as well as production of large batches or a high number of complex tailor-made targets necessitates a substantial enlargement of the current workforce and an increased use of automatization. Likewise, high-repetition-rate experiments will deliver a trove of data that can be compared to theoretical predictions and used for their refinement. Crucial bottleneck is the understaffing at novel large-scale facilities for operating experiments, and for working on theoretical models.

B. Objectives

This Action will build a sustainable community around the target supply chain for IFE, comprising participants from different fields and joining experimental and theoretical groups. Challenges are addressed by (i) design optimization as well as methodology development and sharing of successful procedures for joint studies on batch production, (ii) interdisciplinary collaboration to promote cooperation of actors with complimentary capabilities in Plasma Physics, Nuclear Physics, Fusion Science, Chemistry, Material Science, and Additive Manufacturing, and (iii) creating a new interdisciplinary workspace for the definition of supply chain elements and timelines. The common challenge of understaffing will be addressed by joining forces for outreach and training activities. The Research Coordination Objectives provide guidelines for the thematic of this Action, supporting activities with a clear focus on targetry for IFE and the pathway towards the definition of efficient fuel and fuel supply. The Capacity-building Objectives define the scope of strategic goals for the newly founded community.

The ICED Action Research Coordination Objectives entail:

- sharing and acquisition of new scientific knowledge and technical know-how, especially by the creation of synergies among Action participants from different backgrounds (theory / experiment) and fields (physics, material science, additive manufacturing, chemistry, nuclear engineering),
- development of breakthroughs needs international coordination, due to the fragmented nature of the current research landscape, with strong specializations that divide groups, even with the same background and field,
- development of a common understanding of essential elements of a target supply chain for Inertial Fusion Energy and a common terminology,
- coordination of information seeking in experiments and for theoretical studies, comprising the benchmarking of numerical codes through the dialogue between theory and experiment, and improved confidence levels through the comparative analysis of data,
- coordination of metrology and diagnostics procedures, including cross-calibration of methods,
- consolidation of knowledge in a new international interdisciplinary community by creating open spaces for the free circulation of ideas and the mobility of researchers, enabling fundamental research and subsequent societal applications,
- conception of safety related strategies (ionizing radiation, EMP, non-proliferation). The Action therefore aims at supporting related scientific exploration regarding
- target topologies relevant for IFE, notably via printed and chemical foams, to define scalable technologies and numerical tools for their description,
- emerging technologies relevant for IFE, comprising wetting and cryogenic wetting of foams, micro- and nano-structuring as well as doping,
- ionization, absorption efficiency, instability growth, mixing, propagation of shocks of driven fuel and wetting before drive, processes of which optima are all depending on design parameters of targets
- diagnostics and metrology procedures, comprising neutron detection, to qualify targets at different stages of the supply chain.
- Time resolved measurements, numerical simulations and analytical calculations

This will foster collaboration between partners and unite their small-scale initiatives. It will also attract new partners and generate interdisciplinary feedback loops that aid optimizing ongoing processes.

The ICED Action Capacity-building Objectives entail:

- broadening and facilitating access to research infrastructures in Europe and outside,

- fostering the knowledge exchange between scientists of different backgrounds in different fields,
- bridging the fields of physics, chemistry, material science and additive manufacturing,
- developing joint research agendas in the field of IFE targetry with an interdisciplinary approach,
- disseminating new ideas and research concepts to promote scientific breakthroughs, and to advance knowledge and innovation,
- involving emerging researchers focusing to specific target groups such as underrepresented groups, gender, Early Career Investigators, newly established teams/facilities, and researchers from countries/regions with less capacity or support in the field to increase plurality,
- growing the number of participating young researchers and early career scientists, to build the foundation of the future workforce,
- growing the community of collaborators by identifying new stakeholders for the network and emerging scientific topics,
- enabling focused collaboration of a joint community with industry actors,
- acting as a driving force for the conception of a roadmap towards a sustainable target supply chain relevant for IFE studies, with a clear perspective towards reactor-ready technology,
- acting as a stakeholder in planning and supporting future capabilities and extensions of existing large-scale user facilities,

The action therefore aims at supporting

- (i) established conference formats and scientific journals in different fields that are of interdisciplinary character, to strengthen the case of interdisciplinarity and showcase research highlights which came to light through collaborations in the framework of this Action,
- (ii) mobilities of researchers, either to join collaborations as expert for specialized interventions, or to allow young researchers to take part in research endeavours using STSM tool,
- (iii) boosting the career of Early Career Investigators by providing a network for knowledge exchange, networking and the coordinated preparation of campaigns that aim at their research interest, as well as supporting them with conference grants,
- (iv) outreach activities like yearly meetings of COST action partners with satellite events to involve stakeholders, training activities for M.Sc. and Ph.D. level graduate students such as the creation of a series of winter schools and the contribution of specialized sessions to established summer school formats, which render the new community attractive for a future generation of scientific leaders.

C. State-of-the-art

Nuclear fusion achieved a milestone with first controlled experiments realizing a gain of energy larger than one in the domain of laser-driven inertial confinement fusion (ICF) at NIF (US). It was then followed by a series of frequent developments of performances at NIF, up to the last one of April 2025, with 8.6 MJ of yield with 2.08 MJ of overall laser energy, resulting in a target gain of 4.13 [5].

European research institutes play a major role in the promotion of Inertial Fusion Energy (IFE) by contributing with groundbreaking studies and providing experimental platforms to international collaborations. They profit from the knowledge and experience acquired during the many years of experiments at the NIF, the several direct-drive implosion experiments conducted at lower energy on OMEGA, and the many other experiments on smaller-scale facilities like ABC, LULI2000, PALS, PHELIX, and Vulcan. A first European large-scale infrastructure comparable with NIF is the Laser Megajoule (LMJ), which is being commissioned in France at present.

One of the key factors behind the ongoing series of successful exploratory experiments at NIF is the exceptional quality of the tailor-made target capsules [6]. Careful techniques of characterization of the targets prior of the experiments allowed to have clear indication on the reasons for overall performance degradation due to material defects.

NIF results have renewed the worldwide interest on ICF, but the path to future power plants is long and requires important scientific and technological steps to be undertaken. Today's cryogenic targets cost about 10 kEUR, require long preparation and characterization, and about one hour to be injected in the chamber and properly aligned [7]. For a future reactor, cheap target technology (< 1 EUR/target) will be mandatory, as well as the development of techniques for target injection and alignment at more than 1 Hz repetition rate. The development of a capability of mass production of targets and the implementation of fast and accurate methods for preparation, characterization, insertion and alignment is thus a primary set of required steps. These requirements cannot be practically accomplished with

indirect-drive schemes, and for this reason advanced direct drive methodologies, such as Shock Ignition and Fast Ignition, are today investigated as the most promising candidates for the future [1]. One of the important limitations of these schemes, where laser beams interact directly with the surface of the fuel capsule, is the onset of hydrodynamic instabilities (Rayleigh–Taylor,...) because of the non-uniform compression of the target. The most advanced proposals for solutions to these problems use micro-structured materials (also known as ‘foams’). Foams are today of interest for ICF indeed for many reasons: to enhance laser absorption, to smooth laser inhomogeneities in the transverse energy profile, to enhance ablation loading, to reduce SBS instability, to be employed inside the hohlraums to prevent wall expansion, and to function as support material for liquid nuclear fuel, namely as ‘wetted foams’ [8].

New recent advances in manufacturing, simulations and diagnostics are opening the way to a deeper and more fundamental investigation on the characteristics of the plasma generated by the action of high-power lasers. The widespread importance and interest in target topics for ICF, including also foams, has been shown by funded EUROfusion projects [9], by EU and US expert groups [10] and by tailored workshops on them [11].

Notable particular achievements comprise first steps towards automated production of foam targets for medium size batches [12] additive manufactured foam targets for experiments on high-power laser-matter interaction [13], incorporation of tracer elements in such targets [14], and their polishing [15], as well as hybrid materials based on plasma polymer thin films and nanoparticles in combination with sputtering and adjustable intrinsic porosity and structure [16]. Early experimental work investigated shock dynamics and shock collision in foam layered targets [17], foam topologies for effective and robust direct laser acceleration of electrons [18], and Rayleigh–Taylor instability growth on low-density foam targets [19].

Structuring of target surfaces and entirely structured targets have been shown to be more effective for particle (e.g. proton) acceleration [20] by enhanced laser beam energy absorption [21] Theoretical work in that respect discusses a potential for nanowire ‘implosion’ under a high-power laser beam irradiation

[22] paving the way of using such nanostructured morphologies for inertial fusion.

Technology has been used for target production and characterization, and expertise to qualify targets has been ramped up through means provided by other European and national projects. Readily available at participating infrastructures are for

- (i) production:
 - a. large scale e-beam sputtering of dielectrics (oxides, fluorides, nitrides)
 - b. metal sputter coating by physical vapor deposition (PVD) techniques
 - c. synthesis of boron, nitrogen, carbon-containing materials like NH_3BH_3 or any derivatives (with more N, more C, as well as metallic derivatives with alkali and alkaline earth elements / deuterated analogues)
 - d. pulsed laser deposition / vapor-liquid-solid technique for (bottom-up) hetero-nanostructure grow
 - e. plasma polymerization
 - f. spin coating
 - g. sol-gel process
 - h. standard thin film manual assembly
 - i. multilayering
 - j. two photon polymerization 3D printing with nanoscale resolution
 - k. SLA 3D printing
 - l. workshops with um manufacturing precision (metals)
 - m. fine cleaning
 - n. metal / metal-oxide nanoparticles incorporation into target materials
 - o. plasma nanocoating of nanoparticles and nanocomposites
 - p. soft-templating and hard-templating, for nano-structuration
 - q. nanostructured targets by electrochemical methods and by focused ion beam
 - r. low-temperature plasma-based methods for the synthesis of nanomaterials
 - s. carbon and boron freestanding targets
 - t. foams by chemical methods;
- (ii) characterization:
 - a. mass spectrometry for diagnostics of HV outgassing and HV compatibility

- b. optical spectrometry and imaging for surface diagnostics
- c. electron and ion beam microscopy and composite analysis
- d. chemical characterization
- e. short – and long – range crystalline structure characterization

D. Rationale for choosing networking to address the main challenge

IFE is attracting interest in research communities and industry, clearly demonstrated by emerging flagship programs at large-scale user facilities in Europe and a growing number of startup companies aiming at laser-fusion. This action aims at different levels of coordination, in between actors on the same level and across levels, involving (i) large-scale research infrastructures, (ii) academic groups, and (iii) industry actors. To this date, existing efforts remain on an institutional level, at best backed by national agendas (i.e. in France and Germany), which gives rise to incoherent developments by different stakeholders.

- (i) Large-scale infrastructures across Europe are already committed to ramp up their targetry capabilities, and several won grants for this purpose or are actively taking part in ongoing calls for proposals. This project aims at the coordination of new capabilities across multiple European institutes that will avoid doubling Research and Development efforts.
- (ii) The goal of the ICED Action is to bring together existing competences and reach out to involve yet disconnected research groups, to maximize the production of new knowledge, possibly giving way to breakthrough discoveries. Networking will add value by bringing together experts with diverse backgrounds, able to investigate problems with complimenting methodology.
- (iii) The Action will build bridges between traditional competitors and increase their research output through synergetic use of resources. The Action will deliver an interdisciplinary roadmap outlining essential parts of the supply chain and therefore map out investment opportunities. Cost-efficient solutions are feasible when approaching industry actors as a consolidated community demanding larger volumes, and not as small-scale actors.

Especially links between theoretical and experimental groups will allow for faster feedback cycles between theoretical conception and experimental benchmark towards targeted facility developments. A rapid ramping up of capabilities would not be possible without coordination due to the scattered nature of research groups and competencies across Europe.

Outreach and capacity-building dominate deliverables of this action. Their elaboration and implementation require many experts from different fields and background, which is only possible through pooling of resources of participating institutions and efficient networking with creative contributors. The fragmented presentation of outcomes done by individual institutions is less efficient than an Action which is able to highlight the multidisciplinary character of research outcomes.

Although user facilities finance beamtimes and support campaigns with equipment, university-based researchers face financial barriers when applying for beamtime allocation based on excellence, because they lack the means to support travel for their teams, particularly junior researchers and students. This Action involves university-based groups, empowers them to conduct excellent science and allows them to benefit from organizational skills developed in larger partner institutions. The Action will promote the use of Short Term Scientific Missions (STSM) to aid researcher mobility, especially offering opportunities to young researchers to participate in experiments, network with their peers and get trained. These efforts foster meaningful knowledge exchange, strengthen collaborative networks, and provide essential human resources for complex experimental work.

E. Critical mass of the network

The Action will gather participants that clearly demonstrate excellence in a field related to IFE targetry through past publications and their leading role in international science campaigns. Members of this Action will contribute by providing access to laboratories, specialized equipment, unique know-how, a network of collaborators and last but not least the human resources needed to address the objectives of this Action.

All partners of the Action work on growing the community by approaching potential research partners and other stakeholders in Europe and beyond. The Action will grow the network of participants in exchange with established projects, initiatives and research infrastructures, i.e.

- ELI ERIC user facilities (ESFRI): High-repetition-rate laser systems are now available in open calls for proposals, and ELI ERIC made IFE a priority by implementing an additional mission-based access scheme for dedicated studies. Decision makers and researchers working at ELI

have overlapping interests regarding this Action, i.e. to tackle the challenge of large-scale production of targets, building up a sustainable community, and training the future workforce.

- EUROFUSION Enabling Research projects exploring topics in the field of ICF: Fusion Science around ICF is the groundwork for IFE, and projects address specialised samples as basis for studies. Exploratory ICF experiments are low-repetition rate, with only several shots per week per facility, but target fabrication techniques and metrology procedures are a cornerstone of every successful study. The production of complex targets in an interdisciplinary environment therefore is an overlapping challenge regarding this Action.
- EuXFEL facility (ESFRI): High-brightness sources of X-rays and related diagnostics are foundational for precise metrology of IFE targets. EuXFEL makes beamtime available in open calls for proposals, and defined IFE a key priority for facility development, i.e. towards the implementation of a high-energy high-repetition-rate laser system. A common challenge with regard to this Action is the large-scale production of targets, community buildup and metrology.
- LaserLab Europe: The integrated pan-European initiative comprises European laser facilities and research centres that can provide beamtime for experiments and expertise to tackle joint challenges. The initiative is interdisciplinary, comprising 35 organizations from 18 countries which are active in different fields of research enabled by lasers. Common challenges of the initiative and this Action is about community growth and networking as well as the strengthening of interdisciplinary scientific collaborations based on researcher mobilities.
- LaserNetUS: The initiative communicates open calls for access and outreach activities on behalf of leading laser-facilities in the United States, aiming at attracting an international user-base to US facilities. Common challenges of the initiative with this Action comprise interdisciplinary community building to the end of interdisciplinary scientific collaborations conceiving proposals and research outputs.
- Laser4EU: Incorporate major laser research infrastructures (27) from a large number (14) of countries offering access to a broad user community from academia to industry worldwide.

The ICED Action will benefit from an exchange with industry and startup companies through the creation of career opportunities in the private sector which render the targetry community more attractive for university level students and lecturers.

2. IMPACT

A. Impact related to objectives

The Action ICED will allow researchers to work on emerging topics in an interdisciplinary environment. It will produce new scientific knowledge relevant to the scientific community of thermonuclear controlled fusion, as well as to related disciplines such as plasma physics, nuclear physics, chemistry, nano-material science, 2-photon-polymerization 3D printing, and cryogenics. All impacts are derived from research coordination and capacity building through this Action. Objectives are fully consistent with the EU's commitment to strategic autonomy in energy, technology, and industrial capability, as outlined in the European Parliament briefing on strategic autonomy and the green and digital transition.

The first objective is design optimization as well as a review of methodology and sharing of successful procedures for joint studies on batch production. It will lead to increase of created knowledge and available datasets in open repositories, allowing for faster R&D cycles and ramped up production capabilities. The second objective is interdisciplinary collaboration to promote cooperation of actors with complimentary capabilities in Plasma Physics, Nuclear Physics, Fusion Science, Chemistry, Material Science, and Additive Manufacturing. It will aid the conception of novel ideas for research endeavours and allow for realization of complex targets that are not feasible to date. The third objective is to create a new interdisciplinary space for the definition of supply chain elements and timelines. It will fast-track the development of a clear path towards IFE, allowing stakeholders to invest resources in key elements. The common objective to make efficient use of resources will be addressed by optimizing use of already allocated research grants and research endeavours of the limited workforce by building transverse connections between projects and their participants.

Short-term impacts that can be achieved in the early years of the Action comprise

- more efficient use of resources provided by national and European grants to individual

participants, allowing them to focus on their main effort and solve secondary goals in new collaborations and consortia, by providing a coordinated interdisciplinary environment,

- facilitation of access to user-facilities for exploratory studies, allowing participants to increase the likelihood of beamtime allocation, by joining similar ideas in proposals with larger scope,
- knowledge-transfer to future generations of scientists, allowing graduate students for the first time to obtain a focused insight into the science behind supplying targets for laser fusion, and young researchers to participate in high-level international collaborative research projects, by training events and an early involvement of partners,

Mid-term impacts that can be achieved towards the end of the Action are related to

- optimization of future funding opportunities through a clear guideline for policy makes, allowing projection of steps required towards a target supply chain for IFE power plants, by providing a roadmap,
- engagement of private-sector investment through involvement of industry actors, allowing outsourcing of technology development from mid-TRL to high-TRL, by providing a detailed community-based description of technology required for future supply chains.

Long-term impacts that will be enabled after the end of the Action comprise

- more excellence initiatives in the field of IFE targetry, allowing the continued creation of new knowledge through regular coordinated research efforts, by forming a joint interest group and strong collaborations,
- technology leadership in Europe, allowing participants to obtain an edge with respect to other actors, by management of intellectual property created during the action and knowledge-transfer,
- the conception of compact high-brightness neutron sources in Europe, allowing the exploration of reactor wall materials for fusion power plants and novel studies in nuclear physics, by deriving metrological tools and high-yield target designs from the scientific output of this Action,
- the implementation of IFE power plants in Europe, allowing energy independence for future generations, by creating a lasting community that tackles one of the main pillars of IFE.

Graduate students will for the first time obtain a focused insight into the science behind supplying targets for laser fusion, motivating them to participate with their research.

B. Involvement of stakeholders

This action targets experts, industry actors, policy makers and civil society. The **scientific communities** of thermonuclear fusion, material science, 2-photon-polimerization 3D printing and cryogenics will be engaged through the creation of dedicated sessions during established conferences and the organization of workshops. Particular goal is to present results in the field of IFE targetry in a special issue in partnership with **established publishers of open-source journals** (i.e. High-Power Laser Science and Engineering of Cambridge University Press). Researchers at **user-driven facilities** will have available higher-precision targetry and better theoretical models, facilitating experimental design and improving throughput. The specialization of individual efforts inside a new European framework will lead to optimization of investment at facilities and sharing of technology. Decision makers at facilities will obtain a clear roadmap with investment opportunities. **Young researchers** will benefit from an early active involvement in high-level international collaborations and experiments at large-scale facilities, which will transmit advanced skills for high-energy-density-science experiments, theoretical modelling and target manufacturing. Specific multidisciplinary training events will be organized to foster curiosity and collaboration, like a winter school “ICED in Winter” and dedicated sessions in established summer schools like the Kudowa Summer School “Towards Fusion energy”, ELISS, PlasmaSurf, and LaPlaSS. **Graduate students** will be motivated to participate with their research to the emerging topic of IFE targetry by dedicated training events during workshops. **Companies** developing target systems, cryogenics, robotics, additive manufacturing, and related metrology will benefit from co-development opportunities and traditional procurement in large-scale volumes addressing all relevant actors at the same time. Industry actors will be contacted in the framework of traditional fairs and invited to participate with their view in workshops organized by this Action. **Policy-makers** and public funders will obtain a clear roadmap for the development of target manufacturing towards the large-scale production needed for exploratory science today and fusion power plans tomorrow. National fusion programs, major international initiatives and DG RTD will gain an interdisciplinary community that can participate in future calls for high-repetition, high-gain IFE targetry. Through the project’s public engagement activities and outreach materials, the **general**

public and education stakeholders will benefit from increased transparency and understanding of fusion R&D. Annual open days at the partners are expected to attract over 100 participants. Virtual outreach impact will be measured via engagement statistics from our news and communication channels, by expecting tens of thousands of visualizations.

C. Communication, dissemination and valorisation

C. Communication, dissemination and valorisation														
TOOL →														
AUDIENCE:	website	open days	video testimonials	career-relevant posts	close-up insight posts	seminar	conferences / publications	open data	educational material	citizen Science	newsletter	press release	workshop with satellites	
general public														
school pupils														
teachers (any)														
teachers (STEM)														
university students														
young researchers														
researchers														
experts														
journalists														
politicians														
administrations														
industry actors														

D. Table 1: Summary of **CORE ACTIVITIES** and **SIDE ACTIVITIES** for dissemination and communication to different audiences by means of specific communication tools.

Outreach of the ICED Action will aim at a diverse audience on different levels, ranging from civil society at large, over students as well as scientists at universities and facilities, to political actors and administrative bodies. **Dissemination of new academic knowledge** through established formats will include **open datasets** on the Zenodo platform, **peer-reviewed publications** in open-access journals (i.e. two per year per partner indexed in Scopus/WoS) of high impact and presentations at **international scientific conferences** (e.g. more than one per year per partner at IFSA, ECLIM, HEDS). Bundling of the contributions respectively on a dedicated workspace, in dedicated sessions and a special issue will allow the adequate presentation of the multi-disciplinary field with interdisciplinary research opportunities. The establishment of monthly **online seminars** will aid the transverse exchange between Action participants and render the Action accessible to interested researchers who might consider to become participants. To the same end, a webpage and a monthly **newsletter** “ICED Times” will be published which will contain references and information to past and future events and a summary of disseminated materials. The **webpage will serve as a platform and repository** that unites and cross-links all contributions.

ICED will engage in modern dissemination tools like **social media** and **Citizen Science**, which allow for direct feedback. Informative and accessible video series and testimonials will be contributed on video platforms such as YouTube and TikTok, research career opportunities will be showcased on networks like LinkedIn and ResearchGate, and close-up insights into the work of scientists will be posted on Facebook and Twitter channels. Citizen Science will be meaningful in the framework of meticulous analysis of large datasets of target metrology, which will deliver a large verified set of training data for future machine Learning routines.

The Action will prepare **educational material** for secondary school level classes and share it with schools and teachers that are already partnering with Action participants in the framework of other projects. Follow up **visits** at interested schools will allow to showcase to pupils individual testimonials of researchers and their excitement and motivation.

Internal communications will be structured around monthly videoconferences of each working

group where group leaders will review the progress with participants and streamline Action activities. Group leaders will meet quarterly to discuss transverse activities and identify synergies between activities.

Yearly **workshops** of the ICED Action will be the opportunity to identify transverse synergies for all action participants and address different audiences by bringing them in direct contact with Action participants. Participants from different fields will obtain a platform to build links from bottom-up. Workshops will contain **satellite events** dedicated to the general public (e.g. presentation of Citizen Science opportunities), teachers (e.g. round tables for the discussion of educational materials), university students (e.g., hands-on hands on manufacturing exercises), young researchers (e.g. poster sessions), industry actors (e.g. roundtables on commercialization at scale) and policy makers (e.g. roundtables on regulatory issues). **Press releases** will summarize prominent examples for Action outcomes and engagement with different stakeholders.

3. IMPLEMENTATION

A. Action Structure

The Action will be implemented with five Working Groups, specializing on (1) training and dissemination, multi-disciplinary work towards (2) foam and cryogenic targets, (3) structured targets, and (4) doped targets, as well as the (5) drafting of a roadmap for sustainable target supply. Globally, Working Groups (2 – 4) focus on tasks involving experimental studies and theoretical modelling, i.e. their design and optimization, including analysis of results. Researchers working on theory and numerical methods will be brought into contact with experimentalists, to create closed feedback loops (a-b-a) that inform (a) the development and validation of the code chain as well as (b) the design of further experimental studies. These global networking activities will aid to resolve the challenge of uniting small and fragmented initiatives to a new community for application-oriented IFE targetry. The experimental and theoretical work will benefit from programs and infrastructure which are already established at various facilities. WGs will encourage preparation of scientific proposals to access large scale user-facilities and supercomputing platforms. Applications for access to European facilities will follow the framework of access through scientific excellence facilitated by programs like LaserLab or directly at large-scale user facilities like EuXFEL, ELI and APOLLON. Research centres outside Europe will be accessed through similar frameworks to increase the research output, e.g. through LaserNetUS in the US. The Management Committee will meet periodically to follow and encourage transverse collaboration between Working Groups. Working Group participants reassess their progress monthly in online meetings, and Working Group leaders meet quarterly to identify opportunities for implementing joint actions involving different Working Groups.

(WG1) Training, networking and dissemination: This Working Group coordinates and organizes training activities as outlined in section 2.B and dissemination / networking as described in section 2.C. It summarizes and interconnects the communication of all outcomes, i.e. experimental results, theoretical insights and steps towards a roadmap. The WG will steer the interconnection of all Working Groups and tackle the challenge to overcome a fragmented landscape with small-scale actors by building new links also within Working Groups. Particularly for the challenge to enlarge the future workforce, young researchers will be addressed actively through dissemination channels. Their inclusion into large international collaborations for research activities based in leading facilities will be aided through STSM, building up their skillset for collaborative research, management and intercultural activities. Early involvement will facilitate their career path through different academic stages (BSc. – MSc. – PhD. – Post-Doc. – Assoc. Prof.) through a consistent research interest, contributing to other Working Groups of this Action with academic thesis.

(WG2) Fuel Supply at Interdisciplinary Crossroads (Plasma Physics, Material Science, Cryogenics and Resin Development): This working group brings together experts from the fields of plasma physics, cryogenic science and technology as well as resin development for additive manufacturing via 2PP-polymerization 3D printing. The WG encompasses all experimental and theoretical results to build a basis for the large-scale production and supply of cryogenic foam targets relevant for IFE. Industry partners will be involved, i.e. from the areas of additive manufacturing, resin development and cryogenic technology.

(WG3) Efficient Fuel at Interdisciplinary Crossroads (Plasma Physics, Material Science and Chemistry): This working group unites plasma physicists, material scientists and experts in the

field of chemistry and additive manufacturing. The WG aims at experimental and theoretical results that explore micro- and nano-structuring of targets to the end of enhancing absorption efficiency of laser-light, suppressing instability growth, reducing preheat and combatting production of high-velocity projectiles emitted after Laser-Plasma interaction. Industry partners with a background in additive manufacturing, micro-mechanics and nano-structuring will be involved. This WG addresses the challenge of producing efficient fuel in an interdisciplinary environment.

(WG4) Fuel Metrology at Interdisciplinary Crossroads (Physics and Material Science): This Working group brings together scientists with a background in plasma physics, nuclear physics and material science to explore strategies for target doping beneficial to IFE applications. The WG comprises experimental and theoretical activity aiding studies relevant for WG2 and WG3 by determining target doping that allows for metrology of ignition in all stages. This WG addresses the challenge of creating metrology at relevant scales for efficient diagnosis of fuel parameters before experiments and at all stages of ignition.

(WG5) Target supply chain for IFE experiments towards energy from fusion: This Working Group collects feedback from experts in working groups WG1 to WG4 to design a sustainable target supply chain for large-scale exploratory science and a roadmap towards targetry capabilities capable of matching future demand by IFE power plants. This WG incorporates findings from WG2, WG3 and WG4 to answer to the challenge of a high demand for large batches of new target designs along with advanced metrology techniques.

WG-Management: Participants of Working Groups will plan and execute research oriented mobilities in close coordination with other national and institutional programs through STSMs. The Action will closely follow up on the creation of Intellectual Property during jointly coordinated transverse activities. While the main proposer of respective scientific activities must follow through patenting with backing of their institution, some collaborators might contribute enabling designs or utilities which allow for separate patenting. The Management Committee will elect a “Coordinator for IP” among its members that obtains the mandate to proactively enter in dialogue with involved partners to identify enabling contributions and to motivate their patenting if the main proposer chose to patent. Identification and mitigation of risks is an important aspect which the Management Committee will pay special attention to. The elected “Coordinator for Risks” will follow up on global risks of the Action and update a risk register in close collaboration with leaders of the Working Groups. It is duty of the Action Chair to enforce implementation of proposed mitigation strategies.

B. Work plan (tasks, activities and timeframe)

The Action will work out the state of the art in IFE-related targetry, with an emphasis on active issues and research opportunities, to define a realistic roadmap build on available technology and plausible near-term advances. Research and technology projects will be executed in parallel to community building activities, intended to strengthen collaborations, interdisciplinarity and career opportunities for the future workforce.

WG1 – Task1.1 Training: Subtasks are devoted to spark the interest in IFE targetry to build the future generation of scientists with a diverse background.

Task 1.1.1 Winter School “ICED in Winter”: Goal is the creation of a new framework for a winter school, which will deliver a three-day program to 30-60 participants enrolled to MSc. or PhD. programmes. Lecturers are participants of the Action and internationally recognized experts. Winter schools should be organized yearly in the last three years of the Action. A poster session will encourage young researchers to share their work with peers and an evaluation panel formed by lecturers will give direct feedback on their presentation skills.

Task 1.1.2 Training events during workshops and winter schools: Half-day training events will be organized as satellite activity during annual workshops and winter schools. Hands-on activities are feasible if workshops or winter schools are located close to one of the participating institutions; in addition, scientific proposal writing training and fostering of presentation skills in an inter-disciplinary environment are projected.

Task 1.1.3 Synergies with existing summer school formats: Thematic sessions on “IFE targetry” will be proposed to existing summer school formats, with lecturers elected based on their contribution to annual workshops of the Action. These sessions will contain an interactive part in which the audience is either polled at the beginning of the session or invited for a open discussion at its end. Feedback will be collected regarding the accessibility of hiring procedures at partner institutions, the visibility of the

targetry community, the perception of inter-disciplinarity and the career expectations of young researchers and their view on research opportunities.

Task 1.2 Networking: Subtasks comprise activities dedicated to unite small-scale initiatives and bring into contact actors from different disciplines.

Task 1.2.1 Kick-off meeting: The Action will be initiated by a kick-off meeting at its beginning for all partners to meet and have an initial dialogue of their capabilities and priorities. The Management Committee will be established and enter in its first session to elect Working Group leaders and coordinators for STSM and IP.

Task 1.2.2 Yearly workshops: Showcasing multi-disciplinary research endeavours in plenary sessions will be the core of each workshop, to be scheduled towards the end of each elapsed year. Working Group leaders will be asked to identify interdisciplinary topics for sessions or satellite events. In addition, Working Groups will present results in dedicated parallel sessions and satellite events added to address different stakeholders. The general public can be engaged through the presentation of Citizen Science opportunities, teachers can be invited for round tables about educational materials, university students can be motivated through hands-on-manufacturing exercises, young researchers can obtain a platform to present their research in a poster session, researchers and experts can enter in goal-oriented interdisciplinary roundtable discussions, journalists can be invited for reporting, politicians and administrative bodies can be engaged in roundtable discussions about regulatory issues, and industry actors can participate in an industry session for presenting their R&D and discuss commercialization at scale.

Task 1.2.3 Sourcing of dissemination materials: The state of the Action will be captured during annual workshops and quarterly meetings of the Working Group leaders. This task will compile a detailed overview of WG activities for annual reports and submit it to the Management Committee. WG Leaders will be tasked to contribute information from their WG. Most importantly, this task will relate accessible information derivatives to specialised tasks for website (T1.3.1), newsletters (T1.3.2) and educational materials for secondary schools (T1.3.3).

Task 1.2.4 Outreach to established conferences and established journals: Established conferences and journals are contacted for an implementation of sessions, satellite events or special issues related to IFE target, which are based on contributions to annual workshops of the Action. The latter allows to increase visibility and attract new participants.

Task 1.3 Dissemination: Subtasks have to goal to improve visibility and accessibility of outcomes.

Task 1.3.1 Website and Social Media: A webpage will be mounted and maintained from the beginning of the Action, not later than 6 months after its start (milestone 2). Initial information will include an accessible overview over the Action structure, memorandum of understanding, partners and results from the kick-off meeting. The website will be extended to comprise results from workshops and reports in accessible form and contain cross-linking for data-repositories and all materials created for stakeholders during the Action. Appropriate materials will be prepared for social media channels of the Action and participants.

Task 1.3.2 Newsletter: The “ICED Times” will publish monthly updates of accomplishments and announce planned activities and indicate how stakeholders can get involved. The first edition will be published not later than at the end of the first trimester (milestone 1).

Task 1.3.3 Secondary school education: Educational materials are prepared for teachers, and outreach to stakeholders will be part of annual workshops. Feedback will help improve drafted materials and networking will create a base of early adaptors can use the materials in classes. Visits of researchers to schools to share career-related and research-related testimonies can be coordinated with interested teachers.

Task 1.3.2 Open data: Scientific outputs will be prepared with emphasis on compliance with Open Science practices, i.e. open data sets will be prepared and published.

WG2 – Task 2.1 Framework for fuel supply relevant to IFE: Subtasks intended for the first year of the Action are devoted to facilitate scientific exploration towards efficient target supply.

Task 2.1.1 State of the art of target production relevant for IFE: The state-of-the art is captured and basis for a forecast on plausible achievements on a timescale of four years, considering other global actors and the agenda of the Action (milestone 3). Results are given to T5.1.1 for summary. Task 2.1.2

Ramping up production capabilities and capacity: Synergies between partners will be exploited to jointly ramp up the volume of produced targets. First batch productions are envisaged for the tenth trimester (milestone 26) Integral part of this task is the creation of a logistics framework and the

recommendation of best-practices for traceable targetry.

Task 2.2 Foam target printing: Subtasks work on practical aspects of printing and numerical description.

Task 2.2.1 Testing of different topologies: New proposals for topologies and proven concepts will be implemented by different partners at existing 2PP-printing infrastructure starting by the fourth trimester (milestone 8), to support experimental activity.

Task 2.2.2 Numerical methods: Simulation codes and theoretical models are to be refined to follow up on the correct description of now technologically feasible predictable topologies, in collaboration with Task T2.3.2 for common problems like ionisation. A first set of simulations will inform parametric studies in the sixth trimester (milestone 16). A report will cover the comparison of experimental results to theoretical predictions.

Task 2.2.3 Resin development: Materials like photopolymers and preceramic resins will be optimized. Printing with developed resins commences in the fifth trimester (milestone 12).

Task 2.3 Chemical foams: Subtasks work on practical aspects of controlled production of chemical foams and their numerical description.

Task 2.3.1 Comparison and optimization of fabrication techniques: Established techniques will be compared and suitable candidates identified by the seventh trimester (milestone 19), which will be further optimized towards mass production. First large batch production is envisaged for the twelfth trimester (milestone 30).

Task 2.3.2 Numerical methods: Simulation codes and theoretical models for stochastic foams will be optimized, in collaboration with Task T2.2.2 for common problems like ionisation. A first set of simulations inform parametric studies in the eighth trimester (milestone 21). A report will cover the comparison of experimental results to theoretical predictions.

Task 2.4 Wetting technology: Subtasks work on facilitation of foam wetting.

Task 2.4.1 Cryogenic technology: Cryogenic technology needed for wet deuterated fuel will be studied and opportunities for implementation specific to different facilities will be laid out. Test implementations are foreseen with the second round of experiments in the thirteenth trimester (milestone 31).

Task 2.4.2 Filling and micro-fluidics: Wetting of foam targets will be studied in ambient temperature for ceramic foams wetted with alcohol (milestone 23) and in cryogenic conditions for polymer foams wetted with deuterium (milestone 34).

WG3 – Task 3.1 Framework for efficient fuel relevant to IFE: Subtasks are devoted to facilitate scientific exploration towards rendering fuel more efficient.

Task 3.1.1 State of the art of target efficiency relevant for IFE: The state-of-the-art is captured and basis for a forecast on plausible achievements on a timescale of four years, considering other global actors and the agenda of the Action (milestone 4). Results are given to T5.1.1 for summary. Task 3.1.2 Parameters for fuel efficiency: Parameters that influence fuel efficiency are identified and research opportunities are summarized as basis for scientific proposals (milestone 13).

Task 3.2 Micro- and nano-structuring techniques: Subtasks work on practical aspects of structuring.

Task 3.2.1 Testing of different topologies: New proposals for topologies and proven concepts will be implemented by different partners starting by the fourth trimester (milestone 9), to support experimental activity.

Task 3.2.2 Numerical methods: Simulation codes and theoretical models are to be refined to follow up on the correct description structured targets. A first set of simulations will inform parametric studies in the sixth trimester (milestone 17). A report will cover the comparison of experimental results to theoretical predictions.

Task 3.3 Exploration of advanced structuring: Subtasks facilitate preparation of studies and scientific exploration, with milestones for first analysis results during the third year of the Action.

Task 3.3.1 Effects on absorption efficiency of laser-light (milestone 24) Task 3.3.2 Instability growth (milestone 27)

Task 3.3.3 Preheat (milestone 32)

Task 3.3.4 Production of shrapnel (milestone 35)

WG4 – Task 4.1 Framework for fuel metrology relevant to IFE: Subtasks are devoted to facilitate scientific exploration for metrology techniques and optimised operating procedures in close collaboration with Tasks T2.2, T2.3 and T3.2, towards complete metrological datasets and standardizations.

Task 4.1.1 State of the art of target metrology relevant for IFE: The state-of-the art is captured and

basis for a forecast on plausible achievements on a timescale of four years, considering other global actors and the agenda of the Action itself (milestone 5). Results are related to T5.1.1 for summary.

Task 4.1.2 Definition of a complete set of metrology: Parameters important for experiments and numerical studies are identified and research opportunities are summarized as basis for scientific proposals (milestone 7).

Task 4.2 Dedicated metrology for each step in the supply chain: Subtasks aim at grouping essential methods for metrology at different stages of target fabrication and delivery.

Task 4.2.1 Quality control: Producing large batches of targets requires novel metrology procedures and the identification of suitable techniques available at participating institutions (milestone 10).

Task 4.2.2 Pre-shot diagnostics: Imaging of samples before interaction gives valuable feedback for the initial state, recommendations are to be issued for first experiments (milestone 14).

Task 4.2.3 On-shot diagnostics: Shock-dynamics and mixing can be diagnosed by following tracers (milestone 36).

WG5 – Task 5.1 Framework of a target supply chain: Subtasks are devoted to lay out a path towards large-scale manufacturing of highly specialised fuel samples for exploratory experiments and a final supply chain for reactor fuel.

Task 5.1.1 State of the art: A systematic analysis (milestone 6) and related information from task 5.2 as well as from other Working Groups (T2.1.1, T3.1.1, T4.1.1 and T6.1.1) are summarized for a review paper.

Task 5.1.2 Supply chain definition: A sustainable target supply chain is defined for large-scale exploratory science and a roadmap towards targetry capabilities that match future demand of IFE power plants, with feedback from WG1 to WG4 and Task 5.2 collected mid-term (milestone 25). Task 5.1.3 Groundwork for implementation: Drafts for the r roundtable discussed with stakeholders and feedback is implemented (milestone 18 for a first draft and 28 for an improved draft). The roadmap is published as white paper, and stakeholders from industry, politics, and administrative bodies will be invited for a dedicated round table discussion during the last annual workshop (milestone 37).

Task 5.2 Accelerating technologies: Subtasks are devoted to create new links to technologies identified as acceleration factors.

Task 5.2.1 Insertion technology: Beginning with one-by-one handover (milestone 15), the goal is the batch insertion at elevated repetition rate (milestone 22) and a clear roadmap towards systems ready for high-repetition-rate operation (milestone 29).

Task 5.2.2 Automatic alignment: Laser- and target alignment procedures are developed and standardized to scale from manual operation (milestone 11) to fully automated shot-to-shot alignment (milestone 20) at high-repetition-rate (milestone 33).

WG-Management

The Management Committee will check and approve annual reports summarizing the status of all Working Groups, outreach activities, IP, STSM and a financial breakdown of spending and spending goals, that have been compiled by the Core Group

C. Deliverables

The deliverables are split into two groups related to the objectives of the Action, “networking deliverables” (N) for community building and accessible presentation of Action outcomes, as well as “scientific deliverables” (S) to demonstrate scientific excellence. Both groups can be subdivided into (P) periodic outputs for scheduled periodic activities, (I) individual outputs for types of deliverables which cannot yet be quantified, and (D) defined outputs that address distinct tasks for this Action. This Action creates a new interdisciplinary community around fuel for IFE, but it must be stressed that it will not contain any attempt to actually create fusion energy, build a power plant or implement bright neutron sources in commercial applications. Tangible outputs from this Action are intended to bring together a new community comprising actors with backgrounds in Physics, Material Science, and Additive Manufacturing, in order to lay out the state of the art with active issues as basis for a roadmap towards a fuel supply chain for IFE.

D1 (N:D) Report from the kick-off meeting (T1.2.1), detailing on the state-of-art, current capabilities of partners and their priorities for future developments.

D2 + D8 + D14 + D21 (S+N:P) Reports from the annual workshops (T1.2.2), detailing on the progress of work in each Working Group and their collaboration. Scientific results are highlighted, and

a report on each research project is broken down in key steps, i.e. preparation, proposal, implementation, execution, analysis, and dissemination. Results from satellite events will be summarized, including feedback. It will be elaborated how stakeholders have been involved, and if improvements to applied concepts can be proposed for the future. The second and following reports will detail how improvements to concepts have been implemented and their evaluation.

D3 (N:D) Educational materials for training during annual workshops and winter schools (T1.1.2), delivering a systematic description of activities and required equipment for trainers, including slides for introductory presentations and handout material for participants.

D4 (S:D) Peer-reviewed publication on the state of the art (T5.1.1), detailing the state of the art within Europe and on a global scale, as well as forecasting plausible research achievements for the period of the following four years with mention of prerequisites, constraints and facilitation strategies.

D5 + D10 + D16 + D25 (N:P) Annual reports (M.1) summarizing activities of each WG and stakeholder involvement based on the respective annual workshop report and outcomes from quarterly meetings of Working Group leaders and regular meetings of the Management Committee.

D6 (S:D) Joint best practices for logistics (T2.1.2), detailing strongpoints of participating institutions and how they can be interwoven to maximize production capacity.

D7 + D13 + D20 (N:P) Reports from the annual winter schools (T1.1.1) detailing on the diverse background of participants, the programme and summarizing the sessions, including feedback.

D9 (S+N:D) Educational materials for secondary school level education (T1.3.3), delivering a set of proven methods for classes and an anonymised systematic description of experiences gained during early adaptation.

D11 (S:D) Joint input to standards for metrology of the quality of produced targets (T4.2.1), detailing available technology and working procedures suitable for diagnosing large batches of targets.

D17 (S:D) Joint report on the comparison of experimental results to theoretical predictions (T2.2.2, T2.3.2, and T3.2.2), detailing on experimental results, how they compare to theoretical predictions, and recommendations for steps forward.

D18 (S:D) Joint input to standards for metrology of the state of targets before and during shots (T4.2.2 and T4.2.3), on available technology and working procedures suitable for the interaction environment. **D19 (N+S:D) White paper** "Target supply chain for IFE experiments towards energy from fusion" (T5.1.3) detailing the state of the art, essential elements of a supply chain, a common terminology and key pillars which have to be developed to ramp up capabilities. This document is intended as end-point of the feasibility evaluation and starting point for future proposals of the community created by the Action. **D22 (N:D) Report** on synergies with established summer schools (T1.1.3) summarizing the contributions of the Action to established summer schools and their impact, i.e. reporting the number of audience and their academic level as well as feedback collected during the events.

D23 (S:D) Joint report for metrology procedures and first performance results (T4.2.1, T4.2.2 and T4.2.3), detailing available technology, working procedures and obtained uncertainties and accuracies. **D24 (S:D) Joint report** for accelerating technologies and first performance results (T5.2.1 and T5.2.2), detailing available technology, working procedures and obtained uncertainties and accuracies.

D15 (N:D) Report on implementation of new spaces for communication at established conferences and scientific journals (T1.2.4) summarizing the contributions of the Action to established conferences and journals and their impact, i.e. reporting the number of audience as well as feedback collected during the events, or the number of citations.

D12 + D26 (N:D) Mid-term and final reports (M.2) summarizing activities of each WG and stakeholder involvement based on the workshop reports, outcomes from quarterly meetings of Working Group leaders, STSM, IP creation, creation of educational material and delivered training events, dissemination, and feedback collected during events. A financial breakdown will be included.

Deliverables for individual outputs (S:I) concern the following scientific deliverables:

- Research proposals will be submitted and valorised in individual deliverable **documents** containing detailed **technical diagrams**, albeit access to this content will be restricted until the proposal will have been implemented.
- **Open datasets** containing research output, raw data, meta information, setup and proposal documents / diagrams.

- Scientific peer-reviewed **papers** and **publications** which result from research of collaborations inside Working Groups and in between Working Groups, especially from the jointly proposed research activities and STSM. Topics are
 - the development of foam targets and cryogenic technology towards IFE,
 - the exploration of mechanisms which can enhance fuel efficiency,
 - the implementation of scientific instruments and methodology for metrology of targets relevant for IFE,
 - the testing of avenues towards inserter technology and automatic alignment routines,
 - the creation, optimization and benchmarking of numerical methods and theoretical models able to describe contemporary target technology,
 - the synergetic development of bright neutron sources using IFE relevant targetry.
- **Patent** submissions which result from collaborative work with a potential for commercial exploitation, i.e. for novel target topologies, inserter technology, novel simulation codes and compact bright neutron sources.

D. Gantt chart

The Action covers four years subdivided into trimesters. Deliverables indicated for each trimester are delivered at its respective end. Work starts for all Working Groups at the beginning of the first trimester.

Year	1				2				3				4			
Trimester	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
WG:	Deliverables:															
1: Net. + Dis.	1	2	3	5	7	8	9	10	13	14	15	16	20	21	22	25
2: Fuel sup.				6								17				
3: Efficiency								11					18			23
4: Metrology													19			24
5: Sup. chain			4													
Management								12								26
	Milestones:															
1: Net. + Dis.	1	2														
2: Fuel sup.		3		8	12	16	19	21	23	26		30	31	34		
3: Efficiency		4		9	13	17			24	27			32	35		
4: Metrology		5	7	10	14									36		
5: Sup. chain		6		11	15	18	20	22	25	28	29		33		37	
Management																

Table 2: Gantt chart summarizing the timeline for deliverables and milestones for each Working Group.

Working Groups 2, 3, and 4 work on scientific challenges and deliver individual output on the timeline of future calls for proposals which will be known only in the upcoming years, for each individual respective year. Already projected research activity is devoted to the access of large-scale laser facilities for experimental studies following excellence access and mission-oriented access schemes, i.e.

- experiments at the ELI laser facility “Beamlines”, in planar geometry, deploying batches of foam targets to explore ionization, absorption efficiency, instability growth, mixing, propagation of shocks and wetting,
- experiments at the ELI laser facility “Nuclear Physics”, in planar geometry, deploying batches of foam targets and structured targets to explore fusion reaction yields,
- experiments at the CLPU laser facility “VEGA”, in planar geometry, deploying structured tape targets to explore diagnostics for neutron production and develop detectors for target metrology,
- experiments at the ENEA laser facility “ABC”, in planar geometry, deploying individual foam targets and structured targets to develop detectors for metrology.

New proposals for infrastructure access will be formulated and submitted in the first year of the Action. Implementation and execution of research activities are foreseen for the second year. Results will be analysed in the third year as basis for next-level proposals, to find refined answers and determine open questions. The fourth year is devoted to the finalization of research activities,

executing last studies and disseminating all results.

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