CLEAN AVIATION
JOINT UNDERTAKING

2nd Call for Proposals: List and description of topics

ANNEX to CAJU-GB-Writ proc 2023-01 Second Amend Work Programme and Budget 2022-2023

Revision History Table		
Version n°	Issue Date	Reason for change
PP0	19/12/2022	Preliminary version of the Call topics for consultation purposes prior to launch of the Governing Board decision on adoption of the Work Programme
PP1	20/01/2023	Launched for adoption to the Governing Board
PP2	02/02/2023	Final published

Important notice on FAQ

Applicants are invited to submit their questions (technical and administrative) via the functional mailbox: CFP-2023-01@clean-aviation.eu

Questions will be analysed and, when appropriate, the Q&A will be published via the Funding &Tenders (F&T) Portal.

The FAQ session will open with the ***launch of the Call, foreseen on 9 February 2023****.*
Q&As are linked to the topics concerned. Applicants are therefore invited to check the topic documentation on the F&T Portal.

The closure date of the FAQ will be clearly stated on the F&T Portal.

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List of Topics for Calls for Proposals

Identification Code	Title	Type of Action	Ind. Value (Funding in M€)
Hydrogen-powered aircraft topics			
HORIZON-JU-CLEAN-AVIATION-2023-02-HPA-01	Hydrogen Fuel System for Direct Burn Engine Ground Test Execution and Flight Test Preparation	IA	20
HORIZON-JU-CLEAN-AVIATION-2023-02-HPA-02	Aircraft Liquid Hydrogen Fuel Distribution System Technologies for Direct Burn Applications	IA	10
HORIZON-JU-CLEAN-AVIATION-2023-02-HPA-03	Multi-MW Fuel Cell Propulsion System for Hydrogen-Powered Aircraft	IA	35
Hybrid-electric powered regional aircraft topics			
HORIZON-JU-CLEAN-AVIATION-2023-02-HER-01	Innovative Fuselage/Empennage Design for Hybrid-Electric Regional Aircraft	IA	25
HORIZON-JU-CLEAN-AVIATION-2023-03-HER-02	Open Digital Platform for Hybrid-Electric Regional Aircraft Design	IA	7
Short/short-medium range aircraft topics			
HORIZON-JU-CLEAN-AVIATION-2023-02-SMR-01	High-TRL Flight Demonstration Means for Ultra Efficient Propulsion Systems for Short and Short-Medium Range Aircraft	IA	20
HORIZON-JU-CLEAN-AVIATION-2023-02-SMR-02	Ultra Performance Wing Technologies and Integration for Short and Short-medium Range Aircraft	IA	13
HORIZON-JU-CLEAN-AVIATION-2023-02-SMR-03	Advanced Cabin and Cabin Systems Integration for Short Range and Short-Medium Range for Hydrogen-Powered Aircraft	IA	7
TOTAL	8 topics		

Identification Code	Title	Type of Action	Ind. Value (Funding in M€)
Coordination and Support Actions			
HORIZON-JU-CLEAN-AVIATION-2023-01-CSA-01	Aviation Climate and Technology Impact Monitoring Methodology	CSA	0.75
TOTAL	1 topic		

1. Clean Aviation – Hydrogen-Powered Aircraft (HPA)

I. HORIZON-JU-CLEAN-AVIATION-2022-01-HPA-01: Hydrogen Fuel System for Direct Burn Engine Ground Test Execution and Flight Test Preparation

Description of the call topic and topic and specific conditions	
Specific eligibility criterion	Legal entities established in Russia, Belarus, or in non-government controlled territories of Ukraine — Given the illegal invasion of Ukraine by Russia and the involvement of Belarus, there is currently no appropriate context allowing the implementation of the actions foreseen in this programme with legal entities established in Russia, Belarus, or in non-government controlled territories of Ukraine. Therefore, even where such entities are not subject to EU restrictive measures, such legal entities are not eligible to participate in any capacity. This includes participation as beneficiaries, affiliated entities, associated partners, third parties giving in-kind contributions, subcontractors or recipients of financial support to third parties (if any). Exceptions may be granted on a case-by-case basis for justified reasons.
Expected EU contribution per project	The Clean Aviation Joint Undertaking estimates that an EU contribution of up to EUR 20 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative funding budget for the topic is EUR 20 million. The Clean Aviation Joint Undertaking may award up to 1 project with funding depending on the outcome of the evaluation and the complementarity of the proposed actions.
Indicative project duration	Maximum 36 months.
Type of Action	Innovation Actions.
Technology Readiness Level	Activities are expected to achieve TRL 6 at fuel distribution system level at project completion (end of Phase 1), ready for an eventual flight test in Phase 2. Applicants must provide a detailed plan of the TRL steps and a roadmap (aligned with the SRIA and with the objectives as defined in the Work Programme) that can deliver the technology maturity needed by the end of Clean Aviation for the results of their project to be included in new aircraft with an entry into service no later than 2035. See General Annex B of Horizon Europe for a guide to the TRL definitions and criteria to be used.
Special skills and/or capabilities expected from the applicant(s)	The Clean Aviation Joint Undertaking expects proposals to be submitted by consortia that include system-level integrators and their supply chain with a proven track record in developing and delivering globally

	competitive fuel distribution systems to aircraft programmes, as well as key contributors from the domain of academic/scientific research and technology development. The consortium configuration should ensure the appropriate industrial, economic and supply chain interests are represented in the project and can ensure the transition from research to product innovation and market deployment no later than 2035, and with a clearly articulated route that supports the aim of replacing 75% of the operating fleet by 2050. Applicant(s) should also be able to manage large and complex international aeronautical programs demonstrating a track record of successful design, development, manufacturing and certification in the aeronautical supply chain of regional and/or single aisle aircraft at the level relevant to the topic's scope as described. Applicants should ensure their proposals and consortium reflect all necessary expertise and capabilities needed. Applicants should identify and include the additional expertise needed to complement the traditional aeronautical domain, in order to effectively address the incorporation of new/disruptive technologies. Where appropriate, the consortium should include newcomers to the programme and to the field of aeronautics and in particular SMEs, start-ups and/or knowledge centres that can bring disruptive innovation to the project as proposed.
Membership/Consortium Agreement	The topic is identified as a key contributor to the overall aircraft concepts related to short range and short-medium range aircraft. The JU Members participating in the topic must ensure compliance with the existing Membership Agreement and must conclude with the participants to the project, a suitable Consortium Agreement [CA] governing the project and its consortium. A model of the Consortium Agreement is available on the F&T portal.
Cooperation Agreement(s)	In order to ensure a programmatic approach and implementation of the programme, project(s) launched under this topic should share/exchange, as appropriate, relevant results generated in the project with other relevant projects. For this purpose, the participants in the projects selected under this topic must conclude within six months of signature of the Grant Agreement (a) Cooperation Agreement(s) with the participants implementing the projects selected under the other relevant JU topics under this call and with the ongoing projects selected under the first CAJU Call for Proposals (CfP): see further under "other relevant projects". A model of the Cooperation Agreement applicable to the projects funded under the first call CAJU CfP will be made available on the Funding & Tenders portal (F&T portal).
Impact Monitoring	Under the Impact Monitoring framework, the participants selected in this topic are also required to mention to which aircraft concept they are willing to contribute to (either SMR or HER as listed in the CAJU Work Programme) and to exchange all relevant information and data with the

	ongoing project[s] selected under the first CAJU Call for Proposals (CfP)[1], in particular SMR ACAP[2] and/or HERA[3]. The exchange should be implemented on a yearly basis as well as a final impact/performance assessment at project completion including a TRL assessment, in order to establish the Impact Monitoring mechanism as described in the Clean Aviation SRIA and Work Programme by providing a performance assessment of the key technologies, sub-systems or systems for possible integration on the future aircraft concept model developed in SMR ACAP[4] and/or HERA[5]. This will serve to assess the performance of the aircraft concepts as described in the work programme against the programme specific objectives listed in the SBA. Applicants must ensure that their internal Consortium Agreement includes the necessary provisions to allow such required exchanges of information and data outside the consortium.
Project Monitoring	The JU will perform a number of gate reviews with a key review at month 12 (or at a fixed date, to be determined) to assess the overall progress against the project plan and against the performance targets. Depending on the outcome of this key gate review, the scope of the project may be revised and/or funding reduced in case of significant issues. Mitigation actions may be requested by the JU as condition for continued funding.
In-kind contributions (IKOP/IKAA by JU Members; co-funding by other applicants)	In order to ensure the obligations for in-kind contributions by Members of the CAJU (i.e. "Founding Member", "Associated Member" and affiliated entities to a Member) can be fulfilled as set in Article 61 of the Council Regulation (EU) 2021/2085[6], annual deliverables on in-kind contributions will be set in the grant agreements for the projects selected under this topic, as well as appropriate reporting requirements. The Members responding to this topic (i.e. "Founding Member", "Associated Member" and affiliated entities) must describe in the proposal the planned in-kind contributions, indicating the level and the nature, to be provided in the course of the project. In-kind contributions to additional activities should be declared via the template model available on the F&T portal. The amount of the total in-kind contributions (i.e. in-kind contribution to operation activities and in-kind contribution to additional activities) should be no less than 1.5[7] times the funding request in aggregate for the proposal.

[1] HORIZON-JU-CLEAN-AVIATION-2022-01: link

[2] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[3] HERA Hybrid-Electric Regional Architecture; Project ID: 101102007

[4] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[5] HERA Hybrid-Electric Regional Architecture; Project ID: 101102007

[6] Council Regulation (EU) 2021/2085 of 19 November 2021. Official Journal: OJ L 427, 30.11.2021, p. 17–119. (https://data.consilium.europa.eu/doc/document/ST-12156-2021-INIT/en/pdf)

[7] In order to support a leverage factor of no less than the ratio between the contribution from members other than the Union (EUR 2 400 000 000) and the Union financial contribution (EUR 1 700 000 000), which are defined in the Council Regulation (EU) 2021/2085

	Considering that in accordance with Article 61 of the Council Regulation (EU) 2021/2085[8], only the Members of the CAJU are able to provide and report on the required minimum level of in-kind contributions, participants in the proposal who are not a "Member" of the CAJU should explain in the proposal which resources, key competences, technical and financial contributions they will be able to provide to the project and to the programme/Strategic Research and Innovation Agenda[9] at large.

Other relevant projects	This project should run in close cooperation and synchronisation with other relevant projects that will be selected under this call, as well as with ongoing projects selected under the first CAJU Call for Proposals (CfP)[10], in particular with HERA[11], SMR ACAP[12] and HYDEA[13]. The applicants should: - ensure their proposal is aligned with the Gantt chart(s) of the relevant thrust(s) as published in the Clean Aviation Work Programme 2022-2023, and duly consider interfaces and interdependencies therein, in order to ensure a consistent and coordinated approach with the other relevant projects selected under this call and the first CAJU CfP; - draw up in their proposal a list of projects selected under the first call and a list of topics published under this call for which a cooperation and access rights will be needed in order to achieve the proposal's objectives and implement the impact monitoring framework; - commit in their proposal to sign a cooperation agreement with the ongoing SMR ACAP[14] and/or HERA[15] project[s] and with the other identified projects selected under the first CAJU CfP[16]; - define a deliverable which will provide the specific technical requirements, the necessary data/information exchanges and the delivery schedule thereof with respect to the other relevant projects to support an integrated programme planning across the projects with interfaces, including a list of milestones and deliverables across the contributing projects. This deliverable must be issued by the applicants at month 6. During grant preparation, the JU may propose amendments or additions to the

[8] Council Regulation (EU) 2021/2085 of 19 November 2021 establishing the Joint Undertakings under Horizon Europe and repealing Regulations (EC) No 219/2007, (EU) No 557/2014, (EU) No 558/2014, (EU) No 559/2014, (EU) No 560/2014, (EU) No 561/2014 and (EU) No 642/2014

[9] available on the F&T portal

[10] HORIZON-JU-CLEAN-AVIATION-2022-01: link

[11] HERA - Hybrid-Electric Regional Architecture; Project ID: 101102007

[12] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[13] HYDEA – HYdrogen DEmonstrator for Aviation; Project ID: 101102019

[14] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[15] HERA - Hybrid-Electric Regional Architecture; Project ID: 101102007

[16] HORIZON-JU-CLEAN-AVIATION-2022-01: link

	list of other relevant projects on the basis of the experts' evaluation. The cooperation agreements to be concluded should allow for the future inclusion of additional relevant projects that may result from future calls. For further information, please also consult the Rules for Submission, evaluation and selection and the dedicated part in the CAJU Work Programme.
Involvement of EASA	Each project is required to exploit the involvement and expertise of EASA in the proposal to de-risk and secure the certification of novel technologies with the aim to assess and define how the envisaged solutions will have the potential for certification. Applicants are requested to establish contacts with EASA in view of seeking their possible involvement in the proposal, to discuss their possible contribution under the topic and define a detailed description of their technical activities and estimated budget which should be included in the proposal, see also section below on "Scope". The contribution of EASA should take the form of in-kind contribution under Article 9 of the Horizon Europe model Grant Agreement to be agreed under the proposal and to be implemented in the form of a service contract to be signed with EASA. The involvement of EASA in the proposal as third party may be complemented, where applicable, by other possible agreements already in place between EASA and the consortium partner in charge of the certification aspects and which may be relevant for the topic and the project execution. In such a case, the applicant should describe in the proposal the synergies and the articulation of EASA tasks and their costs coverage under such agreements in order to optimise the use of resources under the proposal. The service contract should be established based on the CAJU model service contract published under the F&T Portal. With regard to the status and role of EASA in CAJU projects, see also the CAJU Work Programme. Further guidance on EASA involvement and legal status in the proposal will be provided in the 1st Q&A of the call. Practical modalities for contacting EASA will be laid down in the 1st Q&A of the call.

Expected Outcome: Project results are expected to contribute to the following expected outcomes:

- Development (design and manufacturing of verification prototypes and verification tests) of liquid hydrogen engine fuel distribution system components for direct burn propulsion systems;
- Design, development, manufacturing and qualification testing of engine fuel control system (hardware and software), i.e. the extended control system (including interface to cockpit, interface to FADEC and engine and aircraft fuel systems) up to functional test bench;
- Deliver the qualified engine fuel system for wet rig tests and ground test of the H2 direct burn demonstration engine;

- Support validation testing of the engine fuel system up to dry and wet rig tests (without an engine) and up to ground demonstration of full functional system (with an engine) at TRL 6 by the end of Phase 1 (including post-test design adaptations/modifications);
- Determine the authorisation to proceed to installation of the integrated engine/aircraft system configuration onto the flight demonstrator aircraft including pylon detailed design (seals and heat shields), nacelle adaptations, and fire detection and protection system (i.e. enable the initiation of the "permit to fly" process);
- Anticipate flight test operations.

Scope:
Safe and reliable H2 fuel distribution systems and components (for various functions such as pumping, heating, metering, inerting, purging, cooling down) are critical for H2-powered aviation and need to be developed, extensively tested, and certified for commercial aviation.

H2 distribution system solutions will be very different when applied to liquid hydrogen storage tanks and for large or small aircraft categories and corresponding power and fuel consumption levels. In comparison to currently operational H2 distribution systems in space or automotive applications, aeronautic H2 distribution systems have very different requirements due to the operational environment (vibration, temperature, ambient pressure, sloshing, etc.) and due to the type of market (lifetime, reliability, safety, life cycle cost, etc.). The scope of this topic is the H2 engine fuel distribution system, understood as the network of all sub-systems and components starting from the HP pump, the HP distribution to the injectors including heating-up/vaporisation (and metering if done in the gas phase). Conversely, the aircraft fuel distribution system is understood as the network of all sub-systems and components, from the refuelling connection to the storage tank(s), up to the engine (i.e. up to but excluding the pylon). The main sub-systems and components are the fuelling system, the storage system and the LP pumping and LP distribution system (potentially metering if done in the liquid phase) on the aircraft side. The interface between the engine and the aircraft fuel system is considered to be before the HP pump including the pylon detailed design (seals and heat shields), nacelle adaptations, and fire detection and protection system.

The H2 fuel distribution system should provide the key functionalities:

a) adequately transport and provide the necessary H2 at the required conditions (pressure, temperature, mass flow);
b) safe and reliable operation for H2 flow control, system health monitoring, leakage detection;
c) global systemic vision of the H2 distribution system, including the overall H2 heat management and system integration on a/c level;
d) present verified components, initiate flightworthiness demonstration and an overall certifiable system to potentially feed future product needs;
e) Integration of the H2 fuel distribution system controls required to operate multiple components in coordination with each other.

The associated challenges to be addressed mainly include:

- The control of the H2 thermo-fluidic state and behaviour of H2 along the fuel system, including phase change management with the control of thermal exchanges, accounting for potential leakage of H2 and sloshing of LH2 in the H2 distribution system;

- Materials degradation with respect to H2 embrittlement, behaviour at low temperature and resistance to thermal cycling and the consequences on material life duration, but also low weight and high strength;
- H2 leakage due to improper sealing systems and the general issue of permeability for H2; Assuming there is no tight H2 equipment due to permeability, the area of H2 components has to be secured by double walls, ventilation etc., considering the higher system level aspects due to the closed aircraft environment;
- Insulation concepts of the auxiliaries that combine thermal insulation and leakage issues;
- Icing issues, in particular under cold ambient working conditions of the fuel system;
- Safety issues in case of leakage, e.g. including continuous H2 detection and monitoring (active and passive safety);
- Adequate Flow control and metering;
- Developing specific LH2 equipment: pumps, valves, heat exchangers for heating up/vaporisation, sensors, etc. adapted and scaled from existing applications to the requirements of commercial aeronautics application, e.g. regardless of the aircraft manoeuvres H2 has to be delivered to the energy consumers in the specified amount.

The main technology developments for the H2 fuel distribution system are expected to cover the following (non-exhaustive) areas:

- Safety analysis of the fuel system, including equipment failure analysis, with identification of required safety redundancy, number of tanks and equipment, use of active and passive tanks, leakage detection and management. Together with the overall system definition, also methods to evaluate overall system weight should be developed;
- Development of a specific engine fuel control system, including metering;
- Development, testing and life duration assessment of fluid-mechanical equipment and components in an aeronautics environment;
- Identification and design of required sensors in specific H2 environment (temperature sensors, pressure sensors, mass flow rate sensors, etc.);
- Investigation and demonstration of sealing technologies for the aeronautic environment. Sealing has already been used also for H2 but mainly for space application where long-term functionality is not required;
- Investigation of fire safety issues, fire extinction strategy and associated H2 specific fire system protection including sensors;
- Design of heat exchangers and pumping systems for liquid/gaseous H2;
- Investigation of insulation technologies for lightweight fuel pipes for cryogenic liquid or gaseous H2, e.g. lightweight double-insulated pipes potentially with cryogenic cooling;
- Liquid H2 pumps must be specifically developed to meet a range of pressures and mass flows demanded by a H2 propulsion system;
- Investigation and design of H2 venting mechanisms on board of the aircraft;
- Investigation of material aspects, thermal fatigue, leakage prevention / H2 permeability, fire protection;
- Analysis of safety and certification issues aspects such as standards & normalisation (and support to EPCA transversal initiatives on certification), including the identification of gaps in DO160 and proposed changes to address H2-specific topics and environments, and test facilities, ground / flight tests;
- Development of modelling and simulation capabilities: H2 flow modelling / thermal modelling / Computational Fluid Dynamics (CFD), modelling tools will have to be developed, as the behaviour of liquid or gaseous H2 will differ greatly from conventional liquid fuels. The system simulation must cover the static and especially the transient cases with the interaction and fluid

motion of liquid H2 and two-phase behaviour modelling. The models will be used for functional analysis with failure hazards assessment, system safety analysis and common mode analysis of the system;
- Activities also relevant for other areas such as H2 Storage so therefore those relevant aspects must be covered as well;
- Support Ground demonstration of full functional system (i.e. from tank to engine) with a focus on transient operations (management of LH2 vaporisation, pressure management, global heat management, etc.);
- Preparation of in-flight demonstration.

Sufficient industrial maturity should be ensured:

- Demonstrate component level TRL 4 by mid-2025 (component validation in lab environment);
- Demonstrate system level TRL 5 by end of 2025 (with sub-system validation in lab environment);
- Demonstrate system level TRL 6 by end of 2026 (sub-system prototype validation in relevant environment).

Performance Targets:

The performance targets should be defined by the applicant, consistently with constraints that are customary in the design of liquid hydrogen distribution systems for aircraft/engine applications. The applicant should provide a clear analysis of how this has been determined and how the project will develop solutions compliant with these targets. This analysis should also include effective means of monitoring progress and optimising the work statements.
The applicant should determine performance targets down to component level (pump, pipes, heat exchanger, valves, sensors, etc.) including a maturity roadmap and a strategic development plan. The latter should identify performance improvements until 2030 for critical components in view of LH2 distribution solutions in relevant aircraft integration configurations.

The main key performance indicators (KPIs) to be addressed for the relevant components of the system are summarised in the following (non-exhaustive) list:

a) Technologies Common to LH2 Equipment
   - Materials, assembly, and joining methods, including surface finish, coating and sealing;
   - Low / acceptable hydrogen permeability;
   - Manufacturing process, including management of risks e.g. contamination;
   - Management of risks related to high temperature differentials between ambient and operating conditions, e.g. thermal stresses and fatigue;
   - Compatible thermal insulation solutions;
   - Electrical and fibre-optic hermetic connections and feedthroughs for cryogenic hydrogen and flammable leakage zone environments;
   - Safety, operations and maintenance philosophy, including Prognostic Health Monitoring (PHM);
   - Standardisation and certification.

b) LH2 Fuel Pumps

- Address key risks relating to performance and life with low NPSH, including bearing solutions, materials and seals;
- Development of design process and analysis methodologies for LH2 pumps;
- Development of design solutions for electrical motor and control electronics including integration and thermal management in relation to the local LH2 environment;
- Development of LH2 pump safety and maintenance philosophies including PHM and related design solutions, in addition to review and mitigation of potential gaps in associated certification methods;
- KPIs:
    - Life (without scheduled maintenance) [HP engine pump 15 000 hours / Boost pump 60 000 Hours],
    - Hydraulic power delivered per unit mass. (in-tank electrically driven boost pump 0.3 kW/kg).

c) LH2 Valves

- Development of actuated valves for control of liquid and gaseous hydrogen distribution, addressing hydrogen compatibility, external and shutoff leakage rates, cycle life, operating speed and thermal insulation;
- Development of non-actuated valves for control of liquid and gaseous hydrogen distribution, addressing hydrogen compatibility, external and functional leakage rates and performance, cycle life, and thermal insulation:
    - Check Valves, Pressure Relief Valves, Pressure Regulation Valves.
- KPIs – individual values to be identified according to agreed project baseline for valve type:
    - Cycle Life [100 000 - 600 000] depending on type;
    - Weight per unit flow area, (≤ 3400 kg/m2 for insulated, actuated valve).

d) LH2 Conveyance Technology

- Development of LH2 pipework technology to address hydrogen environment, life, acceptable leakage, installation, thermal insulation, coupling solutions and overall weight optimisation.
- KPIs:
    - Weight per metre for a reference flow area vacuum insulated pipe (Target ≤ 1 kg/m for 1 inch flow diameter);
    - Other compatible thermal insulation solutions (< 0.1 W/mK).

e) LH2 Tank Fuel Quantity Gauging

- Develop technology for a liquid hydrogen environment, addressing safety, life and reliability when considering measurement of liquid level, tank pressure and temperature.
- KPIs:
    - Accuracy (1%) and must read zero at flight unusable fuel condition;
    - Life: (120 000 hours) operational 24 hours per day;
    - MTBF and maintainability: Solution compatible with no tank entry or tank purging except for 12-year mid-life tank access, or preferably no tank entry or tank purging in 24year life.

Proposals should include a detailed project plan with key milestones and deliverables and a list of performance targets per critical technologies associated to this plan.

Each project is required to exploit the involvement and expertise of EASA in the proposal to de-risk and secure the certification of novel fuel distribution technologies with the aim to assess and define how the envisaged solutions will have the potential for certification. Applicants are requested to establish contacts with EASA in view of seeking their possible involvement in the proposal, to discuss their possible contribution under the topic and define a detailed description of their technical activities and estimated budget which should be included in the proposal (see topic conditions related to "Involvement of EASA").

II. HORIZON-JU-CLEAN-AVIATION-2023-02-HPA-02: Aircraft Liquid Hydrogen Fuel Distribution System Technologies for Direct Burn Applications

Description of the call topic and topic and specific conditions	
Specific eligibility criterion	Legal entities established in Russia, Belarus, or in non-government controlled territories of Ukraine — Given the illegal invasion of Ukraine by Russia and the involvement of Belarus, there is currently no appropriate context allowing the implementation of the actions foreseen in this programme with legal entities established in Russia, Belarus, or in non-government controlled territories of Ukraine. Therefore, even where such entities are not subject to EU restrictive measures, such legal entities are not eligible to participate in any capacity. This includes participation as beneficiaries, affiliated entities, associated partners, third parties giving in-kind contributions, subcontractors or recipients of financial support to third parties (if any). Exceptions may be granted on a case-by-case basis for justified reasons.
Expected EU contribution per project	The Clean Aviation Joint Undertaking estimates that an EU contribution of up to EUR 10 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative funding budget for the topic is EUR 10 million. The Clean Aviation Joint Undertaking may award up to 1 project with funding depending on the outcome of the evaluation and the complementarity of the proposed actions.
Indicative project duration	Maximum 36 months.
Type of Action	Innovation Actions.
Technology Readiness Level	Activities are expected to achieve TRL 5 at fuel distribution system level at project completion, ready for an eventual flight test in Phase 2. Applicants must provide a detailed plan of the TRL steps and a roadmap (aligned with the SRIA and with the objectives as defined in the Work Programme) that can deliver the technology maturity needed by the end of Clean Aviation for the results of their project to be included in new aircraft with an entry into service no later than 2035. See General Annex B of Horizon Europe for a guide to the TRL definitions and criteria to be used.
Special skills and/or capabilities expected from the applicant(s)	The Clean Aviation Joint Undertaking expects proposals to be submitted by consortia that include system level integrators and their supply chain with a proven track record in developing and delivering globally competitive fuel distribution systems to aircraft programmes, as well as key contributors from the domain of academic/scientific research and technology development.

	The consortium configuration should ensure the appropriate industrial, economic and supply chain interests are represented in the project and can ensure the transition from research to product innovation and market deployment no later than 2035, and with a clearly articulated route that supports the aim of replacing 75% of the operating fleet by 2050. Applicant(s) should also be able to manage large and complex international aeronautical programs demonstrating a track record of successful design, development, manufacturing and certification in the aeronautical supply chain of regional and/or single aisle aircraft at the level relevant to the topic's scope as described. Applicants should ensure their proposals and consortium reflect all necessary expertise and capabilities needed. Applicants should identify and include the additional expertise needed to complement the traditional aeronautical domain, in order to effectively address the incorporation of new/disruptive technologies. Where appropriate, the consortium should include newcomers to the programme and to the field of aeronautics and in particular SMEs, start-ups and/or knowledge centres that can bring disruptive innovation to the project as proposed.
Membership/Consortium Agreement	The topic is identified as a key contributor to the overall aircraft concepts related to short range and short-medium range aircraft. The JU Members participating in the topic must ensure compliance with the existing Membership Agreement and must conclude with the participants to the project, a suitable Consortium Agreement [CA] governing the project and its consortium. A model of the Consortium Agreement is available on the F&T portal.
Cooperation Agreement(s)	In order to ensure a programmatic approach and implementation of the programme, project(s) launched under this topic should share/exchange, as appropriate, relevant results generated in the project with other relevant projects. For this purpose, the participants in the projects selected under this topic must conclude within six months of signature of the Grant Agreement (a) Cooperation Agreement(s) with the participants implementing the projects selected under the other relevant JU topics under this call and with the ongoing projects selected under the first CAJU Call for Proposals (CfP): see further under "other relevant projects". A model of the Cooperation Agreement applicable to the projects funded under the first call CAJU CfP will be made available on the Funding & Tenders portal (F&T portal).
Impact Monitoring	Under the Impact Monitoring framework, the participants selected in this topic are also required to mention to which aircraft concept they are willing to contribute to (either SMR or HER as listed in the CAJU Work Programme) and to exchange all relevant information and data with the ongoing project[s] selected under the first CAJU Call for Proposals (CfP)[17],

[17] HORIZON-JU-CLEAN-AVIATION-2022-01: link

	in particular SMR ACAP[18] and/or HERA[19]. The exchange should be implemented on a yearly basis as well as a final impact/performance assessment at project completion including a TRL assessment, in order to establish the Impact Monitoring mechanism as described in the Clean Aviation SRIA and Work Programme by providing a performance assessment of the key technologies, sub-systems or systems for possible integration on the future aircraft concept model developed in SMR ACAP[20] and/or HERA[21]. This will serve to assess the performance of the aircraft concepts as described in the work programme against the programme specific objectives listed in the SBA. Applicants must ensure that their internal Consortium Agreement includes the necessary provisions to allow such required exchanges of information and data outside the consortium.
Project Monitoring	The JU will perform a number of gate reviews with a key review at month 12 (or at a fixed date, to be determined) to assess the overall progress against the project plan and against the performance targets. Depending on the outcome of this key gate review, the scope of the project may be revised and/or funding reduced in case of significant issues. Mitigation actions may be requested by the JU as condition for continued funding.
In-kind contributions (IKOP/IKAA by JU Members; co-funding by other applicants)	In order to ensure the obligations for in-kind contributions by Members of the CAJU (i.e. "Founding Member", "Associated Member" and affiliated entities to a Member) can be fulfilled as set in Article 61 of the Council Regulation (EU) 2021/2085[22], annual deliverables on in-kind contributions will be set in the grant agreements for the projects selected under this topic, as well as appropriate reporting requirements. The Members responding to this topic (i.e. "Founding Member", "Associated Member" and affiliated entities) must describe in the proposal the planned in-kind contributions, indicating the level and the nature, to be provided in the course of the project. In-kind contributions to additional activities should be declared via the template model available on the F&T portal. The amount of the total in-kind contributions (i.e. in-kind contribution to operation activities and in-kind contribution to additional activities) should be no less than 1.5[23] times the funding request in aggregate for the proposal. Considering that in accordance with Article 61 of the Council Regulation

[18] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[19] HERA Hybrid-Electric Regional Architecture; Project ID: 101102007

[20] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[21] HERA Hybrid-Electric Regional Architecture; Project ID: 101102007

[22] Council Regulation (EU) 2021/2085 of 19 November 2021. Official Journal: OJ L 427, 30.11.2021, p. 17–119. (https://data.consilium.europa.eu/doc/document/ST-12156-2021-INIT/en/pdf)

[23] In order to support a leverage factor of no less than the ratio between the contribution from members other than the Union (EUR 2 400 000 000) and the Union financial contribution (EUR 1 700 000 000), which are defined in the Council Regulation (EU) 2021/2085

	(EU) 2021/2085[24], only the Members of the CAJU are able to provide and report on the required minimum level of in-kind contributions, participants in the proposal who are not a "Member" of the CAJU should explain in the proposal which resources, key competences, technical and financial contributions they will be able to provide to the project and to the programme/Strategic Research and Innovation Agenda[25] at large.

Other relevant projects	This project should run in close cooperation and synchronization with other relevant projects that will be selected under this call, as well as with ongoing projects selected under the first CAJU Call for Proposals (CfP)[26], in particular with HERA[27], SMR ACAP[28] and HYDEA[29] and potentially H2ELIOS[30]. The applicants should: - ensure their proposal is aligned with the Gantt chart(s) of the relevant thrust(s) as published in the Clean Aviation Work Programme 2022-2023, and duly consider interfaces and interdependencies therein, in order to ensure a consistent and coordinated approach with the other relevant projects selected under this call and the first CAJU CfP; - draw up in their proposal a list of projects selected under the first call and a list of topics published under this call for which a cooperation and access rights will be needed in order to achieve the proposal's objectives and implement the impact monitoring framework; - commit in their proposal to sign a cooperation agreement with the ongoing SMR ACAP[31] and/or HERA[32] project[s] and with the other identified projects selected under the first CAJU CfP[33]; - define a deliverable which will provide the specific technical requirements, the necessary data/information exchanges and the delivery schedule thereof with respect to the other relevant projects to support an integrated programme planning across the projects with interfaces, including a list of milestones and deliverables across the contributing projects. This deliverable must be issued by the applicants at month 6. During grant preparation, the JU may propose amendments or additions to the list of other relevant projects on the basis of the experts' evaluation.

[24] Council Regulation (EU) 2021/2085 of 19 November 2021 establishing the Joint Undertakings under Horizon Europe and repealing Regulations (EC) No 219/2007, (EU) No 557/2014, (EU) No 558/2014, (EU) No 559/2014, (EU) No 560/2014, (EU) No 561/2014 and (EU) No 642/2014

[25] available on the F&T portal

[26] HORIZON-JU-CLEAN-AVIATION-2022-01: link

[27] HERA - Hybrid-Electric Regional Architecture; Project ID: 101102007

[28] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[29] HYDEA – HYdrogen DEmonstrator for Aviation; Project ID: 101102019

[30] H2ELIOS - HydrogEn Lightweight & Innovative tank for zerO-emisSion aircraft, Project ID 101102003

[31] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[32] HERA - Hybrid-Electric Regional Architecture; Project ID: 101102007

[33] HORIZON-JU-CLEAN-AVIATION-2022-01: link

	The cooperation agreements to be concluded should allow for the future inclusion of additional relevant projects that may result from future calls. For further information, please also consult the Rules for Submission, evaluation and selection and the dedicated part in the CAJU Work Programme.
Involvement of EASA	Each project is required to exploit the involvement and expertise of EASA in the proposal to de-risk and secure the certification of novel technologies with the aim to assess and define how the envisaged solutions will have the potential for certification. Applicants are requested to establish contacts with EASA in view of seeking their possible involvement in the proposal, to discuss their possible contribution under the topic and define a detailed description of their technical activities and estimated budget which should be included in the proposal, see also section below on "Scope". The contribution of EASA should take the form of in-kind contribution under Article 9 of the Horizon Europe Model Grant Agreement (MGA) to be agreed under the proposal and to be implemented in the form of a service contract to be signed with EASA. The involvement of EASA in the proposal as third party may be complemented, where applicable, by other possible agreements already in place between EASA and the consortium partner in charge of the certification aspects and which may be relevant for the topic and the project execution. In such a case, the applicant should describe in the proposal the synergies and the articulation of EASA tasks and their costs coverage under such agreements in order to optimise the use of resources under the proposal. The service contract should be established based on the CAJU model service contract published under the F&T Portal. With regard to the status and role of EASA in CAJU projects, see also the relevant section in the CAJU Work Programme. Further guidance on EASA involvement and legal status in the proposal will be provided in the 1st Q&A of the call. Practical modalities for contacting EASA will be laid down in the 1st Q&A of the call.

Expected Outcome: Project results are expected to contribute to the following expected outcomes:

- Design, development, manufacturing and qualification of aircraft liquid hydrogen fuelling and fuel distribution system components for direct burn propulsion systems (including modelling and simulation), up to ground demonstration of full functional system at TRL 5 by the end of Phase 1.
- Perform validation testing of the aircraft fuel system up to dry and wet rig tests (without the engine fuel system).
- Support the authorisation to proceed to installation of the integrated engine/aircraft system configuration onto the flight demonstrator aircraft.
- Address all aircraft integration issues expected in relation to:

- o H2 distribution system integration in terms of space allocation of all components (pipes, manifolds, valves, pumps, heat exchangers, etc) in fuselage, wings, pylons of aircraft;
- o Heat management and component cooling system, potentially including synergies with the design of superconducting electric systems and advanced engine thermodynamics cycles intercooling;
- o Maintenance concept challenge due to cryogenics and H2 embrittlement.

Scope:

Safe and reliable H2 distribution systems and components are critical for H2-powered aviation and need to be developed, extensively tested, and certified for commercial aviation.

H2 distribution system solutions will be very different when applied to liquid hydrogen storage tanks, for large or small aircraft categories and corresponding power and fuel consumption levels. In comparison to currently operational H2 distribution systems in space or automotive applications, aeronautic H2 distribution systems have very different requirements due to the operational environment (vibration, temperature, ambient pressure, sloshing etc.) and due to the type of market (lifetime, reliability, safety, life cycle cost, etc.).

The scope of this topic is the H2 fuel distribution system onboard of the aircraft. It is understood as the network of all sub-systems and components from the refuelling connection to the storage tank(s) up to the engine (i.e. up to but excluding pylon). The main sub-systems and components are the fuelling system, the storage system and the LP pumping and distribution system (potentially metering if done in the liquid phase) on aircraft side. HP pumping and distribution to the injectors as well as vaporisation (and metering if done in the gas phase) are considered to be on the engine side.

The H2 distribution system should provide the key functionalities:

- Adequately transport and provide the necessary H2 at the required conditions (pressure, temperature, mass flow) from the tanks to the main energy conversion systems;
- Safe and reliable operation for H2 flow control, system health monitoring, leakage detection;
- auxiliary functions, e.g. cooling of temperature critical components in powertrain or other sub-systems like superconducting electric equipment (may be applicable to aircraft-side pumping systems), exploiting the low or cryogenic temperature and high pressure of H2 in the H2 distribution system;
- Global systemic vision of the H2 distribution system, including the overall H2 heat management and system integration on aircraft level;
- Present qualified components, and an overall certifiable system to feed future product needs;
- Integration of the overall control system required to operate multiple components, and energy conversion systems in coordination with each other.

The main technology developments for the H2 distribution system should include:

- Development of a specific fuel control system for the aircraft side of the fuel system including metering and components, including connectors, valves (pressure regulators, flow meters);
- Development, testing and life duration assessment of fluid-mechanical equipment and components in an aeronautics environment;

- Identification and design of a required sensor in specific H2 environment within the aircraft fuel system (fuel mass flow sensors, temperature sensors, pressure sensors, mass flow rate sensors, leak detection sensors etc.);
- Investigation and demonstration of sealing technologies for pipework connections and connections to hydrogen components, for the aeronautic environment;
- Investigation of fire safety issue, fire suppression and extinction strategy and associated H2 specific fire system protection including sensors. Specifically, this is to be studied within the aircraft internal zones where potential leakage of pressurised flammable fluid is a potential fire risk, excluding the propulsion system area;
- Design of pumping systems for liquid/gaseous H2;
- Investigation of insulation technologies for lightweight fuel pipes for cryogenic liquid or gaseous H2 e.g. lightweight double-insulated pipes potentially with cryogenic cooling.
- Liquid H2 pumps must be specifically developed to meet a range of pressures and mass flows demanded by a hybrid H2-propulsion system. This study will look at the aircraft side pumping equipment, and particularly the dual requirements for stable liquid extraction from on-board tanks and the provision of correct HP Pump inlet requirements at the engine interface;
- Investigation and design of H2 venting mechanisms on the aircraft;
- Investigation of material aspects, such as, thermal fatigue, leakage proof, H2 permeability and embrittlement, fire protection of the aircraft fuel system.
- Analysis of safety and certification issues aspects such as, standards and normalisation (and support to Clean Aviation transversal initiatives on certification); including the identification of gaps in DO160 and proposed changes to address H2-specific topics and environments, and test facilities, ground tests;
- Development of modelling and simulation capabilities: H2 flow modelling / thermal modelling / CFD, modelling tools will have to be developed for the aircraft fuel system, as the behaviour of liquid or gaseous H2 will differ greatly to conventional liquid fuels. The system simulation must cover the static and especially the transient cases with the interaction and fluid motion of liquid H2 and two-phase behaviour modelling. The models will be used for functional analysis with failure hazards assessment, system safety analysis and common mode analysis of the system;
- Ground demonstration of full functional system with focus on transient operations (LH2-vaporisation management, pressure management, global heat management). Overall system architectural digital integration for digital twin is required for system development and monitoring;
- Identify strategies and means to perform maintenance on LH2 systems, including the ground service equipment needs;
- Development of purging or inerting functions needed for refuelling, maintenance, operation or consumer shut-down.

Sufficient industrial maturity should be ensured:
- Demonstrate component level TRL 3-4 by 2024 (component validation in lab environment).
- Demonstrate system level TRL 3-4 by 2025 (with sub-system validation in lab environment).

- Demonstrate system level TRL 4-5 by end of 2026 (sub-system prototype validation in relevant environment).

Performance Targets:

The performance targets should be defined by the applicant, consistently with constraints that are customary in the design of liquid hydrogen distribution systems for aircraft applications. The applicant should provide a clear analysis of how this has been determined and how the project will develop solutions compliant with these targets. This analysis should also include effective means of monitoring progress and optimising the work statements.

The applicant should determine performance targets down to component level (pump, pipes, heat exchanger, valves, sensors, etc.) including a maturity roadmap and a strategic development plan. The latter should identify performance improvements until 2030 for critical components in view of LH2 distribution solutions in relevant aircraft integration configurations.

The main key performance indicators (KPIs) to be addressed are summarised in the following (non-exhaustive) list:

a) Technologies Common to LH2 Equipment
    - Materials, assembly, and joining methods, including surface finish, coating and sealing;
    - Low / acceptable hydrogen permeability;
    - Manufacturing process, including management of risks, e.g. contamination;
    - Management of risks related to high temperature differentials between ambient and operating conditions, e.g. thermal stresses and fatigue;
    - Compatible thermal insulation solutions;
    - Electrical and fibre-optic hermetic connections and feedthroughs for cryogenic hydrogen and flammable leakage zone environments;
    - Safety, operations and maintenance philosophy, including Prognostic Health Monitoring (PHM);
    - Standardisation and certification;

b) LH2 Fuel Pumps
    - Address key risks relating to performance and life with low NPSH, including bearing solutions, materials and seals;
    - Development of design process and analysis methodologies for LH2 pumps
    - Development of design solutions for electrical motor and control electronics including integration and thermal management in relation to the local LH2 environment;
    - Development of LH2 pump safety and maintenance philosophies including PHM and related design solutions, in addition to review and mitigation of potential gaps in associated certification methods;
    - KPIs:
        - Life (without scheduled maintenance) [HP engine pump 15,000 hours / Boost pump 60,000 Hours];

        - Hydraulic power delivered per unit mass. [In-tank Electrically driven boost pump 0.3 kW/kg].

c) LH2 Valves
- Development of actuated valves for control of liquid and gaseous hydrogen distribution, addressing hydrogen compatibility, external and shutoff leakage rates, cycle life, operating speed and thermal insulation;
- Development of non-actuated valves for control of liquid and gaseous hydrogen distribution, addressing hydrogen compatibility, external and functional leakage rates and performance, cycle life, and thermal insulation;
    - Check Valves, Pressure Relief Valves, Pressure Regulation Valves
- KPIs – individual values to be identified according to agreed project baseline for valve type:
    - Cycle Life [100,000 - 600,000] depending on type;
    - Weight per unit flow area, (≤ 3400 kg/m2 for insulated, actuated valve).

d) LH2 Conveyance Technology
- Development of LH2 pipework technology to address hydrogen environment, life, acceptable leakage, installation, thermal insulation, coupling solutions and overall weight optimisation.
- KPIs:
    - Weight per metre for a reference flow area vacuum insulated pipe (Target ≤ 1 kg/m for 1 inch flow diameter);
    - Other compatible thermal insulation solutions (< 0.1 W/mK).

e) LH2 Tank Fuel Quantity Gauging
- Develop technology for a liquid hydrogen environment, addressing safety, life and reliability when considering measurement of liquid level, tank pressure and temperature.
- KPIs:
    - Accuracy (1%) and must read zero at flight unusable fuel condition
    - Life: (120,000 hours) operational 24 hours per day
    - MTBF and maintainability: Solution compatible with no tank entry or tank purging except for 12-year mid-life tank access, or preferably no tank entry or tank purging in 24 year life.

Proposals should include a detailed project plan with key milestones and deliverables and a list of performance targets per critical technologies associated to this plan.

Each project is required to exploit the involvement and expertise of EASA in the proposal to de-risk and secure the certification of novel fuel system technologies with the aim to assess and define how the envisaged solutions will have the potential for certification. Applicants are requested to establish contacts with EASA in view of seeking their possible involvement in the proposal, to discuss their possible contribution under the topic and define a detailed description of their technical activities and estimated budget which should be included in the proposal (ref topic conditions related to "Involvement of EASA").

III. HORIZON-JU-CLEAN-AVIATION-2023-02-HPA-03: Multi-MW Fuel Cell Propulsion System for Hydrogen-Powered Aircraft

Description of the call topic and topic and specific conditions	
Specific eligibility criterion	Legal entities established in Russia, Belarus, or in non-government controlled territories of Ukraine — Given the illegal invasion of Ukraine by Russia and the involvement of Belarus, there is currently no appropriate context allowing the implementation of the actions foreseen in this programme with legal entities established in Russia, Belarus, or in non-government controlled territories of Ukraine. Therefore, even where such entities are not subject to EU restrictive measures, such legal entities are not eligible to participate in any capacity. This includes participation as beneficiaries, affiliated entities, associated partners, third parties giving in-kind contributions, subcontractors or recipients of financial support to third parties (if any). Exceptions may be granted on a case-by-case basis for justified reasons.
Expected EU contribution per project	The Clean Aviation Joint Undertaking estimates that an EU contribution of up to EUR 35 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative funding budget for the topic is EUR 35 million. The Clean Aviation Joint Undertaking may award up to one project with funding depending on the outcome of the evaluation and the complementarity of the proposed actions.
Indicative project duration	Maximum 36 months.
Type of Action	Innovation Actions.
Technology Readiness Level	Activities are expected to achieve TRL 5 at sub-systems level (1MW power level), and at least TRL 4 up to full system ground demonstration at multi-MW power level at project completion. Applicants must provide a detailed plan of the TRL steps and a roadmap (aligned with the SRIA and with the objectives as defined in the Work Programme) that can deliver the technology maturity needed by the end of Clean Aviation for the results of their project to be included in new aircraft with an entry into service no later than 2035. See General Annex B of Horizon Europe for a guide to the TRL definitions and criteria to be used.
Special skills and/or capabilities expected from the Applicant(s)	The Clean Aviation Joint Undertaking expects proposals to be submitted by consortia that include aircraft propulsion system integrators and their supply chain with a proven track record in developing and delivering globally competitive propulsion systems to aircraft programmes, as well as key contributors from the domain of academic/scientific research and technology development.

	The consortium configuration should ensure the appropriate industrial, economic and supply chain interests are represented in the project and can ensure the transition from research to product innovation and market deployment no later than 2035, and with a clearly articulated route that supports the aim of replacing 75% of the operating fleet by 2050. Applicant(s) should also be able to manage large and complex international aeronautical programs demonstrating a track record of successful design, development, manufacturing and certification in the aeronautical supply chain of regional and/or single aisle aircraft at the level relevant to the topic's scope as described. Applicants should ensure their proposals and consortium reflect all necessary expertise and capabilities needed. Applicants should identify and include the additional expertise needed to complement the traditional aeronautical domain, in order to effectively address the incorporation of new/disruptive technologies. Where appropriate, the consortium should include newcomers to the programme and to the field of aeronautics and in particular SMEs, start-ups and/or knowledge centres that can bring disruptive innovation to the project as proposed.
Membership/Consortium Agreement	The topic is identified as a key contributor to the overall aircraft concepts related to short range and short-medium range aircraft. The JU Members participating in the topic must ensure compliance with the existing Membership Agreement and must conclude with the participants to the project, a suitable Consortium Agreement [CA] governing the project and its consortium. A model of the Consortium Agreement is available on the F&T portal.
Cooperation Agreement(s)	In order to ensure a programmatic approach and implementation of the programme, project(s) launched under this topic should share/exchange, as appropriate, relevant results generated in the project with other relevant projects. For this purpose, the participants in the projects selected under this topic must conclude within six months of signature of the Grant Agreement (a) Cooperation Agreement(s) with the participants implementing the projects selected under the other relevant JU topics under this call and with the ongoing projects selected under the first CAJU Call for Proposals (CfP): see further under "other relevant projects". A model of the Cooperation Agreement applicable to the projects funded under the first call CAJU CfP will be made available on the Funding & Tenders portal (F&T portal).
Impact Monitoring	Under the Impact Monitoring framework, the participants selected in this topic are also required to mention to which aircraft concept they are willing to contribute to (either SMR or HER as listed in the CAJU Work Programme) and to exchange all relevant information and data with the ongoing project[s] selected under the first CAJU Call for Proposals (CfP)[34], in particular SMR ACAP[35] and/or HERA[36]. The exchange should be implemented on a yearly basis as well as a final impact/performance assessment at project completion including a TRL assessment,

[34] HORIZON-JU-CLEAN-AVIATION-2022-01: link
[35] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955
[36] HERA Hybrid-Electric Regional Architecture; Project ID: 101102007

	in order to establish the Impact Monitoring mechanism as described in the Clean Aviation SRIA and Work Programme by providing a performance assessment of the key technologies, sub-systems or systems for possible integration on the future aircraft concept model developed in SMR ACAP[37] and/or HERA[38]. This will serve to assess the performance of the aircraft concepts as described in the work programme against the programme specific objectives listed in the SBA. Applicants must ensure that their internal Consortium Agreement includes the necessary provisions to allow such required exchanges of information and data outside the consortium.
Project Monitoring	The JU will perform a number of gate reviews with a key review at month 12 (or at a fixed date, to be determined) to assess the overall progress against the project plan and against the performance targets. Depending on the outcome of this key gate review, the scope of the project may be revised and/or funding reduced in case of significant issues. Mitigation actions may be requested by the JU as condition for continued funding.
In-kind contributions (IKOP/IKAA by JU Members; co-funding by other applicants)	In order to ensure the obligations for in-kind contributions by Members of the CAJU (i.e. “Founding Member”, “Associated Member” and affiliated entities to a Member) can be fulfilled as set in Article 61 of the Council Regulation (EU) 2021/2085[39], annual deliverables on in-kind contributions will be set in the grant agreements for the projects selected under this topic, as well as appropriate reporting requirements. The Members responding to this topic (i.e. “Founding Member”, “Associated Member” and affiliated entities) must describe in the proposal the planned in kind contributions, indicating the level and the nature, to be provided in the course of the project, to be provided in the course of the project. In-kind contributions to additional activities should be declared via the template model available on the F&T portal. The amount of the total in-kind contributions (i.e. in-kind contribution to operation activities and in-kind contribution to additional activities) should be no less than 1.5[40] times the funding request in aggregate for the proposal. Considering that in accordance with Article 61 of the Council Regulation (EU) 2021/2085[41], only the Members of the CAJU are able to provide and report on the required minimum level of in-kind contributions, participants in the proposal who are not a “Member” of the CAJU should explain in the proposal which resources, key competences, technical and financial contributions they will be able to provide to the project and to the programme/Strategic Research and Innovation Agenda[42]

[37] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[38] HERA Hybrid-Electric Regional Architecture; Project ID: 101102007

[39] Council Regulation (EU) 2021/2085 of 19 November 2021. Official Journal: OJ L 427, 30.11.2021, p. 17–119. (https://data.consilium.europa.eu/doc/document/ST-12156-2021-INIT/en/pdf)

[40] In order to support a leverage factor of no less than the ratio between the contribution from members other than the Union (EUR 2 400 000 000) and the Union financial contribution (EUR 1 700 000 000), which are defined in the Council Regulation (EU) 2021/2085

[41] Council Regulation (EU) 2021/2085 of 19 November 2021 establishing the Joint Undertakings under Horizon Europe and repealing Regulations (EC) No 219/2007, (EU) No 557/2014, (EU) No 558/2014, (EU) No 559/2014, (EU) No 560/2014, (EU) No 561/2014 and (EU) No 642/2014

[42] available on the F&T portal

	at large.
Other relevant projects	This project should run in close cooperation and synchronisation with other relevant projects that will be selected under this call, as well as with ongoing projects selected under the first CAJU Call for Proposals (CfP)[43], in particular with HERA[44]. The applicants should: - ensure their proposal is aligned with the Gantt chart(s) of the relevant thrust(s) as published in the Clean Aviation Work Programme 2022-2023, and duly consider interfaces and interdependencies therein, in order to ensure a consistent and coordinated approach with the other relevant projects selected under this call and the first CAJU CfP; - draw up in their proposal a list of projects selected under the first call and a list of topics published under this call for which a cooperation and access rights will be needed in order to achieve the proposal's objectives and implement the impact monitoring framework; - commit in their proposal to sign a cooperation agreement with the ongoing SMR ACAP[45] and/or HERA[46] project[s] and with the other identified projects selected under the first CAJU CfP[47]; - define a deliverable which will provide the specific technical requirements, the necessary data/information exchanges and the delivery schedule thereof with respect to the other relevant projects to support an integrated programme planning across the projects with interfaces, including a list of milestones and deliverables across the contributing projects. This deliverable must be issued by the applicants at month 6. During grant preparation, the JU may propose amendments or additions to the list of other relevant projects on the basis of the experts' evaluation. The cooperation agreements to be concluded should allow for the future inclusion of additional relevant projects that may result from future calls. For further information, please also consult the Rules for Submission, evaluation and selection and the dedicated part in the CAJU Work Programme.
Involvement of EASA	Each project is required to exploit the involvement and expertise of EASA in the proposal to de-risk and secure the certification of novel technologies with the aim to assess and define how the envisaged solutions will have the potential for certification. Applicants are requested to establish contacts with EASA in view of seeking their possible involvement in the proposal, to discuss their possible contribution under the topic and define a detailed description of their technical

[43] HORIZON-JU-CLEAN-AVIATION-2022-01: link
[44] HERA - Hybrid-Electric Regional Architecture; Project ID: 101102007
[45] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955
[46] HERA - Hybrid-Electric Regional Architecture; Project ID: 101102007
[47] HORIZON-JU-CLEAN-AVIATION-2022-01: link

	activities and estimated budget which should be included in the proposal, see also section below on "Scope". The contribution of EASA should take the form of in-kind contribution under Article 9 of the Horizon Europe model Grant Agreement to be agreed under the proposal and to be implemented in the form of a service contract to be signed with EASA. The involvement of EASA in the proposal as third party may be complemented, where applicable, by other possible agreements already in place between EASA and the consortium partner in charge of the certification aspects and which may be relevant for the topic and the project execution. In such a case, the applicant should describe in the proposal the synergies and the articulation of EASA tasks and their costs coverage under such agreements in order to optimise the use of resources under the proposal. The service contract should be established based on the CAJU model service contract published under the F&T Portal. With regard to the status and role of EASA in CAJU projects, see also the relevant section of the CAJU Work Programme. Further guidance on EASA involvement and legal status in the proposal will be provided in the 1st Q&A of the call. Practical modalities for contacting EASA will be laid down in the 1st Q&A of the call.

Expected Outcome: Project results are expected to contribute to the following expected outcomes:

- Perform a detailed design optimisation (including nacelle design and integration) of a complete, compact and lightweight high-efficiency full-electric propulsion system (drive train), based on an aviation native fuel cell (as energy source from LH2) at multi-MW power level (2-4 MW), associated sub-systems and auxiliary systems (Balance of Plant: BoP), sized for regional aircraft application up to FL250;
- Demonstrate and validate experimentally by ground tests the above-described complete system at least at MW level (1MW) while proving the scalability up to multi-MW level (2-4 MW) of the complete propulsion system (drive train);
- Perform integrated research and development on components and demonstrate the validation of the above sub-systems up to TRL 5 at MW power level, in 2025, at least up to full system ground demonstration at TRL 4 at multi-MW power level;
- Investigate reliability, durability (lifetime), ageing kinetics, acoustic and vibrations, thermal, multi-stack optimisation aspects, in connection with size, weight, output power, energy efficiency, power densities (at both stack and sub-system levels), in line with the validation requirements of the previous outcome:
    - Identify main issues (including safety, reliability and certification concerns), constraints, limitations, major trade-offs required and proposed solutions or mitigations;
    - Anticipate areas which may require particular attention/efforts in subsequent R&D (e.g. technology maturity issues, heat dissipation issues, cooling requirements, thermal

management; ways to satisfy various aircraft system needs: ECS, anti-ice, etc.; system integration; compatibility of technologies with aircraft environment; methodologies, tools, testing requirements, etc.; membrane robustness to contaminants and pollution; recycling strategies, etc.)

- Perform ground demonstration and tests of a generic system incorporating the TRL 4 (1st generation) technology bricks (i.e. allowing to reach TRL 5) at a max power level allowing demonstration within the timeframe of the project;
- Identify gaps versus a new product development (Multi-MW Fuel Cell Propulsion System for full electric Regional Aircraft);
- Identify gaps in relation to certification of the H2 direct burn technology and focus on new means of compliance. Propose a qualification and certification plan linked to the proposed activities and relevant to both HER and SMR aircraft;
- Identify gaps/needs in relation to aircraft integration and in relation to information exchange (inputs/outputs) with other relevant linked projects (see table above).

<u>Scope:</u>
The topic aims to demonstrate a multi-MW fuel cell (FC) propulsion system for hydrogen-powered aircraft. In terms of a propulsion system or complete drive train, in principle, three different concepts have the potential to achieve the emissions reduction objective of -50% fuel burn (at aircraft level) for regional aircraft applications. All concepts will drive propellers to maximise propulsive efficiency as required for the given typical regional mission and range. The propulsion concepts are associated each to a reference aircraft configuration, size, scalability potential and limits:

1. Electric motors on wing and LH2 fuel cells (full electric) (~ at least 50 passengers range);
2. a) Electric motors on wing and turbogenerator and batteries (serial hybrid) (50<passengers< 85);
   b) Gas turbines on wing and motor/generator and batteries or fuel cells (parallel hybrid) (50<passengers< 85);
3. a) H2 burning gas turbines on wing (> 85 passengers);
   b) H2 burning gas turbines on wing and motor/generator and batteries or H2 fuel cells (H2 parallel hybrid) (> 85 passengers).

The present topic focuses only on the first concept.. Complete propulsion system (drive train), refers to a system or chain of components comprising all of the following elements (from LH2 tank to propeller, including all intermediate components, here referred to as “sub-systems”):

- Hydrogen Line / storage and distribution system (including LH2 tank including sensing and level metering, valve system and pipings, LH2 controls, mass-flow and pressure control for the fuel cell stack, anode recirculation, H2 purge, etc.);
- Air systems line (air inlet, filter, compressor, intercooler, humidification system, cathode recirculation, water separation, water management, air exhaust, piping and tubing, valves);
- Aviation-grade fuel cell stack sub-system with high efficiency (> 45%) and high power density (>2kW/kg) – (endplates including sensors, bipolar plates, membrane electrolyte assembly including the membrane, catalyst, gas diffusion layers (GDL), sealing, housing, attachment), including optimisation of weight and size per stack, multi-stack architecture optimisation;

- Cooling line (cooling fluids, pumps, filters, reservoirs, piping and tubing, sensors, valves, heat exchangers);
- Power line (electric distribution from fuel cells to electric motor(s), power management system (potentially including management of non-propulsive loads), motor control units, BoP inverters and BoP batteries (if needed), electric motors, gearbox and propeller).

While the second and third propulsion concepts in addition to technology bricks for electric motors, motor/generators, turbogenerators, batteries and hybrid turboprop engines are being developed under the HER thrust of the Clean Aviation partnership, the benchmark and trade-off analyses to achieve a propulsion architecture suitable to HER will be performed under the HER architecture / the platform project selected under the first CAJU Call for Proposals. HERA[48] will therefore be a significant contributor to the HER propulsion and architecture and will coordinate efforts closely with projects under the H2 thrust.

In anticipation of future work, coordination between HER aircraft architecture and propulsion systems-related projects, and with relevant activities performed outside of Clean Aviation's scope will be key to ensuring consistency at all levels (concept, configuration, programmatic, timing, objectives, orientations, etc.) and also overall work optimisation relative to the whole aircraft, systems, sub-systems and components.

A hydrogen-powered commercial aircraft with a fuel cell propulsion system is an innovative, disruptive solution that differs greatly from the current "plug and play" solution. The propulsion system and entire aircraft architecture are highly interdependent. Therefore, the propulsion, system, and aircraft architectures need to be co-designed in an integrated manner to fully match the requirements of an efficient, optimised and reliable aircraft solution.

A key enabler of this technology is the right integration. This must be optimised and demonstrated on all levels:

- Demonstration of component's integration into the fuel cell system (FCS);
- Integration of the FCS into a propelling unit (i.e. an engine) and its nacelle;
- Preparation of the integration of the engine into an aircraft.

The focus of the demonstration should be on the entire powertrain including the hydrogen storage and distribution systems. The power-to-thrust drive chain (electrical motor(s), gear box(es) and propulsor(s)) depend on both the aircraft architecture and the propulsion system architecture.

When all effects are carefully accounted for, the power-to-thrust drive train can also be compared to other concepts such as H2 direct burn technologies. This is because it also encapsulates a power provider part and a power-to-thrust part of the drive chain. On the other hand, the electrical power line needs to be considered or emulated to evaluate the system and sub-system coupling effects:

- LH2-system with fuel cell system and thermal management system (TMS);
- fuel cell system with air supply (ASP) and TMS;
- fuel cell system power with motor control unit (MCU) and motor;
- Aircraft propulsor with motor and fuel cell system;

[48] HERA - Hybrid-Electric Regional Architecture; Project ID: 101102007

- Fuel cell system with power take off for other aircraft consumers (non-propulsive loads).

The core of this topic is the use of an aviation native fuel cell for a full electric powertrain. In contrast to commercial-of-the-shelf FC stacks (i.e. stemming from automotive sector applications), an aviation graded FC powertrain for aircraft propulsion includes several specifications, requirements and constraints which need to be met and demonstrated on component level (fuel cell stack) and on system level (powertrain):

- Certification specifications for large airplanes (CS-25) and FL 250;
- Aviation specific supply chain processes and requirements;
- Safety requirements & safety policies (failure analysis, failure propagation, redundancy paths) also depending on the aircraft platform and the overall aircraft architecture;
- Operational requirements (maintainability, dispatch, reliability, endurance / lifetime)
- Performance requirements (power density, volume, overall mass, efficiency, parasitic loads, etc.).

Further benefits of an aviation native fuel cell will come from including the need of having aviation dedicated voltage levels and requirements on overall low mass architectures.

Aviation-native technologies are an effective way of ensuring that aviation-specific requirements are taken into account from the start Focusing efforts on not only technological aspects such as materials, special processes, stack technologies but also on qualification and certification activities, and the supply chain for example quality management, special process qualification and production stability over time can prove worthwhile. This is due the fact that the need to demonstrate compliance can have a significant impact on design solutions.

Current architectures of innovative aircraft candidates that support the aviation sector's transformation of the above-mentioned segment require optimised energy-to-power fuel cell powertrains that deliver 2-4 MW electrical output power. It is assumed that at demonstration level an output power of around 1 MW is required (depending on the platform) with proven scalability up to 2-4 MW. Appropriate means of relevance for the above-mentioned segment need to be made clear from an aircraft level top-down view in the proposal. It is mandatory to ensure that the envisaged test facility fits the demonstration needs.

Technologies other than PEM (polymer electrolyte membrane) fuel cells are considered less mature to have concrete application and/or demonstration within the Clean Aviation timeframe. Therefore, such technologies are not considered in-scope of this topic. Their component maturation should be performed as part of other dedicated research programmes such as the Clean Hydrogen Partnership.

Nevertheless, beneficial alternative technologies and architectures resulting in improvements in global fuel cell performance (e.g., efficiency, power-to-weight ratio) can be considered and may start to a reasonable extent from lower TRL levels.

The inclusion of batteries as an energy source in the proposed powertrain architecture is not obligatory (other than for a start-up function or similar) although solutions not including batteries will be favoured. As such, the nominal power of the system is equivalent to the nominal power of the fuel (minus losses and parasitic/non-propulsive loads). Overall system compacity and integration optimisation as well as minimisation of the electrical distribution voltage level are additional advantages which may be obtained from the use of fuel cell stacks specifically designed for aviation applications and will be positively assessed.

The powertrain system design optimisation (and ground test experimental validation) should include the thermal management solution and nacelle integration. The system control should also ideally include the management of non-propulsive loads.

Performance targets

The performance targets should be defined, developed and specified by the applicant consistently with all constraints pertaining to the design of hydrogen fuel cell power trains. The applicant should provide a clear analysis substantiating these targets and explaining how the project is developing solutions compliant with them, while providing effective means for monitoring progress and optimizing the work statements.

The applicant should determine the above targets at system, sub-system, down to component level. The targets should be accompanied by a maturity roadmap and a strategic development plan including performance improvements for critical components covering the time period until 2030, taking into account the overall HER goals defined in the Clean Aviation SRIA.

In the process of defining the above targets, appropriate parameters should be used, which may be comprised of, but not limited to: total system power, fuel cell power per stack, fuel cell stack energy efficiency, overall power system energy efficiency, bulkiness/volume/weight related efficiencies and power densities, at stack, at packaging levels and at overall power systems levels.

Each project is required to exploit the involvement and expertise of EASA in the proposal to de-risk and secure the certification of novel propulsion technologies with the aim to assess and define how the envisaged solutions will have the potential for certification. Applicants are requested to establish contact with EASA in view of seeking their possible involvement in the proposal, to discuss their possible contribution under the topic and define a detailed description of their technical activities and estimated budget which should be included in the proposal (see topic conditions related to “Involvement of EASA”).

2. Clean Aviation – Hybrid-electric powered Regional Aircraft (HER)

I. HORIZON-JU-CLEAN-AVIATION-2023-02-HER-01: Innovative Fuselage/Empennage Design for Hybrid-Electric Regional Aircraft

Description of the call topic and topic and specific conditions	
Specific eligibility criterion	Legal entities established in Russia, Belarus, or in non-government controlled territories of Ukraine — Given the illegal invasion of Ukraine by Russia and the involvement of Belarus, there is currently no appropriate context allowing the implementation of the actions foreseen in this programme with legal entities established in Russia, Belarus, or in non-government controlled territories of Ukraine. Therefore, even where such entities are not subject to EU restrictive measures, such legal entities are not eligible to participate in any capacity. This includes participation as beneficiaries, affiliated entities, associated partners, third parties giving in-kind contributions, subcontractors or recipients of financial support to third parties (if any). Exceptions may be granted on a case-by-case basis for justified reasons.
Expected EU contribution per project	The Clean Aviation Joint Undertaking estimates that an EU contribution of up to EUR 25 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative funding budget for the topic is EUR 25 million. The Clean Aviation Joint Undertaking may award one project with funding depending on the outcome of the evaluation and the complementarity of the proposed actions.
Indicative project duration	Maximum 36 months.
Type of Action	Innovation Actions.
Technology Readiness Level	Proposed solutions and technologies are expected to have TRL 3 at subsystem or component level at their minimum entry point. Activities are expected to achieve TRL 5 at major component/assembly or system level (e.g. a barrel) at project completion. Applicants must provide a detailed plan of the TRL steps and a roadmap (aligned with the SRIA and with the objectives as defined in the Work Programme) that can deliver the technology maturity needed by the end of Clean Aviation for the results of their project to be included in new aircraft with an entry into service no later than 2035. See General Annex B of Horizon Europe for a guide to the TRL definitions and criteria to be used.
Special skills and/or capabilities expected from the applicant(s)	The Clean Aviation Joint Undertaking expects proposals to be submitted by consortia that include airframe/aerostructures integrators and their supply chain with a proven track record in developing and delivering

	globally competitive airframe/aerostructures to aircraft programmes, as well as key contributors from the domain of academic/scientific research and technology development. The consortium configuration should ensure the appropriate industrial, economic and supply chain interests are represented in the project and can ensure the transition from research to product innovation and market deployment no later than 2035, and with a clearly articulated route that supports the aim of replacing 75% of the operating fleet by 2050. Applicant(s) should be able to manage large and complex international aeronautical programs demonstrating a track record of successful design, development, manufacturing and certification in the aeronautical supply chain of regional and/or single aisle aircraft at the level relevant to the topic's scope as described. Applicants should ensure their proposals and consortium reflect all necessary expertise and capabilities needed. Applicants should identify and include the additional expertise needed to complement the traditional aeronautical domain, in order to effectively address the incorporation of new/disruptive technologies. Where appropriate, the consortium should include newcomers to the programme and to the field of aeronautics and in particular SMEs, start-ups and/or knowledge centres that can bring disruptive innovation to the project as proposed.
Membership/Consortium agreement	The topic is identified as a key contributor to the overall aircraft concepts related to regional and short and short-medium range aircraft. The JU Members participating in the topic must ensure compliance with the existing Membership Agreement and must conclude with the participants to the project, a suitable Consortium Agreement [CA] governing the project and its consortium. A model of the Consortium Agreement is available on the F&T portal.
Cooperation Agreement(s)	In order to ensure a programmatic approach and implementation of the programme, project(s) launched under this topic should share/exchange, as appropriate, relevant results generated in the project with other relevant projects. For this purpose, the participants in the projects selected under this topic must conclude within six months of signature of the Grant Agreement (a) Cooperation Agreement(s) with the participants implementing the projects selected under the other relevant JU topics under this call and with the ongoing projects selected under the first CAJU Call for Proposals (CfP)[49]: see further under "other relevant projects". A model of the Cooperation Agreement applicable to the projects funded under the first call will be made available on the Funding & Tenders portal (F&T portal).

[49] HORIZON-JU-CLEAN-AVIATION-2022-01: link

Impact Monitoring	Under the Impact Monitoring framework, the participants selected in this topic are also required to mention to which aircraft concept they are willing to contribute to (either SMR or HER as listed in the CAJU Work Programme) and to exchange all relevant information and data with the ongoing project[s] selected under the first CAJU Call for Proposals (CfP)[50], in particular SMR ACAP[51] and/or HERA[52]. The exchange should be implemented on a yearly basis as well as a final impact/performance assessment at project completion including a TRL assessment, in order to establish the Impact Monitoring mechanism as described in the Clean Aviation SRIA and Work Programme by providing a performance assessment of the key technologies, sub-systems or systems for possible integration on the future aircraft concept model developed in SMR ACAP[53] and/or HERA[54]. This will serve to assess the performance of the aircraft concepts as described in the work programme against the programme specific objectives listed in the SBA. Applicants must ensure that their internal Consortium Agreement includes the necessary provisions to allow such required exchanges of information and data outside the consortium.
Project Monitoring	The JU will perform a number of gate reviews with a key review at month 12 (or at a fixed date, to be determined) to assess the overall progress against the project plan and against the performance targets. Depending on the outcome of this key gate review, the scope of the project may be revised and/or funding reduced in case of significant issues. Mitigation actions may be requested by the JU as condition for continued funding.
In-kind contributions (IKOP/IKAA by JU Members; co-funding by other applicants)	In order to ensure the obligations for in-kind contributions by Members of the CAJU (i.e., "Founding Member", "Associated Member" and affiliated entities to a Member) can be fulfilled as set in Article 61 of the Council Regulation (EU) 2021/2085[55], annual deliverables on in-kind contributions will be set in the grant agreements for the projects selected under this topic, as well as appropriate reporting requirements. The Members responding to this topic (i.e., "Founding Member", "Associated Member" and affiliated entities) must describe in the proposal the planned in-kind contributions, indicating the level and the nature, to be provided in the course of the project. In-kind contributions to additional activities should be declared via the template model available on the F&T portal. The amount of the total in-kind contributions (i.e. in-kind contribution to operation activities and in-kind contribution

[50] HORIZON-JU-CLEAN-AVIATION-2022-01: link

[51] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[52] HERA Hybrid-Electric Regional Architecture; Project ID: 101102007

[53] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[54] HERA Hybrid-Electric Regional Architecture; Project ID: 101102007

[55] Council Regulation (EU) 2021/2085 of 19 November 2021. Official Journal: OJ L 427, 30.11.2021, p. 17–119. (https://data.consilium.europa.eu/doc/document/ST-12156-2021-INIT/en/pdf)

	to additional activities) should be no less than 1.5[56] times the funding request in aggregate for the proposal. Considering that in accordance with Article 61 of the Council Regulation (EU) 2021/2085[57], only the Members of the CAJU are able to provide and report on the required minimum level of in-kind contributions, participants in the proposal who are not a "Member" of the CAJU should explain in the proposal which resources, key competences, technical and financial contributions they will be able to provide to the project and to the programme/Strategic Research and Innovation Agenda[58] at large.

Other relevant projects	This project should run in close cooperation and synchronisation with other relevant projects that will be selected under this call, as well as with ongoing projects selected under the first CAJU Call for Proposals (CfP)[59], in particular with HERA[60]: The applicants should: - ensure their proposal is aligned with the Gantt chart(s) of the relevant thrust(s) as published in the Clean Aviation Work Programme 2022-2023, and duly consider interfaces and interdependencies therein, to ensure a consistent and coordinated approach with the other relevant projects selected under this call and the first CAJU CfP; - draw up in their proposal a list of projects selected under the first call and a list of topics published under this call for which a cooperation and access rights will be needed in order to achieve the proposal's objectives and implement the impact monitoring framework; - commit in their proposal to sign a cooperation agreement with the ongoing SMR ACAP[61] and/or HERA[60] project[s] and with the other identified projects selected under the first CAJU CfP[59], - define a deliverable which will provide the specific technical requirements, the necessary data/information exchanges and the delivery schedule thereof with respect to the other relevant projects to support an integrated programme planning across the projects with interfaces, including a list of milestones and deliverables across the contributing projects. This deliverable must be issued by the applicants at month 6.

56 In order to support a leverage factor of no less than the ratio between the contribution from members other than the Union (EUR 2 400 000 000) and the Union financial contribution (EUR 1 700 000 000), which are defined in the Council Regulation (EU) 2021/2085

57 Council Regulation (EU) 2021/2085 of 19 November 2021 establishing the Joint Undertakings under Horizon Europe and repealing Regulations (EC) No 219/2007, (EU) No 557/2014, (EU) No 558/2014, (EU) No 559/2014, (EU) No 560/2014, (EU) No 561/2014 and (EU) No 642/2014

58 available on the F&T portal

59 HORIZON-JU-CLEAN-AVIATION-2022-01: link

60 HERA - Hybrid-Electric Regional Architecture; Project ID: 101102007

61 SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

	During grant preparation, the JU may propose amendments or additions to the list of other relevant projects on the basis of the evaluation. The cooperation agreements to be concluded should allow for future inclusion additional other relevant projects that may result from future calls. For further information, please also consult the Rules for Submission, evaluation and selection and the dedicated part in the CAJU Work Programme.
Involvement of EASA	Each project is required to exploit the involvement and expertise of EASA in the proposal to de-risk and secure the certification of novel technologies with the aim to assess and define how the envisaged solutions will have the potential for certification. Applicants are requested to establish contacts with EASA in view of seeking their possible involvement in the proposal, to discuss their possible contribution under the topic and define a detailed description of their technical activities and estimated budget which should be included in the proposal, see also section below on “Scope”. The contribution of EASA should take the form of in-kind contribution under Article 9 of the Horizon Europe model Grant Agreement to be agreed under the proposal and to be implemented in the form of a service contract to be signed with EASA. The involvement of EASA in the proposal as third party may be complemented, where applicable, by other possible agreements already in place between EASA and the consortium partner in charge of the certification aspects and which may be relevant for the topic and the project execution. In such a case, the applicant should describe in the proposal the synergies and the articulation of EASA tasks and their costs coverage under such agreements in order to optimise the use of resources under the proposal. The service contract should be established based on the CAJU model service contract published under the F&T Portal. With regard to the status and role of EASA in CAJU projects, see also the CAJU Work Programme. Further guidance on EASA involvement and legal status in the proposal will be provided in the 1st Q&A of the call. Practical modalities for contacting EASA will be laid down in the 1st Q&A of the call.

Expected Outcome:

Project results are expected to contribute to the following expected outcomes:

- Deliver an in-depth analysis of the 2020 state-of-the-art for all relevant components of the fuselage plus sub-/systems and the expected developments currently underway. The analysis should also highlight the new unique elements in the proposed activity compared to previous research projects (e.g. funded under the Clean Sky 2 programme) and how results from these projects can be leveraged.

- Identify and deliver an innovative complete fuselage design including the empennage for the targeted concept for a hybrid-electric regional (HER) aircraft with maximum aerodynamic efficiency and minimum weight, contributing to the targeted fuel burn reduction of minimum 50%[62] at aircraft level, while taking into account:
    - the integration of the hybrid-electric propulsion system and subsystems into the fuselage (depending on aircraft architecture),
    - the installation of electric power devices plus subsystems such as batteries or fuel cells (depending on aircraft architecture),
    - the hydrogen storage including the distribution system and subsystems (depending on aircraft architecture),
    - the integration of a highly efficient, ultra-light, noise damping in the cabin with all the necessary functional elements in terms of weight;
- Demonstrate a fuel burn reduction potential of no less than 8%[63] at integrated fuselage and empennage level, compared to a clearly identified 2020 state-of-the-art (SoA) reference fuselage, supporting a fuel burn reduction of 50% at aircraft level, taking into account the wing-fuselage effects but excluding the engine installation effects.
- Demonstrate at project completion a potential weight reduction of:
    - no less than 20% at specific component / assembly level,
    - no less than 8% at overall integrated fuselage and empennage level when including energy storage but excluding all other installation effects of the hybrid-electric propulsion system,
    - both depending on the aircraft architecture and compared to a clearly identified 2020 SoA reference fuselage;

  Quantified reduction potential in CO_2 and all other relevant greenhouse gas (GHG) emissions (see performance targets section below) are expected to be derived from the project (both in terms of actual demonstrated and potential performance impact).
- Develop and demonstrate novel approaches to increase structural and aerodynamic performances to boost emission reduction potential beyond the targeted level of aerodynamic and structural efficiency and potential fuel burn reduction/energy efficiency improvement.
- Demonstrate at project completion the fuselage design performance and maturity at TRL 5 at major component assembly level (e.g. a barrel) via relevant ground demonstration(s). The applicant should detail the demonstration plan, with inclusion of relevant component/sub-system and also develop and propose an appropriate simulation and testing programme. to ensure confidence that the required maturity levels and performance targets will be successfully met.
- Deliver a roadmap towards fuselage full-scale demonstration including empennage and part of cabin and cargo to TRL 6 at aircraft level following new certification rules for novel technologies enabling a first flight demonstration not later than 2030 and compatible with an entry into service by 2035.

[62] compared to 2020 state-of-the-art aircraft available for order/delivery and measured as fuel kg per Available Seat Kilometre (ASK) on a typical mission.
[63] measured as fuel kg per Available Seat Kilometre (ASK) on a typical mission

- Propose a qualification and certification plan linked to the proposed activities and suitable to HER aircraft.
- Deliver modules and systems designs compatible with more electrical functions and alternate energy sources such as hydrogen and SAF, enabling disruptive concepts.
- Deliver digital twins and a life-cycle assessment of the components, subsystems and full fuselage system compatible with the reference aircraft digital framework and requirements, in order to regularly assess the contribution to the overall aircraft performance in the context of the impact monitoring framework. These models should be continuously validated and updated at each TRL loop. Solutions may propose a prognostics and health management approach and an associated digital model demonstrating its viability in terms of affordability and certification.
- Identify synergies with activities funded under research and innovation programmes at regional, national[64] and European[65] level, and demonstrate how the project will benefit from these activities by detailing the specific contributions to the expected outcome(s).

Scope:

Greater attention to environmental aspects (even with stringent regulations) and higher market demand are changing the scenario of air mobility in the short range, centred on 500 km and up to 1000 km. Air vehicles (as defined in CS25/FAR25) operating in this range and operational environment (including regional aircraft with a capacity of up to 100 seats) are considered the first application in the scheduled air transport system that will adopt hybrid-electric propulsion technologies and associated complementary solutions for reducing the environmental footprint, toward climate-neutral aviation. Air vehicles operating at shorter distances or on thinner routes will also benefit from electric propulsion solutions tested on regional aircraft testbeds, by sharing the development of power modules and making use of different approaches to air vehicle integration.

A novel fuselage design is one of the key enablers for the successful development of the Hybrid-Electric Regional aircraft (HER) with a targeted fuel burn reduction of minimum 50%[66] at aircraft level. The reference HER aircraft will have a seat capacity of up to 100 passengers in a standard configuration, with a sizing mission of around 1000 km and a typical sector distance flown of around 400-500 km. The necessary overall aircraft power should be in the range of 4 to 10 MW:

- Any deviation from these references as a result of different configuration effects (e.g. for project viability reasons, or for optimising the project outcome) should be identified and substantiated.
- The fuselage performance requirements should be dependent on the targeted HER aircraft architecture configuration(s)[67] including the selected hybrid-electric propulsion system[68] and wing design[69], which will be delivered by one or more separate projects launched under Clean Aviation.

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[64] activities funded in Member States and Associated Countries and/or funded through EU funds administrated by regional or national authorities such as the European Regional Development Fund (ERDF) and the European recovery fund (i.e. NextGenerationEU).

[65] activities funded under Horizon Europe (outside the Clean Aviation Work Programme 2022-2023) and/or other EU programmes.

[66] compared to 2020 state-of-the-art aircraft available for order/delivery and measured as fuel kg per Available Seat Kilometre (ASK) on a typical mission.

[67] HERA - Hybrid-Electric Regional Architecture; Project ID: 101102007

[68] AMBER - InnovAtive DeMonstrator for hyBrid-Electric Regional Application, Project ID: 101102020 and HE-ART - Hybrid Electric propulsion system for regional AiRcrafT, Project ID: 101102013

[69] HERWINGT - Hybrid Electric Regional Wing Integration Novel Green Technologies, Project ID: 101102010

The scope of this topic is to deliver an innovative fuselage design including the relevant technology bricks expected to meet TRL 5 at major component/assembly or system level at project completion and compatible with HER aircraft concept(s) selected at the end of 2025.

The hybrid-electric propulsion system will present challenges concerning both system and aircraft integration. Therefore, a fuselage design and the enabling technologies need to be developed and validated in close connection with solutions and choices at aircraft, system and component level, taking into account interdependencies. The future potential use of hydrogen as an energy source requires the development and demonstration of compatible technologies and sub-systems that will have an impact on the fuselage and on the aircraft architecture. Inputs from relevant hydrogen technology developments (e.g., H2 distribution system), as well as from the propulsion system and wing will be delivered by separate Clean Aviation projects.

The project should also investigate the impact and features of the proposed concept(s) on operations and systems. Life cycle aspects should be considered in the overall environmental impact. A quantitative and qualitative estimation of future potential performance, identifying issues and potential solutions should be provided.

Proposed designs will build on, adapt, complement and add to DO 160, DO 178, CS-25 and any other relevant or to be defined regulations, to highlight any gaps, maximise impact potential, and enable new certification standards whilst maintaining or enhancing safety levels. It should support Clean Aviation initiatives to define new certification or qualification rules as well as new standardisation efforts concerning the areas of the project and others related to them. Any specific safety or certification issue should be highlighted.

The project is required to exploit the involvement and expertise of EASA in the proposal to de-risk and secure the certification of novel fuselage technologies with the aim to assess and define how the envisaged solutions will have the potential for certification. Applicants are requested to establish contact with EASA in view of seeking their possible involvement in the proposal, to discuss their possible contribution under the topic and define a detailed description of their technical activities and estimated budget which should be included in the proposal (ref topic conditions related to “Involvement of EASA”).

Scalability (down and up) to other applications is an opportunity to be pursued in particular regarding the Short and Short-Medium Range (SR/SMR) class. It will be crucial to coordinate efforts with other relevant Clean Aviation projects.

<u>Performance Targets:</u>
A number of top-level goals will be the basis for performance targets, in particular:

- No less than 8% fuel burn reduction at integrated fuselage and empennage level (taking into account wing-fuselage effects but excluding engine installation effects);
- Targeting a minimum of 20% weight reduction at specific component/assembly level;
- Targeting no less than 8% structure weight reduction at full fuselage level when including the energy storage but excluding all other installation effects of the hybrid-electric propulsion system;
- Improved aerodynamic efficiency compared to a clearly identified 2020 SoA reference fuselage;
- Fuselage systems: installed performance contributing to the aircraft performance target of 50% fuel burn reduction, to be extended as much as possible to a target of 50% GHG emissions reduction at aircraft level (possibly expressed, for instance, in terms of overall GHG emissions per passenger kilometre);

- It is implicit that targets must be compatible with safety (certification aspects) as an overarching requirement.

These top-level goals should be broken down in a consistent manner at the different levels: from top-level aircraft requirements down to systems, sub-systems and components level requirements, from where pertinent performance targets including Key Performance Indicators should be derived.

The performance targets (weight and drag reduction, environmental requirements linked with the high voltage electrical network, energy storage, ice protections, thermal insulations, electromagnetic compatibility and electromagnetic interference protection), including KPIs, should be defined and calibrated with the objective of meeting or exceeding the project goals at completion, allowing efficient progress monitoring and providing a sound basis for subsequent work in view of best contributing to the achievement of overall high level goals:

- it is strongly recommended that the definition of targets should be guided by principles such as S.M.A.R.T. objectives[70];
- these performance targets should be established, developed and actual corresponding metrics and quantified values should be specified by the applicant consistently with all constraints pertaining to the design of HER aircraft (e.g., static and dynamic loads, noise, environmental requirements);
- KPIs and the corresponding quantified targets should be defined according to the technologies involved within the fuselage system, in a manner consistent with the overall GHG reduction targets;
- the applicant should provide the assumptions and the rationale underlying those target definitions and values;
- the applicant should also explain how the project is developing solutions compliant with them, including effective means of monitoring progress and optimising work statements.

The project should also investigate the impact, effect, and features of the proposed concept(s) on operations and systems (e.g., propulsion, cabin) including maintenance, repair, availability, fault tolerance, reliability, and safety. A quantitative and qualitative estimation of future potential performance, identifying issues and potential solutions should be provided.

The applicant should determine performance targets down to critical component level (e.g., weight reduction, improved aerodynamic performance, etc), including a maturity roadmap and a strategic development plan including performance improvements until 2030, taking into account:

- Propulsion system (distributed propulsion or not,) engines on fuselage/empennage or on wing).
- Flight control systems (FCS)
- Energy storage
- Energy distribution system
- High voltage electrical network
- Environmental requirements (temperatures, thermal insulations, vibrations, humidity)
- Aeroelastic and dynamic requirements
- Impact and crashworthiness requirements
- Noise requirements
- Regulation

The metrics should be identified for all levels from fuselage system level down to critical component level with the aim of yielding an optimal overall configuration (or several configurations as applicable).

[70] SMART = Specific, Measurable, Achievable, Relevant, Timely

The resulting objectives have to be demonstrated in relevant ground tests enabling the SRIA performance objectives to be met for the aircraft configuration(s) concerned.

All data required to characterise the aircraft emissions and environmental impact over the life cycle should be modelled and measured as required to feed aircraft performance assessment(s).

Proposals should include a detailed project plan with key milestones and deliverables together with a list of performance targets per critical technology.

II. HORIZON-JU-CLEAN-AVIATION-2023-02-HER-02: Open Digital Platform for Hybrid-Electric Regional Aircraft Design

Description of the call topic and topic and specific conditions	
Specific eligibility criterion	Legal entities established in Russia, Belarus, or in non-government controlled territories of Ukraine — Given the illegal invasion of Ukraine by Russia and the involvement of Belarus, there is currently no appropriate context allowing the implementation of the actions foreseen in this programme with legal entities established in Russia, Belarus, or in non-government controlled territories of Ukraine. Therefore, even where such entities are not subject to EU restrictive measures, such legal entities are not eligible to participate in any capacity. This includes participation as beneficiaries, affiliated entities, associated partners, third parties giving in-kind contributions, subcontractors or recipients of financial support to third parties (if any). Exceptions may be granted on a case-by-case basis for justified reasons.
Expected EU contribution per project	The Clean Aviation Joint Undertaking estimates that an EU contribution of up to EUR 7 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative funding budget for the topic is EUR 7 million. The Clean Aviation Joint Undertaking may award one project with funding depending on the outcome of the evaluation and the complementarity of the proposed actions.
Indicative project duration	Maximum 36 months.
Type of Action	Innovation Actions.
Technology Readiness Level	Proposed solutions and technologies are expected to have a software maturity comparable with TRL 3 at sub-system or component level at their minimum entry point. Activities are expected to achieve a software maturity comparable with TRL 5 at system level at project completion (by a pilot case demonstration). Applicants must provide a detailed plan of the TRL steps and a roadmap (aligned with the SRIA and with the objectives as defined in the Work Programme) that can deliver the software maturity needed by the end of Clean Aviation for the results of their project to be included in new aircraft developments. See General Annex B of Horizon Europe for a general guide to the TRL definitions and criteria.
Special skills and/or capabilities expected from the applicant(s)	The Clean Aviation Joint Undertaking expects proposals to be submitted by consortia that include aircraft integrators and their supply chain with a proven track record in developing and delivering globally competitive

	aircraft systems, as well as key contributors from the domain of academic/scientific research and technology/software development. The consortium configuration should ensure the appropriate industrial, economic and supply chain interests are represented in the project and can ensure the transition from research to product innovation and market deployment no later than 2035, and with a clearly articulated route that supports the aim of replacing 75% of the operating fleet by 2050. Applicant(s) should be able to manage large and complex international aeronautical programs demonstrating a track record of successful design, development, manufacturing and certification in the aeronautical supply chain of regional and/or single aisle aircraft at the level relevant to the topic's scope as described. Applicants should ensure their proposals and consortium reflect all necessary expertise and capabilities needed. Applicants should identify and include the additional expertise needed to complement the traditional aeronautical domain, in order to effectively address the incorporation of new/disruptive technologies. Where appropriate, the consortium should include newcomers to the programme and to the field of aeronautics and in particular SMEs, start-ups and/or knowledge centres that can bring disruptive innovation to the project as proposed.
Membership/Consortium agreement	The topic is identified as a key contributor to the overall aircraft concepts related to regional and short and short-medium range aircraft. The JU Members participating in the topic must ensure compliance with the existing Membership Agreement and must conclude with the participants to the project, a suitable Consortium Agreement [CA] governing the project and its consortium. A model of the Consortium Agreement is available on the F&T portal.
Cooperation Agreement(s)	In order to ensure a programmatic approach and implementation of the programme, project(s) launched under this topic should share/exchange, as appropriate, relevant results generated in the project with other relevant projects. For this purpose, the participants in the projects selected under this topic must conclude within six months of signature of the Grant Agreement (a) Cooperation Agreement(s) with the participants implementing the projects selected under the other relevant JU topics under this call and with the ongoing projects selected under the first CAJU Call for Proposals (CfP)[71]: see further under "other relevant projects". A model of the Cooperation Agreement applicable to the projects funded under the first call will be made available on the Funding & Tenders portal (F&T portal).
Impact Monitoring	Under the Impact Monitoring framework, the participants selected in this topic are also required to mention to which aircraft concept they are

[71] HORIZON-JU-CLEAN-AVIATION-2022-01: link

	willing to contribute to (either SMR or HER as listed in the CAJU Work Programme) and to exchange all relevant information and data with the ongoing project[s] selected under the first CAJU Call for Proposals (CfP)[71], in particular SMR ACAP[72] and/or HERA[73]. The exchange should be implemented on a yearly basis as well as a final impact/performance assessment at project completion including a TRL assessment, in order to establish the Impact Monitoring mechanism as described in the Clean Aviation SRIA and Work Programme by providing a performance assessment of the key technologies, sub-systems or systems for possible integration on the future aircraft concept model developed in SMR ACAP[74] and/or HERA[75]. This will serve to assess the performance of the aircraft concepts as described in the work programme against the programme specific objectives listed in the SBA. Applicants must ensure that their internal Consortium Agreement includes the necessary provisions to allow such required exchanges of information and data outside the consortium.
Project Monitoring	The JU will perform a number of gate reviews with a key review at month 12 (or at a fixed date, to be determined) to assess the overall progress against the project plan and against the performance targets. Depending on the outcome of this key gate review, the scope of the project may be revised and/or funding reduced in case of significant issues. Mitigation actions may be requested by the JU as condition for continued funding.
In-kind contributions (IKOP/IKAA by JU Members; co-funding by other applicants)	In order to ensure the obligations for in-kind contributions by Members of the CAJU (i.e., "Founding Member", "Associated Member" and affiliated entities to a Member) can be fulfilled as set in Article 61 of the Council Regulation (EU) 2021/2085[76], annual deliverables on in-kind contributions will be set in the grant agreements for the projects selected under this topic, as well as appropriate reporting requirements. The Members responding to this topic (i.e., "Founding Member", "Associated Member" and affiliated entities) must describe in the proposal the planned in-kind contributions, indicating the level and the nature, to be provided in the course of the project. In-kind contributions to additional activities should be declared via the template model available on the F&T portal. The amount of the total in-kind contributions (i.e. in-kind contribution to operation activities and in-kind contribution to additional activities) should be no less than 1.5[77] times the funding

[72] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[73] HERA Hybrid-Electric Regional Architecture; Project ID: 101102007

[74] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[75] HERA Hybrid-Electric Regional Architecture; Project ID: 101102007

[76] Council Regulation (EU) 2021/2085 of 19 November 2021. Official Journal: OJ L 427, 30.11.2021, p. 17–119. (https://data.consilium.europa.eu/doc/document/ST-12156-2021-INIT/en/pdf)

[77] In order to support a leverage factor of no less than the ratio between the contribution from members other than the Union (EUR 2 400 000 000) and the Union financial contribution (EUR 1 700 000 000), which are defined in the Council Regulation (EU) 2021/2085

	request in aggregate for the proposal. Considering that in accordance with Article 61 of the Council Regulation (EU) 2021/2085[78], only the Members of the CAJU are able to provide and report on the required minimum level of in-kind contributions, participants in the proposal who are not a "Member" of the CAJU should explain in the proposal which resources, key competences, technical and financial contributions they will be able to provide to the project and to the programme/Strategic Research and Innovation Agenda[79] at large.

Other relevant projects	This project should run in close cooperation and synchronisation with other relevant projects that will be selected under this call, as well as with ongoing projects selected under the first CAJU Call for Proposals (CfP)[80], in particular HERA[81]: The applicants should: - ensure their proposal is aligned with the Gantt chart(s) of the relevant thrust(s) as published in the Clean Aviation Work Programme 2022-2023, and duly consider interfaces and interdependencies therein, to ensure a consistent and coordinated approach with the other relevant projects selected under this call and the first CAJU CfP; - draw up in their proposal a list of projects selected under the first call and a list of topics published under this call for which a cooperation and access rights will be needed in order to achieve the proposal's objectives and implement the impact monitoring framework; - commit in their proposal to sign a cooperation agreement with the ongoing SMR ACAP[82] and/or HERA[83] project[s] and with the other identified projects selected under the first CAJU CfP[80], - define a deliverable which will provide the specific technical requirements, the necessary data/information exchanges and the delivery schedule thereof with respect to the other relevant projects to support an integrated programme planning across the projects with interfaces, including a list of milestones and deliverables across the contributing projects. This deliverable must be issued by the applicants at month 6. During grant preparation, the JU may propose amendments or additions to the list of other relevant projects on the basis of the evaluation.

78 Council Regulation (EU) 2021/2085 of 19 November 2021 establishing the Joint Undertakings under Horizon Europe and repealing Regulations (EC) No 219/2007, (EU) No 557/2014, (EU) No 558/2014, (EU) No 559/2014, (EU) No 560/2014, (EU) No 561/2014 and (EU) No 642/2014

79 available on the F&T portal

80 HORIZON-JU-CLEAN-AVIATION-2022-01: link

81 HERA - Hybrid-Electric Regional Architecture; Project ID: 101102007

82 SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

83 HERA - Hybrid-Electric Regional Architecture; Project ID: 101102007

	The cooperation agreements to be concluded should allow for future inclusion additional other relevant projects that may result from future calls. For further information, please also consult the Rules for Submission, evaluation and selection and the dedicated part in the CAJU Work Programme.
Involvement of EASA	Each project is required to exploit the involvement and expertise of EASA in the proposal to de-risk and secure the certification of novel technologies with the aim to assess and define how the envisaged solutions will have the potential for certification. Applicants are requested to establish contacts with EASA in view of seeking their possible involvement in the proposal, to discuss their possible contribution under the topic and define a detailed description of their technical activities and estimated budget which should be included in the proposal, see also section below on "Scope". The contribution of EASA should take the form of in-kind contribution under Article 9 of the Horizon Europe model Grant Agreement to be agreed under the proposal and to be implemented in the form of a service contract to be signed with EASA. The involvement of EASA in the proposal as third party may be complemented, where applicable, by other possible agreements already in place between EASA and the consortium partner in charge of the certification aspects and which may be relevant for the topic and the project execution. In such a case, the applicant should describe in the proposal the synergies and the articulation of EASA tasks and their costs coverage under such agreements in order to optimise the use of resources under the proposal. The service contract should be established based on the CAJU model service contract published under the F&T Portal. With regard to the status and role of EASA in CAJU projects, see also the CAJU Work Programme. Further guidance on EASA involvement and legal status in the proposal will be provided in the 1st Q&A of the call. Practical modalities for contacting EASA will be laid down in the 1st Q&A of the call.

Expected Outcome:

Project results are expected to contribute to the following expected outcomes:

- Deliver an in-depth analysis of the 2020 state-of-the-art (SoA) aircraft digital design processes for all relevant design tools and methods, model-based systems engineering (MBSE) approaches and digital solutions, as well as for the expected developments currently underway. The analysis should also highlight how results from previous research projects (e.g. funded under the Clean Sky 2 programme) can be leveraged;
- Develop an innovative open and transferable digital platform, which enables the acceleration of the process of the aircraft design to the manufacturing of the targeted concept for a hybrid-

electric regional (HER) aircraft with a targeted fuel burn reduction of minimum 50%[84] at aircraft level, while taking into account:

- the combination of model based system engineering (MBSE) solutions capturing all of the systems' dimensions and requirements, and a product life cycle management (PLM) system capturing the physical definition of the aircraft and integrated behavioural models (simulation data management - SDM) to capture aircraft behaviours,
- the seamless integration of functional, logical, physical, and behavioural views of the aeronautic product. This is in addition to methods for linking or transforming the functional modelling (requirements allocation, functional decomposition, and allocation to systems architecture structure) to physical/behavioural models. These models should be integrated into a single framework whereby allowing integrated verification of the functional chains of the novel, more integrated system architectures of HER aircraft,
- the application of standardised unitary system models/parts and behavioural models capturing the new hybrid electric aircraft components and technologies,
- the openness of the platform by using open source interfaces (e.g. FMI, DCP, TLM, etc.)[85], exchange formats (e.g. SysML, SSP, etc.)[86], scripting languages (e.g. Python) and API[87] availabilities, to ensure the accessibility of the aircraft design data and the ability to transfer the behaviour of all architectures into other digital environments,
- the smart and efficient management of huge amounts of data and the use of high-performance computing (HPC) capabilities to support the creation of fast large-scale verifications and reduced order models (ROM) /surrogate models, which may become valid, non-proprietary methods;
- the integration of new MBSE platform methods and features supporting the development of critical technologies/systems and the integration of power sources on board such as but not limited to, the hybrid/electric power train, energy and power management, propulsion integration, electromagnetic effects, batteries, fuel cells, H2 storage and distribution, thermal management, distributed propulsion;
- the definition of a modular and expandable architecture of the open digital platform, allowing:
  - interfacing between the modules, so that the different functionalities can communicate and interact among each other,
  - an efficient extension and integration of future functionalities and modules emerging from new requirements, technologies and/or industrialization aspects;

- Demonstrate a targeted time and cost reduction of 50% in the accelerated aircraft design and development phase, compared to a clearly identified 2020 SoA reference, and provide details of the metrics and methodology used to assess the performance indicator(s) and to estimate the actual benefits.

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[84] compared to 2020 state-of-the-art aircraft available for order/delivery and measured as fuel kg per Available Seat Kilometre (ASK) or energy (megajoules) per ASK as applicable.

[85] FMI - Functional Mock up Interface; DCP - Distributed Co-simulation Protocol; TLM - Transmission Line Modeling

[86] SysML - Systems Modeling Language; SSP - System Structure Parametrization

[87] API - Application Programming Interface

- Demonstrate at project completion the digital platform performance and software maturity comparable with TRL 5 at system level via a pilot case demonstration. This could take the form of for example, validation through relevant tests of the final architecture and a digital mock-up of one HER aircraft configuration derived from the HERA[88] project, selected from “HORIZON-JU-CLEAN-AVIATION-2022-01-TRA-01: Aircraft architectures & technology integration for aircraft concepts ranging from regional to short-medium range applications”). The applicant should detail the demonstration plan, with inclusion of relevant (i.e. hybrid/electric or hydrogen) component(s)/sub-system(s) and also develop and propose an appropriate simulation and testing programme to ensure confidence that the required maturity levels and performance targets will be successfully met.
- Define a detailed exploitation path and develop an approach enabling the digital platform to remain accessible and available in the Clean Aviation programme, in particular in Phase 2 of the programme (e.g. by defining solutions to address potential IP issues or proposing an IP management model). This also includes a roadmap towards fully integrated digital platform demonstration with a software maturity comparable with TRL 6 at overall aircraft and system level by the end of the Clean Aviation programme.
- Provide a non-proprietary reference definition of the digital platform framework enabling its wider adoption through the HER value/supply chain. The definition should exploit open formats/interfaces as well as data and connectivity conventions.
- Define technical specifications, criteria and guidelines:
  - to ensure coordinated integration of new numerical models for the new technologies into the platform. This will support the development of the hybrid-electric propulsion concept(s), the on-board aircraft systems, the power sources (thermal, battery, fuel cell) adequate for HER as well as energy management including both the power and thermal loads generated by the new systems. The numerical models themselves will be developed in the separate HER related projects selected from this call and in the ongoing projects selected under the first CAJU Call for Proposals[89] .
  - to harmonise and integrate typical existing software tools for aeronautical solutions (such as but not limited to aerodynamic and aeroacoustics performance, structural features or airframe weight components) and continuity across MSBE, PLM and SDM.
- Detail how the proposed solution contributes to the simplification of aircraft certification and how it supports certification activities under the Clean Aviation programme (e.g. CONCERTO[90], selected from HORIZON-JU-CLEAN-AVIATION-2022-01-TRA-02: Novel Certification Methods and Means of Compliance for Disruptive Technologies).
- Define associated preliminary industrialisation attributes enabling overall production maturity assessment.
- Identify the key enabling technology integration solutions to support a sustainable approach to industrialisation and manufacturing including requirements, criteria, functionalities, and issues.

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[88] HERA - Hybrid-Electric Regional Architecture; Project ID: 101102007

[89] HORIZON-JU-CLEAN-AVIATION-2022-01: link

[90] CONCERTO - Construction Of Novel CERTification methOds and means of compliance for disruptive technologies; Project ID: 101101999

- Identify synergies with activities funded under research and innovation programmes at regional, national[91] and European[92] level (such as but not limited to future activities funded under HORIZON-CL5-2023-D5-01-09: Competitiveness and digital transformation in aviation – advancing further capabilities, digital approach to design). The applicant should also demonstrate how the project will benefit from these activities by detailing the specific contributions to the expected outcome(s).

Scope:

Greater attention to environmental aspects (even with stringent regulations) and higher market demand are changing the scenario of air mobility in the short range, centred on 500 km and up to 1000 km. Air vehicles (as defined in CS25/FAR25) operating in this range and operational environment (including regional aircraft with a capacity of up to 100 seats) are considered the first application in the scheduled air transport system that will adopt hybrid-electric propulsion technologies and associated complementary solutions for reducing the environmental footprint, toward climate-neutral aviation. Air vehicles operating at shorter distances or on thinner routes will also benefit from electric propulsion solutions tested on regional aircraft testbeds, by sharing the development of power modules and making use of different approaches to air vehicle integration.

Novel virtual design processes and tools combined in an open digital design environment will enable integrated design verification and validation during the design/development phase. This will ultimately result an accelerated successful development of the Hybrid-Electric Regional aircraft (HER) with a targeted fuel burn reduction of minimum 50%[93] at aircraft level, and compatible with Entry into Service (EIS) 2035. The reference HER aircraft will have a seat capacity of up to 100 passengers in a standard configuration, with a sizing mission of around 1000 km and a typical sector distance flown of around 400-500 km. The necessary overall aircraft power should be in the range of 4 to 10 MW:

- Any deviation from these references as a result of different configuration effects (e.g. for project viability reasons, or for optimizing the project outcome) should be reflected in the digitalization process.
- The digital platform performance requirements should be able to support the targeted HER aircraft architecture configuration(s)[94] including the selected proposals under this call and the ongoing projects selected under the first CAJU Call for Proposals (CfP)[95] linked to the hybrid-electric regional aircraft activities in Clean Aviation.

The scope of this topic is to deliver an open and transferable digital platform including the relevant technology bricks and digital solutions expected to meet a software maturity comparable with TRL 5 at system level at project completion. The platform should be compatible with HER aircraft concept(s) selected at the end of 2025, whilst also taking into account:

- the development of a common and open environment for digital block models integration across MBSE, PLM and SDM[96];

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[91] activities funded in Member States and Associated Countries and/or funded through EU funds administrated by regional or national authorities such as the European Regional Development Fund (ERDF) and the European recovery fund (i.e. NextGenerationEU).

[92] activities funded under Horizon Europe (outside the Clean Aviation Work Programme 2022-2023) and/or other EU programmes.

[93] compared to 2020 state-of-the-art aircraft available for order/delivery and measured as fuel kg per Available Seat Kilometre (ASK) on a typical mission.

[94] HERA - Hybrid-Electric Regional Architecture; Project ID: 101102007

[95] HORIZON-JU-CLEAN-AVIATION-2022-01: link

[96] Model Based System Engineering (MBSE), Product Lifecycle Management (PLM), Simulation Data Management (SDM)

- detailed modelling of the behaviour of the verified and validated single block models and their associated industrialisation attributes: subsystems, components, subcomponents and related interfaces. This which will ensure the real integration and links.

The main challenges to be addressed are as follows:

- The solution should provide an open collaborative platform, based on the MBSE (Model Based System Engineering) approach, ensuring full monitoring of new hybrid-electric regional aircraft, technologies and related certification. This should facilitate communication between relevant stakeholders without imposing a proprietary solution and using the original models and format. It should be noted that the focus on certification implies that the collaborative platform should construct links between different product views (requirements, functions, behaviours) to ensure the full traceability of the design process, from requirements, to functions, to behaviour models, to testing, to simulation data management;
- The solution should include the ability to interface with the product life cycle management to achieve earlier impact of hybrid-electric regional aircraft, especially concerning sustainability efforts as per the targets identified in the Single Basic Act (SBA);
- The seamless transition between models views will require the definition of ontologies, rules and standardised mechanisms;
- The solution should allow future modules to be added such as aircraft manufacturing, flight/operations, and management procedures. The solution should consider the direct integration of any process that contributes to simplifying aircraft certification.

The hybrid-electric propulsion system will present challenges concerning aircraft design, system/aircraft modelling and manufacturing. Therefore, an open digital platform based on a MSBE approach combined with PLM and SDM needs to be developed and validated in close connection with solutions and choices at aircraft, system and component level, taking into account interdependencies. This will ensure full monitoring of the integration of new hybrid-electric regional aircraft technologies in addition to related certification, facilitating dedicated exchanges amongst relevant stakeholders, including lean interfacing with relevant manufacturing processes to achieve an earlier impact from new aircraft architectures.

The future potential use of hydrogen as an energy source requires the development and demonstration of compatible technologies and sub-systems that will have an impact on aircraft design and manufacturing. Inputs from relevant hydrogen technology developments (e.g. H2 distribution system), as well as from the propulsion system and other HER related topics will be delivered by separate projects launched under Clean Aviation.

The project is required to exploit the involvement and expertise of EASA in the proposal to de-risk and secure the certification of novel technologies with the aim to assess and define how the envisaged solutions will have the potential for certification. Applicants are requested to establish contact with EASA in view of seeking their possible involvement in the proposal, to discuss their possible contribution under the topic and define a detailed description of their technical activities and estimated budget which should be included in the proposal (ref topic conditions related to “Involvement of EASA”).

Performance Targets:

A number of top-level goals will be the basis for performance targets, in particular:

- An open and transferable digital platform and applicable standard approach at appropriate scale to support the integration and down selection of systems/subsystems and aircraft concepts proposed at the end of Phase 1 of the Clean Aviation programme. The platform should facilitate efficient management of all interfaces, both through the different stakeholders and the systems themselves, combining MBSE, PLM and SDM technologies.

- A substantial step change in virtual design approach, notably a 50% improvement in cost-effectiveness and a 50% reduction in lead time of the development and integration of new technologies and innovations related to HER aircraft, both compared to a clearly identified 2020 SoA reference;
- Contributing to an accelerated development and launch of HER aircraft by 2035, supporting the aim of replacing 75% of the operating fleet by 2050;
- It is implicit that targets must be compatible with safety (certification aspects) as an overarching requirement.

These top-level goals should be broken down in a consistent manner at the different levels: from top level aircraft requirements down to systems, sub-systems and components level requirements, from where pertinent performance targets including Key Performance Indicators should be derived.

Those performance targets, including KPIs, should be defined and calibrated with the objective of meeting or exceeding the project goals at completion, allowing efficient progress monitoring and providing a sound basis for subsequent work in view of best contributing to the achievement of overall high level goals:

- it is strongly recommended that the definition of targets should be guided by principles such as S.M.A.R.T. objectives[97];
- the applicant should provide the assumptions and the rationale underlying those target definitions and values;
- the applicant should also explain how the project is developing solutions compliant with them, including effective means of monitoring progress and optimising work statements.

Proposals should include a detailed project plan with key milestones and deliverables together with a list of performance targets per critical technology.

[97] SMART = Specific, Measurable, Achievable, Relevant, Timely

3. Clean Aviation – Short/short-medium range Aircraft (SMR)

I. HORIZON-JU-CLEAN-AVIATION-2023-02-SMR-01: High-TRL Flight Demonstration Means for Ultra Efficient Propulsion Systems for Short and Short-Medium Range Aircraft

Description of the call topic and topic specific conditions	
Specific eligibility criterion	Legal entities established in Russia, Belarus, or in non-government controlled territories of Ukraine — Given the illegal invasion of Ukraine by Russia and the involvement of Belarus, there is currently no appropriate context allowing the implementation of the actions foreseen in this programme with legal entities established in Russia, Belarus, or in non-government controlled territories of Ukraine. Therefore, even where such entities are not subject to EU restrictive measures, such legal entities are not eligible to participate in any capacity. This includes participation as beneficiaries, affiliated entities, associated partners, third parties giving in-kind contributions, subcontractors or recipients of financial support to third parties (if any). Exceptions may be granted on a case-by-case basis for justified reasons.
Expected EU contribution per project	The Clean Aviation Joint Undertaking estimates that an EU contribution up to EUR 20 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative funding budget for the topic is EUR 20 million. The Clean Aviation Joint Undertaking may award up to 1 project with funding depending on the outcome of the evaluation and the complementarity of the proposed actions.
Indicative project duration	Maximum 36 months.
Type of Action	Innovation Actions.
Technology Readiness Level	Activities are expected to achieve a maturity level that will enable to perform flight test in Phase 2. Applicants must provide a detailed plan of the TRL steps and a roadmap (aligned with the SRIA and with the objectives as defined in the Work Programme) that can deliver the technology maturity needed by the end of Clean Aviation for the results of their project to be included in new aircraft with an entry into service no later than 2035. See General Annex B of Horizon Europe for a guide to the TRL definitions and criteria to be used.
Special skills and/or capabilities expected from the Applicant(s)	The Clean Aviation Joint Undertaking expects proposals to be submitted by consortia that include aircraft manufacturers, propulsion system integrators and their supply chain with a proven track record in developing and delivering globally competitive propulsion systems to aircraft

	programmes, as well as key contributors from the domain of academic/scientific research and technology development. The consortium configuration should ensure the appropriate industrial, economic and supply chain interests are represented in the project and can ensure the transition from research to product innovation and market deployment no later than 2035, and with a clearly articulated route that supports the aim of replacing 75% of the operating fleet by 2050. Applicant(s) should be able to manage large and complex international aeronautical programmes demonstrating a track record of successful design, development and certification in the aeronautical supply chain of short and short-medium range aircraft at the level relevant to the topic's scope as described. Applicants should ensure their proposal and consortium reflect all necessary expertise and capabilities. Applicants should identify and include the additional expertise needed to complement the traditional aeronautical domain, in order to effectively address the incorporation of new/disruptive technologies. Where appropriate, the consortium should include newcomers to the programme and to the field of aeronautics and in particular SMEs, start-ups and/or knowledge centres that can bring disruptive innovation to the project as proposed.
Membership/Consortium Agreement	The topic is identified as a key contributor to the overall aircraft concepts related to short range and short-medium range aircraft. The JU Members participating in the topic must ensure compliance with the existing Membership Agreement and must conclude with the participants to the project, a suitable Consortium Agreement [CA] governing the project and its consortium. A model of the Consortium Agreement is available on the F&T portal.
Cooperation Agreement(s)	In order to ensure a programmatic approach and implementation of the programme, project(s) launched under this topic should share/exchange, as appropriate, relevant results generated in the project with other relevant projects. For this purpose, the participants in the projects selected under this topic must conclude within six months of signature of the Grant Agreement (a) Cooperation Agreement(s) with the participants implementing the projects selected under the other relevant JU topics under this call and with the ongoing projects selected under the first CAJU Call for Proposals (CfP): see further under "other relevant projects". A model of the Cooperation Agreement applicable to the projects funded under the first call CAJU CfP will be made available on the Funding & Tenders portal (F&T portal).
Impact Monitoring	Under the Impact Monitoring framework, the participants selected in this topic are also required to mention to which aircraft concept they are willing

	to contribute to (either SMR or HER as listed in the CAJU Work Programme) and to exchange all relevant information and data with the ongoing project[s] selected under the first CAJU Call for Proposals (CfP)[98], in particular SMR ACAP[99] and/or HERA[100]. The exchange should be implemented on a yearly basis as well as a final impact/performance assessment at project completion including a TRL assessment, in order to establish the Impact Monitoring mechanism as described in the Clean Aviation SRIA and Work Programme by providing a performance assessment of the key technologies, sub-systems or systems for possible integration on the future aircraft concept model developed in SMR ACAP[101] and/or HERA[102]. This will serve to assess the performance of the aircraft concepts as described in the work programme against the programme specific objectives listed in the SBA. Applicants must ensure that their internal Consortium Agreement includes the necessary provisions to allow such required exchanges of information and data outside the consortium.
Project Monitoring	The JU will perform a number of gate reviews with a key review at month 12 (or at a fixed date, to be determined) to assess the overall progress against the project plan and against the performance targets. Depending on the outcome of this key gate review, the scope of the project may be revised and/or funding reduced in case of significant issues. Mitigation actions may be requested by the JU as condition for continued funding.
In-kind contributions (IKOP/IKAA by JU Members; co-funding by other applicants)	In order to ensure the obligations for in-kind contributions by Members of the CAJU (i.e. “Founding Member”, “Associated Member” and affiliated entities to a Member) can be fulfilled as set in Article 61 of the Council Regulation (EU) 2021/2085[103], annual deliverables on in-kind contributions will be set in the grant agreements for the projects selected under this topic, as well as appropriate reporting requirements. The Members responding to this topic (i.e. “Founding Member”, “Associated Member” and affiliated entities) must describe in the proposal the planned in-kind contributions, indicating the level and the nature, to be provided in the course of the project. In-kind contributions to additional activities should be declared via the template model available on the F&T portal. The amount of the total in-kind contributions (i.e. in-kind contribution to operation activities and in-kind contribution to additional

[98] HORIZON-JU-CLEAN-AVIATION-2022-01: link
[99] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955
[100] HERA Hybrid-Electric Regional Architecture; Project ID: 101102007
[101] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955
[102] HERA Hybrid-Electric Regional Architecture; Project ID: 101102007
[103] Council Regulation (EU) 2021/2085 of 19 November 2021. Official Journal: OJ L 427, 30.11.2021, p. 17–119. (https://data.consilium.europa.eu/doc/document/ST-12156-2021-INIT/en/pdf)

	activities) should be no less than 1.5[104] times the funding request in aggregate for the proposal. Considering that in accordance with Article 61 of the Council Regulation (EU) 2021/2085[105], only the Members of the CAJU are able to provide and report on the required minimum level of in-kind contributions, participants in the proposal who are not a "Member" of the CAJU should explain in the proposal which resources, key competences, technical and financial contributions they will be able to provide to the project and to the programme/Strategic Research and Innovation Agenda[106] at large.

Other relevant projects	This project should run in close cooperation and synchronization with other relevant projects that will be selected under this call, as well as with ongoing projects selected under the first CAJU Call for Proposals (CfP)[107], in particular with SMR ACAP[108], OFELIA[109] and SWITCH[110]: The applicants should: - ensure their proposal is aligned with the Gantt chart(s) of the relevant thrust(s) as published in the Clean Aviation Work Programme 2022-2023, and duly consider interfaces and interdependencies therein, in order to ensure a consistent and coordinated approach with the other relevant projects selected under this call and the first CAJU CfP; - draw up in their proposal a list of projects selected under the first call and a list of topics published under this call for which a cooperation and access rights will be needed in order to achieve the proposal's objectives and implement the impact monitoring framework; - commit in their proposal to sign a cooperation agreement with the ongoing SMR ACAP[111] and/or HERA[112] project[s] and with the other identified projects selected under the first CAJU CfP[113]; - define a deliverable which will provide the specific technical requirements, the necessary data/information exchanges and the

104 In order to support a leverage factor of no less than the ratio between the contribution from members other than the Union (EUR 2 400 000 000) and the Union financial contribution (EUR 1 700 000 000), which are defined in the Council Regulation (EU) 2021/2085

105 Council Regulation (EU) 2021/2085 of 19 November 2021 establishing the Joint Undertakings under Horizon Europe and repealing Regulations (EC) No 219/2007, (EU) No 557/2014, (EU) No 558/2014, (EU) No 559/2014, (EU) No 560/2014, (EU) No 561/2014 and (EU) No 642/2014

106 available on the F&T portal

107 HORIZON-JU-CLEAN-AVIATION-2022-01: link

108 SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

109 OFELIA - Open Fan for Environmental Low Impact of Aviation; Project ID: 101102011

110 SWITCH - Sustainable Water-Injecting Turbofan Comprising Hybrid-electrics; Project ID: 101102006

111 SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

112 HERA - Hybrid-Electric Regional Architecture; Project ID: 101102007

113 HORIZON-JU-CLEAN-AVIATION-2022-01: link

	delivery schedule thereof with respect to the other relevant projects to support an integrated programme planning across the projects with interfaces, including a list of milestones and deliverables across the contributing projects. This deliverable must be issued by the applicants at month 6. During grant preparation, the JU may propose amendments or additions to the list of other relevant projects on the basis of the experts' evaluation. The cooperation agreements to be concluded should allow for the future inclusion of additional relevant projects that may result from future calls. For further information, please also consult the Rules for Submission, evaluation and selection and the dedicated part in the CAJU Work Programme.
Involvement of EASA	Each project is required to exploit the involvement and expertise of EASA in the proposal to de-risk and secure the certification of novel technologies with the aim to assess and define how the envisaged solutions will have the potential for certification. Applicants are requested to establish contacts with EASA in view of seeking their possible involvement in the proposal, to discuss their possible contribution under the topic and define a detailed description of their technical activities and estimated budget which should be included in the proposal, see also section below on "Scope". The contribution of EASA should take the form of in-kind contribution under Article 9 of the Horizon Europe model Grant Agreement to be agreed under the proposal and to be implemented in the form of a service contract to be signed with EASA. The involvement of EASA in the proposal as third party may be complemented, where applicable, by other possible agreements already in place between EASA and the consortium partner in charge of the certification aspects and which may be relevant for the topic and the project execution. In such a case, the applicant should describe in the proposal the synergies and the articulation of EASA tasks and their costs coverage under such agreements in order to optimise the use of resources under the proposal. The service contract should be established based on the CAJU model service contract published under the F&T Portal. With regard to the status and role of EASA in CAJU projects, see also the CAJU Work Programme. Further guidance on EASA involvement and legal status in the proposal will be provided in the 1st Q&A of the call. Practical modalities for contacting EASA will be laid down in the 1st Q&A of the call.

Expected Outcome:

Project results are expected to provide or contribute to the following expected outcomes:

- Establish at project completion an ultra-advanced flight test demonstrator platform enabling full-scale flight test demonstration of novel ultra-efficient ducted or unducted geared engine architectures that will contribute to the target of at least 30%[114] fuel burn reduction on a typical mission at overall aircraft level. The project result should provide the foundation to progress research and demonstration to enable the development of an ultra-efficient propulsion system for a Short and Short-Medium Range (SR/SMR) aircraft with maximum efficiency, minimum weight and minimum drag penalty, and with a target EIS of no later than 2035.
    - The flight test demonstrator platform should be versatile and fully instrumented, providing flight testing capabilities optimized to enable the full-scale demonstration of an ultra-efficient propulsion system, including relevant airframe systems and airframe/propulsion system interfaces. The propulsion system should be compatible with the selected SR/SMR aircraft architecture[115], contributing to a fuel-burn reduction of no less than 20%[116] at engine level, with full adaptability to 100% (non-blended) SAF.
    - The flight test demonstrator platform should enable full-scale testing of all three following engine architecture configurations (including hybridisation technologies to boost the emissions reduction potential), to perform propulsion system assessment in a SR/SMR representative flight envelope (Mach, altitude) to demonstrate maximum propulsive efficiency and/or thermal efficiency:
        - Configuration *1*: integrated propulsion system based on an unducted engine architecture,
        - Configuration *2:* integrated propulsion system based on ducted engine architecture,
        - Configuration *3:* core engine and combustion technologies, including advanced thermodynamic cycles, to boost the emission reduction potential, and to reduce CO_2 and/or other relevant GHG emissions such as NOx. Develop modular and evolutive flight test instrumentation enabling technology performance and integration assessment, as well as environmental impact evaluations in terms of emissions of GHG, particulates and noise.
- At project completion, achieve flight clearance of the flight test demonstrator platform to perform (in Phase 2 of the Clean Aviation programme) full-scale flight testing on the above-mentioned engine architecture configurations demonstrated at the following maturity levels.
- The project should make use of wind-tunnel testing (verifying impact on low-speed handling qualities, stall characteristics, high-lift performance and wing leading edge configuration selection) and aircraft simulator sessions to support flight clearance of the flight test

[114] compared to 2020 state-of-the-art aircraft available for order/delivery and measured as fuel kg per Available Seat Kilometre (ASK) on a typical mission

[115] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[116] compared to 2020 state-of-the-art engine / propulsion system available for order/delivery and measured as fuel kg per Available Seat Kilometre (ASK) on a typical mission

demonstrator platform. The development and ground demonstration of engine architectures Configuration *1, 2* and *3* are addressed in Clean Aviation dedicated projects[117].

- Deliver a roadmap towards full-scale demonstration of the propulsion system compatible with TRL 6 at aircraft level before the end of the Clean Aviation programme and compatible with an EIS by 2035. Propose a plan to anticipate rule making and means of compliance for potential future certification suitable for SR/SMR aircraft.
- Deliver digital twins of the components, subsystems and the full flight demonstration platform compatible with the reference aircraft digital framework and requirements, as required to feed aircraft performance assessment(s) in the context of the impact monitoring framework.
- Identify synergies with activities funded under research and innovation programmes at regional[118], national[119] and European[120] level, and demonstrate how the project will benefit from these activities by detailing the specific contributions to the expected outcome(s).

Scope:

With growing market demand and an ever-increasing focus on the environmental impact of flight (even with more stringent regulations), the mid-2030s are expected to see the entry of a new generation of SR/SMR aircraft (with a capacity of up to 250 seats) aiming towards sustainable climate-neutral flight. While hybrid/electric energy architectures are considered to pave the way towards climate-neutral aviation on routes shorter than 1000 km, aircraft for classical short and medium-range distances, i.e. from 1000 km up to 3700 km, will rely on ultra-efficient aircraft designs and ultra-efficient thermal energy-based propulsion technologies using sustainable drop-in and non-drop-in fuels.

Propulsion represents a major challenge for the successful development of the SR/SMR aircraft with a targeted fuel burn reduction of no less than 20%[121] at overall engine / propulsion system level, supporting a fuel burn reduction of 30%[122] at aircraft level.

- The assumptions relative to the aircraft operating envelope, to the flight mission profile, to the aircraft range, to the aircraft cruise speed, to the aircraft seating capacities and to the main aircraft sizing parameters in general, should be fully consistent with those applicable in the Clean Aviation project focusing on SR/SMR aircraft architectures[123];

[117]: OFELIA - Open Fan for Environmental Low Impact of Aviation; Project ID: 101102011 and SWITCH - Sustainable Water-Injecting Turbofan Comprising Hybrid-electrics; Project ID: 101102006

[118] activities funded in Member States and Associated Countries and/or funded through EU funds administrated by regional or national authorities such as the European Regional Development Fund (ERDF) and the European recovery fund (i.e. NextGenerationEU).

[119] activities funded in Member States and Associated Countries and/or funded through EU funds administrated by regional or national authorities such as the European Regional Development Fund (ERDF) and the European recovery fund (i.e. NextGenerationEU).

[120] activities funded under Horizon Europe (outside the Clean Aviation Work Programme 2022-2023) and/or other EU programmes.

[121] compared to 2020 state-of-the-art engine / propulsion system available for order/delivery and measured as fuel kg per Available Seat Kilometre (ASK) on a typical mission

[122] compared to 2020 state-of-the-art aircraft available for order/delivery and measured as fuel kg per Available Seat Kilometre (ASK) on a typical mission

[123] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

- Consistent propulsion system specifications should be derived accordingly to the Clean Aviation projects[124]. Any deviation from these references as a result of different configuration effects (e.g. for technical feasibility, project viability reasons, or for optimising the project outcome) should be identified and substantiated.

This topic is intended to deliver an ultra-advanced flight test demonstrator platform enabling the full integration of Configurations *1, 2*, and *3* of engine architectures to assess their efficiency performance in-flight in a SR/SMR representative flight envelope (Mach 0.85, FL400+).

Flight testing capabilities enable testing under the flight envelope conditions are therefore essential to demonstrating that novel propulsion technologies can y reduce fuel burn by no less than 20% at engine level. They will also enable preliminary consideration of aircraft installation effects and their subsequent impact on efficiency performance at aircraft level.

Proposed designs will build on, adapt, complement and add to DO 160, DO 178 and CS-25 and other regulations to highlight any gaps, maximise impact potential, and enable new certification standards, whilst maintaining or enhancing safety levels. The project should propose a plan to anticipate rule making and means of compliance for potential future certification suitable for SR/SMR aircraft. It should also support Clean Aviation initiatives to define new certification or qualification rules as well as new standardisation efforts concerning the areas of the project and others related to them. Any specific safety or certification issue should be highlighted, and mitigation action should be proposed.

The project is required to exploit the involvement and expertise of EASA in the proposal to de-risk and secure the certification of novel propulsion technologies with the aim to assess and define how the envisaged solutions will have the potential for certification. Applicants are requested to establish contact with EASA in view of seeking their possible involvement in the proposal, to discuss their possible contribution under the topic and define a detailed description of their technical activities and estimated budget which should be included in the proposal (ref topic conditions related to “Involvement of EASA”).

<u>Performance Targets:</u>

A number of top-level goals will be the basis for performance targets, in particular:

- No less than a 20% reduction in fuel burn[125] and related emissions on a typical mission at overall propulsion system (not considering other contributions or installation effects);
- Engine/installed performance compliant with the aircraft performance target of 30%[126] fuel burn reduction, to be extended as much as possible to a target of 30% GHG emissions reduction at aircraft level (possibly expressed in terms of overall GHG emissions per passenger kilometre);
- All noise and emissions levels resulting from the project’s outcomes should be consistent with meeting all currently foreseen regulations and standards with sufficient margin to accommodate uncertainty in results at the TRL level achieved;

[124] OFELIA - Open Fan for Environmental Low Impact of Aviation; Project ID: 101102011 and SWITCH - Sustainable Water-Injecting Turbofan Comprising Hybrid-electrics; Project ID: 101102006

[125] compared to 2020 state-of-the-art engine / propulsion system available for order/delivery and measured as fuel kg per Available Seat Kilometre (ASK) on a typical mission

[126] compared to 2020 state-of-the-art aircraft available for order/delivery and measured as fuel kg per Available Seat Kilometre (ASK) on a typical mission

- Weight constraints of the overall propulsion system so as to minimise the propulsion weight ratio to the Operating Empty Weight;
- It is implicit that targets must be compatible with safety as overarching requirement.

These top-level goals should be broken down in a consistent manner at the different levels: from top-level aircraft requirements down to systems, sub-systems and components level requirements, from where pertinent performance targets including Key Performance Indicators (KPIs) should be derived.

The performance targets, including KPIs, should be defined and calibrated with the objective of meeting or exceeding the project goals at completion, allowing efficient progress monitoring and providing a sound basis for subsequent work in view of best contributing to the achievement of overall high level goals:

- it is strongly recommended that the definition of targets should be guided by principles such as S.M.A.R.T.[127] objectives;
- these performance targets should be established, developed and actual corresponding quantified values should be specified by the applicant consistently with all constraints pertaining to the design of SR/SMR aircraft;
- KPIs and the corresponding quantified targets should be defined according to the technologies involved within the propulsion system and depending on its integration in the aircraft, in a manner consistent with the overall GHG reduction targets;
- the applicant should provide the assumptions and the rationale underlying those target definitions and values;
- the applicant should also explain how the project is developing solutions compliant with them, including effective means of monitoring progress and optimising work statements.

The applicant should also determine and quantify the targets at system, sub-system and down to component level.

All data required to characterise the emissions (including non-CO_2 effects) should be modelled and measured as required to feed aircraft performance assessment(s).

Proposal should include a detailed project plan with key milestones and deliverables, together with a list of performance targets per critical technology.

[127] S.M.A.R.T.: Specific, Measurable, Achievable, Relevant, Timely

II. HORIZON-JU-CLEAN-AVIATION-2023-02-SMR-02: Ultra Performance Wing Technologies and Integration for Short and Short-medium Range Aircraft

Description of the call topic and topic specific conditions	
Specific eligibility criterion	Legal entities established in Russia, Belarus, or in non-government controlled territories of Ukraine — Given the illegal invasion of Ukraine by Russia and the involvement of Belarus, there is currently no appropriate context allowing the implementation of the actions foreseen in this programme with legal entities established in Russia, Belarus, or in non-government controlled territories of Ukraine. Therefore, even where such entities are not subject to EU restrictive measures, such legal entities are not eligible to participate in any capacity. This includes participation as beneficiaries, affiliated entities, associated partners, third parties giving in-kind contributions, subcontractors or recipients of financial support to third parties (if any). Exceptions may be granted on a case-by-case basis for justified reasons.
Expected EU contribution per project	The Clean Aviation Joint Undertaking estimates that an EU contribution up to EUR 13 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative funding budget for the topic is EUR 13 million. The Clean Aviation Joint Undertaking may award up to 1 project with funding depending on the outcome of the evaluation and the complementarity of the proposed actions.
Indicative project duration	Maximum 36 months.
Type of action	Innovation Actions.
Technology Readiness Level	Activities are expected to achieve TRL 4 or higher at wing system level at project completion, as indicated in section 'Expected Outcome'. Applicants must provide a detailed plan of the TRL steps and a roadmap (aligned with the SRIA and with the objectives as defined in the Work Programme) that can deliver the technology maturity needed by the end of Clean Aviation for the results of their project to be included in new aircraft with an entry into service no later than 2035. See General Annex B of Horizon Europe for a guide to the TRL definitions and criteria to be used.
Special skills and/or capabilities expected from the Applicant(s)	The Clean Aviation Joint Undertaking expects proposals to be submitted by consortia that include airframe/aerostructures integrators and their supply chain with a proven track record in developing and delivering globally competitive airframe/aerostructures to aircraft programmes, as well as key contributors from the domain of academic/scientific research and technology development.

	The consortium configuration should ensure the appropriate industrial, economic and supply chain interests are represented in the project and can ensure the transition from research to product innovation and market deployment no later than 2035, and with a clearly articulated route that supports the aim of replacing 75% of the operating fleet by 2050. Applicant(s) should also be able to manage large and complex international aeronautical programmes demonstrating a track record of successful design, development and certification in the aeronautical supply chain of short and short-medium range aircraft at the level relevant to the topic's scope as described. Applicants should ensure their proposal and consortium reflect all necessary expertise and capabilities. Applicants should identify and include the additional expertise needed to complement the traditional aeronautical domain, in order to effectively address the incorporation of new/disruptive technologies. Where appropriate, the consortium should include newcomers to the programme and to the field of aeronautics and in particular SMEs, start-ups and/or knowledge centres that can bring disruptive innovation to the project as proposed.
Membership/Consortium agreement	The topic is identified as a key contributor to the overall aircraft concepts related to short range and short-medium range aircraft. The JU Members participating in the topic must ensure compliance with the existing Membership Agreement and must conclude with the participants to the project, a suitable Consortium Agreement [CA] governing the project and its consortium. A model of the Consortium Agreement is available on the F&T portal.
Cooperation Agreement(s)	In order to ensure a programmatic approach and implementation of the programme, project(s) launched under this topic should share/exchange, as appropriate, relevant results generated in the project with other relevant projects. For this purpose, the participants in the projects selected under this topic must conclude within six months of signature of the Grant Agreement (a) Cooperation Agreement(s) with the participants implementing the projects selected under the other relevant JU topics under this call and with the ongoing projects selected under the first CAJU Call for Proposals (CfP)[128]: see further under "other relevant projects". A model of the Cooperation Agreement applicable to the projects funded under the first call will be made available on the Funding & Tenders portal (F&T portal).
Impact Monitoring	Under the Impact Monitoring framework, the participants selected in this topic are also required to mention to which aircraft concept they are willing to contribute to (either SMR or HER as listed in the CAJU Work

[128] HORIZON-JU-CLEAN-AVIATION-2022-01: link

	Programme) and to exchange all relevant information and data with the ongoing project[s] selected under the first CAJU Call for Proposals (CfP)[129], in particular SMR ACAP[130] and/or HERA[131]. The exchange should be implemented on a yearly basis as well as a final impact/performance assessment at project completion including a TRL assessment, in order to establish the Impact Monitoring mechanism as described in the Clean Aviation SRIA and Work Programme by providing a performance assessment of the key technologies, sub-systems or systems for possible integration on the future aircraft concept model developed in SMR ACAP[132] and/or HERA[133]. This will serve to assess the performance of the aircraft concepts as described in the work programme against the programme specific objectives listed in the SBA. Applicants must ensure that their internal Consortium Agreement includes the necessary provisions to allow such required exchanges of information and data outside the consortium.
Project Monitoring	The JU will perform a number of gate reviews with a key review at month 12 (or at a fixed date, to be determined) to assess the overall progress against the project plan and against the performance targets. Depending on the outcome of this key gate review, the scope of the project may be revised and/or funding reduced in case of significant issues. Mitigation actions may be requested by the JU as condition for continued funding.
In-kind contributions (IKOP/IKAA by JU Members; co-funding by other applicants)	In order to ensure the obligations for in-kind contributions by Members of the CAJU (i.e. “Founding Member”, “Associated Member” and affiliated entities to a Member) can be fulfilled as set in Article 61 of the Council Regulation (EU) 2021/2085[134], annual deliverables on in-kind contributions will be set in the grant agreements for the projects selected under this topic, as well as appropriate reporting requirements. The Members responding to this topic (i.e. “Founding Member”, “Associated Member” and affiliated entities) must describe in the proposal the planned in kind contributions, indicating the level and the nature, to be provided in the course of the project . In-kind contributions to additional activities should be declared via the template model available on the F&T portal. The amount of the total in-kind contributions (i.e. in-kind contribution to operation activities and in-kind contribution

[129] HORIZON-JU-CLEAN-AVIATION-2022-01: link
[130] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955
[131] HERA Hybrid-Electric Regional Architecture; Project ID: 101102007
[132] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955
[133] HERA Hybrid-Electric Regional Architecture; Project ID: 101102007
[134] Council Regulation (EU) 2021/2085 of 19 November 2021. Official Journal: OJ L 427, 30.11.2021, p. 17–119. (https://data.consilium.europa.eu/doc/document/ST-12156-2021-INIT/en/pdf)

	to additional activities) should be no less than 1.5[135] times the funding request in aggregate for the proposal. Considering that in accordance with Article 61 of the Council Regulation (EU) 2021/2085[136], only the Members of the CAJU are able to provide and report on the required minimum level of in-kind contributions, participants in the proposal who are not a "Member" of the CAJU should explain in the proposal which resources, key competences, technical and financial contributions they will be able to provide to the project and to the programme/Strategic Research and Innovation Agenda[137] at large.

Other relevant projects	This project should run in close cooperation and synchronization with other relevant projects that will be selected under this call, as well as with ongoing projects selected under the first CAJU Call for Proposals (CfP)[138], in particular with SMR ACAP[139]: The applicants should: - ensure their proposal is aligned with the Gantt chart(s) of the relevant thrust(s) as published in the Clean Aviation Work Programme 2022-2023), and duly consider interfaces and interdependencies therein, in order to ensure a consistent and coordinated approach with the other relevant projects selected under this call and the first CAJU CfP; - draw up in their proposal a list of projects selected under the first call and a list of topics published under this call for which a cooperation and access rights will be needed in order to achieve the proposal's objectives and implement the impact monitoring framework; - commit in their proposal to sign a cooperation agreement with the ongoing SMR ACAP[140] and/or HERA[141] project[s] and with the other identified projects selected under the first CAJU CfP[142]; - define a deliverable which will provide the specific technical requirements, the necessary data/information exchanges and the delivery schedule thereof with respect to the other relevant projects to support an integrated programme planning across the projects with

[135] In order to support a leverage factor of no less than the ratio between the contribution from members other than the Union (EUR 2 400 000 000) and the Union financial contribution (EUR 1 700 000 000), which are defined in the Council Regulation (EU) 2021/2085

[136] Council Regulation (EU) 2021/2085 of 19 November 2021 establishing the Joint Undertakings under Horizon Europe and repealing Regulations (EC) No 219/2007, (EU) No 557/2014, (EU) No 558/2014, (EU) No 559/2014, (EU) No 560/2014, (EU) No 561/2014 and (EU) No 642/2014

[137] available on the F&T portal

[138] HORIZON-JU-CLEAN-AVIATION-2022-01: link

[139] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[140] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[141] HERA - Hybrid-Electric Regional Architecture; Project ID: 101102007

[142] HORIZON-JU-CLEAN-AVIATION-2022-01: link

	interfaces, including a list of milestones and deliverables across the contributing projects. This deliverable must be issued by the applicants at month 6. During grant preparation, the JU may propose amendments or additions to the list of other relevant projects on the basis of the experts' evaluation. The cooperation agreements to be concluded should allow for the future inclusion of additional relevant projects that may result from future calls. For further information, please also consult the Rules for Submission, evaluation and selection and the dedicated part in the CAJU Work Programme.
Involvement of EASA	Each project is required to exploit the involvement and expertise of EASA in the proposal to de-risk and secure the certification of novel technologies with the aim to assess and define how the envisaged solutions will have the potential for certification. Applicants are requested to establish contacts with EASA in view of seeking their possible involvement in the proposal, to discuss their possible contribution under the topic and define a detailed description of their technical activities and estimated budget which should be included in the proposal, see also section below on "Scope". The contribution of EASA should take the form of in-kind contribution under Article 9 of the Horizon Europe model Grant Agreement to be agreed under the proposal and to be implemented in the form of a service contract to be signed with EASA. The involvement of EASA in the proposal as third party may be complemented, where applicable, by other possible agreements already in place between EASA and the consortium partner in charge of the certification aspects and which may be relevant for the topic and the project execution. In such a case, the applicant should describe in the proposal the synergies and the articulation of EASA tasks and their costs coverage under such agreements in order to optimise the use of resources under the proposal. The service contract should be established based on the CAJU model service contract published under the F&T Portal. With regard to the status and role of EASA in CAJU projects, see also the CAJU Work Programme. Further guidance on EASA involvement and legal status in the proposal will be provided in the 1st Q&A of the call. Practical modalities for contacting EASA will be laid down in the 1st Q&A of the call.

Expected Outcome:

Project results are expected to contribute to all the following expected outcomes:

- Identify and deliver an ultra-high performance “dry wing” design for the targeted concepts for a hydrogen-powered Short and/or Short-Medium Range (SR/SMR) aircraft[143] with maximum aerodynamic efficiency and minimum weight. The targeted impact of the ultra-performing wing at aircraft level should be an energy efficiency improvement up to 18% at aircraft mission level compared to a 2020 state of the art aircraft available for order/delivery. The novel ultra-high performance wing should be designed for the targeted concept for an ultra-efficient hydrogen-powered SR/SMR aircraft and should achieve the targeted performance through drag and weight reduction.
- Demonstrate a novel, robust and efficient integration of unducted or ducted engine propulsion system with the proposed wing configuration, maximising aerodynamic and structural performance, whilst enabling an achievable and certifiable SR/SMR flight envelope and minimised acoustic footprints.
- Demonstrate efficient structural and system integration of a novel leading edge for the proposed wing configuration, maximising aerodynamic performance, ice protection efficiency, erosion and bird impact protection, and optimising system integration at wing level.
- Demonstrate wing flutter management and control of the proposed “dry wing” configuration, taking into account transonic aerodynamic conditions and proposing means of compliance for future certification rules.
- Demonstrate at project completion the “dry wing” design performance and detail the demonstration plan (with inclusion of component/sub-system level) to meet TRL 4 or higher at full wing system level at project completion via relevant wind-tunnel and full-scale partial ground tests demonstration. The applicant should develop and propose an appropriate simulation and full-scale testing programme to ensure confidence that the required maturity levels and performance targets will be met.
- Deliver a roadmap towards full-scale demonstration of the wing system[144] compatible with TRL 6 at aircraft level before the end of the Clean Aviation programme and compatible with an EIS by 2035. Propose a plan to anticipate rule making and means of compliance for potential future certification suitable for SR/SMR aircraft.
- Deliver digital twins and a life cycle assessment of the components, subsystems and full wing system[145] compatible with the reference aircraft digital framework and requirements, in order to regularly assess the contribution to the overall aircraft performance in the context of the impact monitoring framework. These models should be continuously validated and updated at each step in the TRL progress loop.

[143] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955
[144] UP WING - Ultra Performance Wing; Project ID: 101101974
[145] UP WING - Ultra Performance Wing; Project ID: 101101974

- Identify synergies with activities funded under research and innovation programmes at regional[146], national[147] and European[148] level, and demonstrate how the project will benefit from these activities by detailing the specific contributions to the expected outcome(s).

Scope:

With growing market demand and an ever-increasing focus on the environmental impact of flight (even with more stringent regulations), the mid-2030s are expected to see the entry of a new generation of SR/SMR aircraft (with a capacity of up to 250 seats) aiming towards sustainable climate-neutral flight. While hybrid/electric energy architectures are considered to pave the way towards climate-neutral aviation on routes shorter than 1000 km, aircraft for classical short and medium-range distances, i.e. from 1000 km up to 3700 km, will rely on ultra-efficient aircraft designs and ultra-efficient thermal energy-based propulsion technologies using sustainable drop-in and non-drop-in fuels.

With its large impact on aircraft's total drag and weight, developing an ultra-high performance "dry wing" with an energy efficiency improvement of 18% at aircraft mission level will be key to the success of the hydrogen-powered SR/SMR aircraft[149]:

- The assumptions relative to the aircraft operating envelope, flight mission profile, aircraft range, cruise speed, seating capacity and to the general sizing parameters, should be fully consistent with those applicable in the Clean Aviation project focusing on SR/SMR aircraft architectures exploiting non-drop in fuels such as hydrogen[150].
- Consistent wing system requirements should be derived accordingly from the SR/SMR aircraft architectures identified in the Clean Aviation projects focusing on SR/SMR aircraft architectures exploiting non-drop fuels such as hydrogen[151] and on wing design for SR/SMR[152]. Any deviation from these references as a result of different configuration effects (e.g., for technical feasibility, project viability reasons, or for optimizing the project outcome) should be identified and substantiated.

Novel ultra-performing technologies will present both challenges and opportunities to minimise drag, optimise flight control devices, high lift and control surfaces, and reduce weight and noise, as well as in-system integration (e.g. wing-fuselage integration and wing-propulsion integration) and the overall aircraft integration. Therefore, these technologies need to be developed and validated in close connection with solutions and choices adopted at aircraft, system and component level, taking into account constraints, requirements and interdependencies.

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[146] Activities funded in Member States and Associated Countries and/or funded through EU funds administrated by regional or national authorities such as the European Regional Development Fund (ERDF) and the European recovery fund (i.e. NextGenerationEU).
[147] Activities funded in Member States and Associated Countries and/or funded through EU funds administrated by regional or national authorities such as the European Regional Development Fund (ERDF) and the European recovery fund (i.e. NextGenerationEU).
[148] Activities funded under Horizon Europe (outside the Clean Aviation Work Programme 2022-2023) and/or other EU programmes.
[149] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955
[150] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955
[151] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955
[152] UP WING - Ultra Performance Wing; Project ID: 101101974

The future potential use of hydrogen as an energy source requires the development and demonstration of compatible technologies and sub-systems that will have an impact on the wing system, as well as on the aircraft architecture. The project should identify and deliver an ultra-high performance wing for the targeted concept for an ultra-efficient SR/SMR aircraft exploiting non-drop-in fuels such as hydrogen. It should also demonstrate a propulsion integrated wing configuration, an optimised leading edge with maximum aerodynamic performance, and novel solutions for wing flutter management. The project should investigate the impact and features of the proposed concept on operations and systems (e.g. flight control systems, anti-icing) including maintenance, repair, availability, fault tolerance, reliability, and safety. The project should develop and propose an appropriate simulation and full-scale testing programme at conditions representative of the SR/SMR flight envelope. When assessing life cycle aspects the overall environmental impact should be considered. A quantitative and qualitative estimation of future potential performance, identifying issues and potential solutions should be provided.

Proposed designs will build on, adapt, complement and add to CS-25 and other regulations to highlight any gaps, maximise impact potential, and enable new certification standards, whilst maintaining or enhancing safety levels. The project should propose a plan to anticipate rule making and means of compliance for potential future certification suitable for SR/SMR aircraft. It should also support Clean Aviation initiatives to define new certification or qualification rules as well as new standardisation efforts concerning the areas of the project and others related to them. Any specific safety or certification issue should be highlighted, and mitigation action should be proposed.

The project is required to exploit the involvement and expertise of EASA in the proposal to de-risk and secure the certification of novel propulsion technologies with the aim to assess and define how the envisaged solutions will have the potential for certification. Applicants are requested to establish contact with EASA in view of seeking their possible involvement in the proposal, to discuss their possible contribution under the topic and define a detailed description of their technical activities and estimated budget which should be included in the proposal (ref topic conditions related to "Involvement of EASA").

<u>Performance Targets:</u>

A number of top-level goals will be the basis for performance targets, in particular:

- The ultra-high performing wing with an increased energy efficiency of up to 18%[153] at aircraft mission level, with maximum aerodynamic efficiency and minimum weight, to be extended as much as possible to a target of 30% GHG emissions reduction at aircraft level (possibly expressed, for instance, in terms of overall GHG emissions per passenger kilometre);
- it is implicit that all targets must be compatible with safety as an overarching requirement.

These top-level goals should be broken down in a consistent manner at the different levels: from top-level aircraft requirements down to systems, sub-systems and components level requirements, from where pertinent performance targets including Key Performance Indicators (KPIs) should be derived.

The performance targets, including KPIs, should be defined and calibrated with the objective of meeting

[153] compared to a clearly identified 2020 SoA reference wing available for order/delivery and measured as fuel kg per Available Seat Kilometre (ASK) or energy (megajoules) per ASK as applicable, on a typical mission

or exceeding the project goals at completion, allowing efficient progress monitoring and providing a sound basis for subsequent work in view of best contributing to the achievement of overall high level goals:

- it is strongly recommended that the definition of targets should be guided by principles such as S.M.A.R.T.[154] objectives;
- these performance targets should be established, developed and actual corresponding quantified values should be specified by the applicant consistently with all constraints pertaining to the design of SR/SMR aircraft;
- KPIs and the corresponding quantified targets should be defined according to the technologies involved within the wing system and depending on its integration in the aircraft, in a manner consistent with the overall GHG reduction targets;
- the applicant should provide the assumptions and the rationale underlying those target definitions and values;
- the applicant should also explain how the project is developing solutions compliant with them, including effective means of monitoring progress and optimizing work statements.

The applicant should also determine and quantify the targets at system, sub-system and down to component level; they should be adapted to the explored wing configuration, and accompanied by maturity roadmaps and development plans, including performance improvements expected by 2030 for critical components, and considering the potential implication of the design on aircraft noise.

All data required to characterize the aircraft emissions and environmental impact over the life cycle should be modelled and measured as required to feed aircraft performance assessment(s).

Proposals should include a detailed project plan with key milestones and deliverables and a list of performance targets per critical technology.

[154] S.M.A.R.T.: Specific, Measurable, Achievable, Relevant, Timely

III. HORIZON-JU-CLEAN-AVIATION-2023-02-SMR-03: Advanced Cabin and Cabin Systems Integration for Short Range and Short-Medium Range for Hydrogen-Powered Aircraft

Description of the call topic and topic specific conditions	
Specific eligibility criterion	Legal entities established in Russia, Belarus, or in non-government controlled territories of Ukraine — Given the illegal invasion of Ukraine by Russia and the involvement of Belarus, there is currently no appropriate context allowing the implementation of the actions foreseen in this programme with legal entities established in Russia, Belarus, or in non-government controlled territories of Ukraine. Therefore, even where such entities are not subject to EU restrictive measures, such legal entities are not eligible to participate in any capacity. This includes participation as beneficiaries, affiliated entities, associated partners, third parties giving in-kind contributions, subcontractors or recipients of financial support to third parties (if any). Exceptions may be granted on a case-by-case basis for justified reasons.
Expected EU contribution per project	The Clean Aviation Joint Undertaking estimates that an EU contribution up to EUR 7 million would allow these outcomes to be addressed appropriately. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative funding budget for the topic is EUR 7 million. The Clean Aviation Joint Undertaking may award 1 project with funding depending on the outcome of the evaluation and the complementarity of the proposed actions.
Indicative project duration	Maximum 36 months.
Type of Action	Innovation Actions.
Technology Readiness Level	Activities are expected to achieve TRL 4 or higher at system level at project completion, as indicated in section 'Expected Outcome'. Applicants must provide a detailed plan of the TRL steps and a roadmap (aligned with the SRIA and with the objectives as defined in the Work Programme) that can deliver the technology maturity needed by the end of Clean Aviation for the results of their project to be included in new aircraft with an entry into service no later than 2035. See General Annex B of Horizon Europe for a guide to the TRL definitions and criteria to be used.
Special skills and/or capabilities expected from the Applicant(s)	The Clean Aviation Joint Undertaking expects proposals to be submitted by consortia that include airframe/aerostructures integrators and their supply chain with a proven track record in developing and delivering globally competitive airframe/aerostructures to aircraft programmes, as well as key

	contributors from the domain of academic/scientific research and technology development. The consortium configuration should ensure the appropriate industrial, economic and supply chain interests are represented in the project and can ensure the transition from research to product innovation and market deployment no later than 2035, and with a clearly articulated route that supports the aim of replacing 75% of the operating fleet by 2050. Applicant(s) should be able to manage large and complex international aeronautical programmes demonstrating a track record of successful design, development and certification in the aeronautical supply chain of short and short-medium range aircraft at the level relevant to the topic's scope as described. Applicants should ensure their proposal and consortium reflect all necessary expertise and capabilities. Applicants should identify and include the additional expertise needed to complement the traditional aeronautical domain, in order to effectively address the incorporation of new/disruptive technologies. Where appropriate, the consortium should include newcomers to the programme and to the field of aeronautics and in particular SMEs, start-ups and/or knowledge centres that can bring disruptive innovation to the project as proposed.
Membership/Consortium agreement	The topic is identified as a key contributor to the overall aircraft concepts related to short range and short-medium range aircraft. The JU Members participating in the topic must ensure compliance with the existing Membership Agreement and must conclude with the participants to the project, a suitable Consortium Agreement [CA] governing the project and its consortium. A model of the Consortium Agreement is available on the F&T portal.
Cooperation Agreement(s)	In order to ensure a programmatic approach and implementation of the programme, project(s) launched under this topic should share/exchange, as appropriate, relevant results generated in the project with other relevant projects. For this purpose, the participants in the projects selected under this topic must conclude within six months of signature of the Grant Agreement (a) Cooperation Agreement(s) with the participants implementing the projects selected under the other relevant JU topics under this call and with the ongoing projects selected under the first CAJU Call for Proposals (CfP)[155]: see further under "other relevant projects". A model of the Cooperation Agreement applicable to the projects funded under the first call will be made available on the Funding & Tenders portal (F&T portal).

[155] HORIZON-JU-CLEAN-AVIATION-2022-01: link

Impact Monitoring	Under the Impact Monitoring framework, the participants selected in this topic are also required to mention to which aircraft concept they are willing to contribute to (either SMR or HER as listed in the CAJU Work Programme) and to exchange all relevant information and data with the ongoing project[s] selected under the first CAJU Call for Proposals (CfP)[156], in particular SMR ACAP[157] and/or HERA[158]. The exchange should be implemented on a yearly basis as well as a final impact/performance assessment at project completion including a TRL assessment, in order to establish the Impact Monitoring mechanism as described in the Clean Aviation SRIA and Work Programme by providing a performance assessment of the key technologies, sub-systems or systems for possible integration on the future aircraft concept model developed in SMR ACAP[159] and/or HERA[160]. This will serve to assess the performance of the aircraft concepts as described in the work programme against the programme specific objectives listed in the SBA. Applicants must ensure that their internal Consortium Agreement includes the necessary provisions to allow such required exchanges of information and data outside the consortium.
Project Monitoring	The JU will perform a number of gate reviews with a key review at month 12 (or at a fixed date, to be determined) to assess the overall progress against the project plan and against the performance targets. Depending on the outcome of this key gate review, the scope of the project may be revised and/or funding reduced in case of significant issues. Mitigation actions may be requested by the JU as condition for continued funding.
In-kind contributions (IKOP/IKAA by JU Members; co-funding by other applicants)	In order to ensure the obligations for in-kind contributions by Members of the CAJU (i.e. “Founding Member”, “Associated Member” and affiliated entities to a Member) can be fulfilled as set in Article 61 of the Council Regulation (EU) 2021/2085[161], annual deliverables on in-kind contributions will be set in the grant agreements for the projects selected under this topic, as well as appropriate reporting requirements. The Members responding to this topic (i.e. “Founding Member”, “Associated Member” and affiliated entities) must describe in the proposal the planned in kind contributions, indicating the level and the nature, to be provided in the course of the project. In-kind contributions to additional activities should be declared via the template model available on the F&T portal. The amount of the total in-kind contributions (i.e. in-kind contribution to operation activities and in-kind contribution to additional

156 HORIZON-JU-CLEAN-AVIATION-2022-01: link
157 SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955
158 HERA Hybrid-Electric Regional Architecture; Project ID: 101102007
159 SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955
160 HERA Hybrid-Electric Regional Architecture; Project ID: 101102007
161 Council Regulation (EU) 2021/2085 of 19 November 2021. Official Journal: OJ L 427, 30.11.2021, p. 17–119. (https://data.consilium.europa.eu/doc/document/ST-12156-2021-INIT/en/pdf)

	activities) should be no less than 1.5[162] times the funding request in aggregate for the proposal. Considering that in accordance with Article 61 of the Council Regulation (EU) 2021/2085[163], only the Members of the CAJU are able to provide and report on the required minimum level of in-kind contributions, participants in the proposal who are not a "Member" of the CAJU should explain in the proposal which resources, key competences, technical and financial contributions they will be able to provide to the project and to the programme/Strategic Research and Innovation Agenda[164] at large.

Other relevant projects	This project should run in close cooperation and synchronization with other relevant projects that will be selected under this call, as well as with ongoing projects selected under the first CAJU Call for Proposals (CfP)[165], in particular with SMR ACAP[166]. The applicants should: - ensure their proposal is aligned with the Gantt chart(s) of the relevant thrust(s) as published in the Clean Aviation Work Programme 2022-2023), and duly consider interfaces and interdependencies therein, in order to ensure a consistent and coordinated approach with the other relevant projects selected under this call and the first CAJU CfP; - draw up in their proposal a list of projects selected under the first call and a list of topics published under this call for which a cooperation and access rights will be needed in order to achieve the proposal's objectives and implement the impact monitoring framework; - commit in their proposal to sign a cooperation agreement with the ongoing SMR ACAP[167] and/or HERA[168] project[s] and with the other identified projects selected under the first CAJU CfP[169]; - define a deliverable which will provide the specific technical requirements, the necessary data/information exchanges and the delivery schedule thereof with respect to the other relevant projects to support an integrated programme planning across the projects with

[162] In order to support a leverage factor of no less than the ratio between the contribution from members other than the Union (EUR 2 400 000 000) and the Union financial contribution (EUR 1 700 000 000), which are defined in the Council Regulation (EU) 2021/2085

[163] Council Regulation (EU) 2021/2085 of 19 November 2021 establishing the Joint Undertakings under Horizon Europe and repealing Regulations (EC) No 219/2007, (EU) No 557/2014, (EU) No 558/2014, (EU) No 559/2014, (EU) No 560/2014, (EU) No 561/2014 and (EU) No 642/2014

[164] available on the F&T portal

[165] HORIZON-JU-CLEAN-AVIATION-2022-01: link

[166] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[167] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[168] HERA - Hybrid-Electric Regional Architecture; Project ID: 101102007

[169] HORIZON-JU-CLEAN-AVIATION-2022-01: link

	interfaces, including a list of milestones and deliverables across the contributing projects. This deliverable must be issued by the applicants at month 6. During grant preparation, the JU may propose amendments or additions to the list of other relevant projects on the basis of the experts' evaluation. The cooperation agreements to be concluded should allow for the future inclusion of additional relevant projects that may result from future calls. For further information, please also consult the Rules for Submission, evaluation and selection and the dedicated part in the CAJU Work Programme.
Involvement of EASA	Each project is required to exploit the involvement and expertise of EASA in the proposal to de-risk and secure the certification of novel technologies with the aim to assess and define how the envisaged solutions will have the potential for certification. Applicants are requested to establish contacts with EASA in view of seeking their possible involvement in the proposal, to discuss their possible contribution under the topic and define a detailed description of their technical activities and estimated budget which should be included in the proposal, see also section below on "Scope". The contribution of EASA should take the form of in-kind contribution under Article 9 of the Horizon Europe model Grant Agreement to be agreed under the proposal and to be implemented in the form of a service contract to be signed with EASA. The involvement of EASA in the proposal as third party may be complemented, where applicable, by other possible agreements already in place between EASA and the consortium partner in charge of the certification aspects and which may be relevant for the topic and the project execution. In such a case, the applicant should describe in the proposal the synergies and the articulation of EASA tasks and their costs coverage under such agreements in order to optimise the use of resources under the proposal. The service contract should be established based on the CAJU model service contract published under the F&T Portal. With regard to the status and role of EASA in CAJU projects, see also the CAJU Work Programme. Further guidance on EASA involvement and legal status in the proposal will be provided in the 1st Q&A of the call. Practical modalities for contacting EASA will be laid down in the 1st Q&A of the call.

Expected Outcome:

Project results are expected to contribute to all the following expected outcomes:

- Develop a systems-based design of the internal fuselage space and cabin with minimum environmental impact for the targeted concepts for a hydrogen-powered Short and/or Short-Medium Range Aircraft (SR/SMR) architecture.[170], contributing to the targeted energy consumption reduction of minimum 15%[171] at aircraft level. Whilst taking into account the aircraft design[172], the project should demonstrate solution(s) efficiently integrating cabin with hydrogen systems located in the fuselage[173] (in particular hydrogen storage[174] and hydrogen fuel distribution[175] systems), maximising the available space and minimising the impact on cabin capacity. This should be achieved through optimised design, installation, and enhanced modularity enabling increased energy efficiency at aircraft level.
    - For the full cabin and cabin systems design, quantified reduction potential in CO_2 and all other relevant GHG emissions (see performance targets section below) are expected to be derived from the project (both in terms of actual demonstrated and potential performance impact).
- Demonstrate a design for optimum integration of aircraft systems with cabin and cargo functions targeting an overall equivalent weight reduction of the cabin and integrated systems of no less than 20% (excluding penalties due to hydrogen technologies) compared to clearly identified 2020 state-of-the-art cabin and integrated systems available for order/delivery.
- Detail the demonstration plan, with inclusion of component/sub-system level, to meet no less than TRL 4 at integrated cabin and cabin systems level at project completion. The performance and the technology maturity of the cabin and cabin systems at project completion should be verified via numerical simulation and relevant ground demonstration. The applicant should develop and propose an appropriate simulation and testing programme to ensure confidence that the required maturity levels and performance targets will be met.
- Deliver a roadmap towards full-scale demonstration of cabin and cabin systems compatible with TRL 6 at aircraft level before the end of the Clean Aviation programme compatible with an entry into service by 2035.
- Anticipate FMEA (Failure Modes and Effects Analysis) affecting safety for the core/basic technologies. Provide guidance on rulemaking for safety, certification and means of compliance and propose a qualification and certification plan linked to the proposed activities and suitable to SR/SMR aircraft.

[170] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[171] compared to 2020 state-of-the-art aircraft available for order/delivery and measured as energy (megajoules) per Available Seat Kilometre (ASK) on a typical mission

[172] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[173] FASTER-H2 (Fuselage, Rear Fuselage and Empennage with Cabin and Cargo Architecture Solution validation and Technologies for H2 integration); Project ID: 101101978

[174] H2ELIOS - HydrogEn Lightweight & Innovative tank for zerO-emisSion aircraft, Project ID 101102003

[175] Clean Aviation JU Call for Proposals n° 2, topic "HORIZON-JU-CLEAN-AVIATION-2023-02-HPA-02: Aircraft Liquid Hydrogen Fuel Distribution System Technologies for Direct Burn Applications"

- Deliver modules and systems designs compatible with more electrical functions and alternate energy sources such as hydrogen, enabling disruptive concepts in line with the fuselage concept[176].
- Deliver digital twins and a Life Cycle Assessment of the components, sub-systems and the full cabin and cabin systems, compatible with the reference aircraft digital framework and requirements, in order to regularly assess the contribution to the overall aircraft performance in the context of the impact monitoring framework. These models should be continuously validated and updated during the overall technology / TRL maturation phase.
- Identify synergies with activities funded under research and innovation programmes at regional[177], national[178] and European[179] level, and demonstrate how the project will benefit from these activities by detailing the specific contributions to the expected outcome(s).

<u>Scope:</u>

With growing market demand and an ever-increasing focus on the environmental impact of flight (even with more stringent regulations), the mid-2030s are expected to see the entry of a new generation of SR/SMR aircraft (with a capacity of up to 250 seats) aiming towards sustainable climate-neutral flight. While hybrid/electric energy architectures are considered to pave the way towards climate-neutral aviation on routes shorter than 1000 km, aircraft for classical short and medium-range distances, i.e. from 1000 km up to 3700 km, will rely on ultra-efficient aircraft designs and ultra-efficient thermal energy-based propulsion technologies using sustainable drop-in and non-drop-in fuels.

A novel cabin and cabin systems integration is an enabler for the successful development of hydrogen-powered SR/SMR aircraft with a targeted energy consumption reduction of minimum 15%[180].

- The assumptions relative to the aircraft operating envelope, to the flight mission profile, to the aircraft range, to the aircraft cruise speed, to the aircraft seating capacities and to the main aircraft sizing parameters in general, should be fully consistent with those applicable in the Clean Aviation project focusing on SR/SMR aircraft architectures exploiting non-drop-in fuels such as hydrogen[181].
- Consistent cabin and cabin systems requirements should be derived accordingly from the Clean Aviation projects focusing on hydrogen-powered SR/SMR aircraft architectures[182] and

[176] FASTER-H2 (Fuselage, Rear Fuselage and Empennage with Cabin and Cargo Architecture Solution validation and Technologies for H2 integration); Project ID: 101101978
[177] activities funded in Member States and Associated Countries and/or funded through EU funds administrated by regional or national authorities such as the European Regional Development Fund (ERDF) and the European recovery fund (i.e. NextGenerationEU).
[178] activities funded in Member States and Associated Countries and/or funded through EU funds administrated by regional or national authorities such as the European Regional Development Fund (ERDF) and the European recovery fund (i.e. NextGenerationEU).
[179] activities funded under Horizon Europe (outside the Clean Aviation Work Programme 2022-2023) and/or other EU programmes.
[180] compared to 2020 state-of-the-art aircraft available for order/delivery and measured as energy (megajoules) per Available Seat Kilometre (ASK) on a typical mission
[181] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955
[182] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

integrated fuselage[183]. Any deviation from these references as a result of different configuration effects (e.g., for technical feasibility, project viability reasons, or for optimizing the project outcome) should be identified and substantiated.

The scope of this topic is to deliver an integrated and modular design of minimum environmental impact cabin and cabin systems including the relevant technology bricks expected to meet TRL 4 at integrated cabin and cabin systems level at project completion and compatible with SR/SMR hydrogen-powered aircraft concept(s) selected at the end of 2025 as well.

The adoption of hydrogen-powered propulsion system will come with challenges in SR/SMR system and aircraft integration, as space available in the fuselage may become even more limited compared to today's reference aircraft. Therefore, cabin and cabin systems design and integration need to be developed and validated in close connection with solutions and choices at aircraft concept level, as well as at fuselage, hydrogen storage and hydrogen fuel system levels, and taking into account interdependencies. Inputs from aircraft architecture[184], fuselage[185], as well as relevant hydrogen technology developments (e.g., hydrogen storage[186] and distribution[187] systems) will be delivered by separated projects launched under Clean Aviation.

The goal is to achieve is TRL 4 at cabin and cabin systems integration level at project completion duly supported by component and subsystem ground tests at appropriate scale at project completion, so that the selected cabin and systems designs can be further matured in the Clean Aviation Programme and embedded and integrated in a specified architecture for (flight) demonstration. Scalability to other applications is an opportunity to be pursued. Life cycle aspects should be considered in the overall environmental impact.

Proposed designs will build on, adapt, complement and add to DO 160, DO 178 and CS-25 and other regulations to highlight any gaps, maximise impact potential, and enable new certification standards, whilst maintaining or enhancing safety levels. The project should propose a plan to anticipate rule making and means of compliance for potential future certification suitable for SR/SMR aircraft. It should also support Clean Aviation initiatives to define new certification or qualification rules as well as new standardisation efforts concerning the areas of the project and others related to them. Any specific safety or certification issue should be highlighted, and mitigation action should be proposed.

The project is required to exploit the involvement and expertise of EASA in the proposal to de-risk and secure the certification of novel propulsion technologies with the aim to assess and define how the envisaged solutions will have the potential for certification. Applicants are requested to establish contact with EASA in view of seeking their possible involvement in the proposal, to discuss their possible contribution under the topic and define a detailed description of their technical activities and estimated budget which should be included in the proposal (ref topic conditions related to "Involvement of EASA").

[183] FASTER-H2 (Fuselage, Rear Fuselage and Empennage with Cabin and Cargo Architecture Solution validation and Technologies for H2 integration); Project ID: 101101978

[184] SMR-ACAP (SMR aircraft architecture and technology integration project); Project ID: 101101955

[185] FASTER-H2 (Fuselage, Rear Fuselage and Empennage with Cabin and Cargo Architecture Solution validation and Technologies for H2 integration); Project ID: 101101978

[186] H2ELIOS - HydrogEn Lightweight & Innovative tank for zerO-emisSion aircraft, Project ID 101102003

[187] Clean Aviation JU Call for Proposals n° 2, topic "HORIZON-JU-CLEAN-AVIATION-2023-02-HPA-02: Aircraft Liquid Hydrogen Fuel Distribution System Technologies for Direct Burn Applications"

Performance Targets:

A number of top-level goals will be the basis for performance targets, in particular:

- Cabin and cabin systems: installed performance contributing to the aircraft performance target of minimum 15%[188] reduction in energy consumption, and where possible expressed in terms of overall GHG emissions per passenger kilometre. The applicant should explicitly provide the reduction in energy consumption targeted by the project, including appropriate metrics;
- Overall equivalent weight reduction of no less than 20%[189] of the cabin and integrated systems (excluding penalties due to hydrogen technologies);
- Targets must be compatible with safety as an overarching requirement.

These top-level goals should be broken down in a consistent manner at the different levels: from top-level aircraft requirements down to systems, sub-systems and components level requirements, from where pertinent performance targets including Key Performance Indicators (KPIs) should be derived.

The performance targets, including KPIs, should be defined and calibrated with the objective of meeting or exceeding the project goals at completion, allowing efficient progress monitoring and providing a sound basis for subsequent work in view of best contributing to the achievement of overall high-level goals:

- it is strongly recommended that the definition of targets should be guided by principles such as S.M.A.R.T.[190] objectives;
- these performance targets should be established, developed and actual corresponding quantified values should be specified by the applicant consistently with all constraints pertaining to the design of SR/SMR aircraft;
- KPIs and the corresponding quantified targets should be defined according to the technologies involved within the cabin and cabin systems, and depending on its integration in the aircraft, in a manner consistent with the overall GHG reduction targets.
- the applicant should provide the assumptions and the rationale underlying those target definitions and values;
- the applicant should also explain how the project is developing solutions compliant with them, including effective means of monitoring progress and optimizing work statements.

The project should also investigate the impact, effect, and features of the proposed concept(s) on operations and systems including maintenance, repair, availability, fault tolerance, reliability, and safety. A quantitative and qualitative estimation of future potential performance, identifying issues and potential solutions should be provided.

The applicant should determine performance targets down to component level (e.g. weight reduction, safety, system efficiency), including maturity roadmap and a strategic development plan including performance improvements until 2030 for critical components, taking into account aspects such as but not limited:

188 compared to 2020 state-of-the-art aircraft available for order/delivery and measured as energy (megajoules) per Available Seat Kilometre (ASK) on a typical mission

189 compared to 2020 state-of-the-art cabin and integrated systems available for order/delivery

190 S.M.A.R.T.: Specific, Measurable, Achievable, Relevant, Timely

- Aircraft and fuselage architectures
- Energy storage
- Energy distribution system
- Regulation.

The metrics should be flowed down in the proposal from cabin and cabin systems level down to component level to deliver optimal overall configuration. The resulting objectives have to be demonstrated in ground tests of the whole fuselage/aircraft system enabling the performance objectives of the respective aircraft delivering targeted performance gains defined in the SRIA.

All data required to characterise the aircraft emissions and environmental impact over the life cycle should be modelled and measured as required to feed aircraft performance assessment(s).

Proposals should include a detailed project plan with key milestones and deliverables together with a list of performance targets per critical technology.

4. Clean Aviation – Coordination and Support Actions (CSA)

I. HORIZON-JU-CLEAN-AVIATION-2023-02-CSA-01: Aviation Climate and Technology Impact Monitoring Methodology

Description of the topic and topic specific conditions	
Specific eligibility criterion	Legal entities established in Russia, Belarus, or in non-government controlled territories of Ukraine — Given the illegal invasion of Ukraine by Russia and the involvement of Belarus, there is currently no appropriate context allowing the implementation of the actions foreseen in this programme with legal entities established in Russia, Belarus, or in non-government controlled territories of Ukraine. Therefore, even where such entities are not subject to EU restrictive measures, such legal entities are not eligible to participate in any capacity. This includes participation as beneficiaries, affiliated entities, associated partners, third parties giving in-kind contributions, subcontractors or recipients of financial support to third parties (if any). Exceptions may be granted on a case-by-case basis for justified reasons.
Expected EU contribution	The Clean Aviation Joint Undertaking estimates that an EU contribution of around EUR 750,000 would allow this specific challenge to be addressed appropriately and brings the expected outcomes. In addition, this budget will allow the involvement of as much participants as possible. Nonetheless, this does not preclude submission and selection of a proposal requesting different amounts.
Indicative budget	The total indicative budget for the topic is EUR 750,000. The Clean Aviation Joint Undertaking expects to award up to 1 project with funding depending on the outcome of the evaluation and the complementarity of the proposed actions.
Project duration	Maximum 18 months This does not preclude submission and selection of a proposal with a different project duration.
Type of Action	Coordination and Support Action
Special skills and/or capabilities expected from the Applicant(s)	The Clean Aviation Joint Undertaking expects proposals to be submitted by consortia that include universities and/or research and technology organisations with a proven track record in aeronautics research and in atmospheric sciences/climatology. The applicants should have the following capabilities and skills: • capacity of coordination and support actions, as well as of dissemination and communication activities; • an extended knowledge of the European and worldwide aeronautics landscape; • an extended knowledge in atmospheric sciences/climatology;

	• an extended knowledge in aeronautics research and aircraft design and technologies (including propulsion systems) capacity to build networking activities/mechanisms and provide technical support to stakeholders.

Expected Outcomes:

While there is an agreed scientific position that non-CO2 aviation emissions play an important role towards climate neutrality, the uncertainty of these non-CO2 forcing agents is high. ICAO-CAEP report on the feasibility of LTAG – Appendix S1[191] presents estimates, based on radiative forcing (RF), effective radiation forcing (ERF), global warming potential (GWP*) and global temperature potential (GTP), metrics. The ICAO-CAEP report also suggests that the estimate is highly uncertain, as are other metric estimates and that no agreement on the choice of the most suitable metric has been obtained so far.

This project aims to provide more clarity and

- identify the climate metrics to be used to monitor the performance of development and demonstration actions, implemented in Horizon Europe Clean Aviation projects,
- deliver a complete literature review and an executive summary on the impact of climate metrics on aviation emissions and
- perform a preliminary impact assessment of a representative test case (e.g., using data from CS2 TE).

The study aims to assist the Technical Committee, the European Commission, the European Aviation Safety Agency and the CAJU. All results and deliverables of this Coordination and Support Action will be made publicly available and regularly presented to the different committees to maintain an effective coordination with Clean Aviation projects, especially the architecture projects for SMR and Regional Aircraft Concepts.

Project's results are expected to contribute to the following outcomes, with a higher priority to Part A than Part B, with the latter not to exceed 15-20% of the financial resources available:

A. Climate Impact of Aviation and GHG Contributions: Identification of Current Understanding, Gaps and Priorities, Metrics, and Assessment Methodology.

- Review and analyse the State-of-the-Art of aviation climate impact assessment methodologies. Special attention should be brought to the analysis of the metrics used considering the impact of short- and long-lived GHG, i.e., the integration period and the radiative forcing factor used (GWP, GTP, etc.). Collect, analyse, and establish the current level of scientific understanding within the community of climatology and atmospheric sciences, of aviation climate impact and its Green House Gas (GHG) emissions contributions, in Europe and worldwide. The action should establish an overview of the existing situation considering the results of previous and ongoing EU-funded actions and research projects on this issue (ATM4E, REACT4C, ACACIA, BECOM, CLIMOP, etc.) as well as other national and international previous and ongoing actions

[191] https://www.icao.int/environmental-protection/LTAG/Documents/ICAO_LTAG_Report_AppendixS1.pdf

(HyPERION, CIRRUS-H2, CIRRUS-HL, etc.). The action should provide a review report on a biannual basis (twice a year) based on the rapid evolution of research in this field.

- Identify knowledge gaps, barriers, and needs for research in view of enabling (net) climate neutral aviation and the relative contributions of the different species of GHG. This is particularly relevant in relation with the impact of net NOx effects at altitude, contrails formation and contrail induced cirrus as a function of particulate and water emissions from the aircraft propulsion system and fuel used (as a minimum required, it is expected that Hydrogen and various SAF options be considered besides kerosene in terms of fuel used). The action will result also in providing solutions/recommendations for targeted technology research and guidelines for aircraft operations for the European aviation sector adapted to the needs for achieving the long-term goals of climate neutrality and zero-emission aircraft. Derive a specific roadmap for further research on aviation climate impact both in terms of emissions at altitude and of local air quality (around airports).
- Formulate a proposal to obtain an answer on how to best translate the Clean Aviation Partnership objectives set out in the Council Regulation (-30% net GHG emission reduction vs SoA 2020) into tangible (simplified) metrics in terms of measurable engine tailpipe emissions (CO2 and non-CO2 specific objectives) and propose an associated impact monitoring methodology for technology projects and aircraft concepts at mission level. The key outputs should include: (1) Best estimates of aviation-specific GWP and GTP values for emissions, including confidence intervals, based on the latest peer-reviewed scientific investigations; (2) A recommendation on the most appropriate GWP/GTP time duration (e.g. 20 year, 50 year, 100 year) considering the Clean Aviation objectives set out in the Council Regulation; (3) A recommendation on which non-CO2 emissions should be considered and which may potentially be neglected with the objective of establishing a practical methodology for impact monitoring in the Clean Aviation programme."
- Compare the merit of using simplified metrics (such as CO2 equivalent) with more elaborate/detailed methodologies and propose a recommended "fit for purpose" climate impact assessment methodology using climate models (including other parameters such as the effect of mission data (route, altitude, latitude, longitude, atmospheric background concentrations, etc.). Propose a set of relevant metrics: integrated (Global Warming Potential) or end point metrics (i.e., Global Temperature Potential or Accumulated Temperature Response).
- Proposals are encouraged to include organisation of workshops and studies to identify win-win opportunities, areas of common interest, barriers, and solutions for improved cooperation in research and technology development as well as recommendations for future actions. Proposers should demonstrate relevant background in aviation research cooperation with third countries.
- Perform dedicated communication and dissemination activities organised in cooperation with Clean Aviation JU during the implementation phase and publish reports (of public nature) on a biannual basis to the benefit of the Aviation community at large.
- Coordinate the project approach with the impact monitoring projects to be developed under the call HORIZON-CL5-2024-D5-01-09: "Impact monitoring of EU Aviation R&I", which itself is

expected to build on and improve an already established reference European toolbox (developed in retained proposal(s) from HORIZON-CL5-2022-D5-01-14) able to assess the impact of European aviation R&I, which is deployed to perform impact assessments of European relevant aviation R&I actions in Horizon Europe.
- The project should depart from existing previous works performed by EASA to support a coherent European approach, at both the European and international level, including the ICAO Committee on Aviation Environmental Protection (CAEP) and Standardisation Bodies (e.g. SAE, ISO). The project participants will regularly share their results with EASA along the project implementation.

B. Survey of Worldwide Open-Source data on aeronautics R&I and its objectives and where relevant its (preliminary) performance/results, in particular with respect to forecast GHG emissions reductions.

- A comprehensive literature review and analysis of the existing advanced/disruptive aircraft concepts/architectures publicly available, including their predicted performance improvements and GHG reduction potential versus a well-defined reference aircraft.
- A list and short description of recent or ongoing research programmes related to those architectures, worldwide, especially addressing hybrid-electric and hydrogen for aviation.
- A list and short description of advanced purpose-built research facilities or test aircraft/demonstrators, worldwide, especially addressing hydrogen for aviation as well as more electric aircraft or hybrid-electric technologies highlighting the criteria adopted. Include and discuss results achieved and publicly available in past and running EU projects or initiatives (e.g., RINGO, IMOTHEP, etc.) delivering such theme is required.
- Categorize these concepts in terms of aerodynamics, structural, systems and propulsion technologies and their associated benefits. This shall be linked to a technology mapping exercise according to an appropriate technology taxonomy and compared to the Clean Sky, Clean Sky 2 and Clean Aviation technology mapping
- Compiling an inventory of relevant aeronautical advanced research activities and technology areas, not only from the aviation community but potentially also from other sectors, if relevant.
- Propose a suitable heuristic approach to collect, compare and analyse existing technology roadmaps on reducing environmental impact from government agencies or projects (EU-funded and others).
- Provide an initial analysis (one for SMR and one for HER) incorporating performances as predicted in comparable initiatives with the aim of estimating performances expected out of the 1st phase of the Clean Aviation programme.
- Propose a ratio and identify know-how and capability gaps in Europe (both in terms of numerical simulations and experimental means) as well as gaps in the European supply chain, for aeronautical technologies and particularly for advanced hydrogen and hybrid-electric technologies.
- Proposals are encouraged to include organisation of workshops and studies to identify win-win opportunities, areas of common interest, barriers and solutions for improved cooperation in

research and technology development as well as recommendations for future actions. Proposers should demonstrate relevant background in aviation research cooperation with third countries.

- Dedicated communication and dissemination activities should be proposed and organized in cooperation with Clean Aviation JU during the implementation phase to the benefit of the aviation community at large.
- Proposals are expected to provide appropriate reports (of public nature) on the above expected outcomes as deliverables on a biannual basis.

Scope:

A. Climate Impact of Aviation and GHG Contributions: Identification of Current Understanding, Gaps and Priorities, Metrics, and Assessment Methodology.

It is well known that CO2 effects and their latency in the atmosphere are fairly well understood whereas non-CO2 effects (NOx, water vapor, contrails, particulates, SOx, etc.) are still at a low level of understanding among the scientific community. Recent publications are shown a certain lack of consensus and in order to understand the gaps to be bridged, a thorough state-of-the-art review would help to establish what is the level of current knowledge as well as the models available to predict the climate effect of aviation in 2050 or in 2100. World renown climatologist studies have been performed in Europe. There is a need to identify what has been performed in other parts of the world (US, Canada, Australia, Japan, etc.).
Another aspect of the impact of emissions is related to local air quality (LAQ) in particular around airports. Here as well, a state-of-the-art review should provide what are the available data as of today, and what are the needs to update aircraft/engine models to predict this. This is related in particular to emissions of particulates (non-volatile particulate matter - nvPM) at ground level (from taxying and take-off).
Particulates seem to have also an important effect at altitude, where they act as nuclei for condensation of water, hence creating contrails. These effects are again complex as they depend on the fuel composition, efficiency of the combustion process, altitude and latitude/longitude.
Hydrogen, for instance, would nearly triple the emissions of water vapour at altitude versus a kerosene-fueled engine (at equivalent energy content of the fuel), but would have less impact in terms of contrails because no particulates are emitted and droplets are optically more transparent, hence creating less radiation change, under current assumptions.
In summary, the scope of this CSA is to address Climate Impact of Aviation and its Greenhouse Gas (GHG) Emissions Contributions and associated metrics to quantify those.

This CSA aims at collecting, analysing and establishing the current level of scientific understanding within the worldwide community of climatology and atmospheric sciences, of aviation climate impact and its Green House Gas (GHG) emissions contributions. It aims at the identification of knowledge gaps, barriers, and needs for research in view of orienting most appropriately the technology research streams for future green and zero-emission aircraft.

However, first and foremost, the main objectives of this call is to obtain an answer on how to best translate the Clean Aviation Partnership objectives set out in the SBA (-30% net GHG emission reduction vs SoA 2020) into tangible metrics in terms of measurable engine tailpipe emissions. CO_2-equivalent is a metric which is commonly used, however based on the GWP (Global Warming Potential) of GHG species which – in case of aviation-related emissions - have very large uncertainties regarding both their absolute value and effect on climate. Beyond the well-known effect and latency of CO2 in the atmosphere, there is a need to identify a commonly agreed aviation-specific GWP value as well as the non-CO2 emissions which should be considered (NOx, water vapour, nvPM, …), or may potentially be neglected (CO, SOx, UHC, …) or have important secondary effects such as the creation of ozone and reduction of methane (NOx), or the creation of contrails and potentially cirrus induced cloudiness (water vapour & particulates).

This, in turn, could have strong consequences on aircraft design and operations. Some of these effects may be mitigated to some extent by modifying flight operations (altitude, trajectory, etc.), which may require an appropriate re-design of the aircraft for best efficiency use, or, could be mitigated by appropriate engine technology such as lean burn/advanced combustion (NOx, particulates) and optimization of its thermodynamic cycle. The perspective of using non-drop-in fuels such as hydrogen raises a critical question about the increased production of water vapour at altitude, which again may have very different impact if flown at typical altitudes of regional aircraft or at cruise altitude of SMR aircraft. Even if SAF can be produced by a carbon neutral process, the composition of the fuel (especially regarding aromatic compounds) alters engine emissions and the impact of this also needs to be assessed.

Since the objectives of reducing CO_2 and NOx are very conflicting requirements in terms of engine cycle optimization, and alternative fuels such as hydrogen may have substantial effects on non-CO2 emissions (contrails and cirrus induced cloudiness), it is crucial to understand the importance of each GHG species on aviation climate impact at altitude.

A close cooperation with the relevant ACARE Working Groups and involvement of all main relevant stakeholders (ICAO CAEP, EASA, FAA, etc.) should be ensured to provide a balanced and comprehensive approach to the theme.

The participants should also work closely together with the relevant European Commission Services, the European Union Aviation Safety Agency, the Clean Aviation (and SESAR3) European Partnerships as well as the European Environment Agency.

It is necessary to ensure that the proposed methodology developed under Part A is compatible with EAER methodological framework and that resulting impact assessments can be integrated into EAER toolset.

The proposed approach shall be aligned to the European Aviation Environmental Report (EAER) that provides the common reference to stakeholders for the monitoring the overall environmental impact of aviation (today operations) with already integrated metrics and tools to reflect the evolution of traffic demand and accounting for the progressive introduction of sustainable aviation fuels (SAF), the evolution of aircraft certification standards (ICAO CAEP) and operational improvements for flight planning (in relation to SESAR programme).

The project should exchange and coordinate its approach to the impact monitoring toolbox to be developed under the call HORIZON-CL5-2024-D5-01-09: “Impact monitoring of EU Aviation R&I”, which itself is expected to build on, and improve an already established reference European toolbox (developed in retained proposal(s) from HORIZON-CL5-2022-D5-01- 14) able to assess the impact of European aviation R&I, which is deployed to perform impact assessments of European relevant aviation R&I actions in Horizon Europe.

All deliverables will be of public nature, to benefit open sharing and a large dissemination among the aeronautical community.

B. Survey of Worldwide Open Source R&I and preliminary performance predictions, in particular with respect to GHG emissions reductions.

Part B of this CSA should be considered as a "technology watch" exercise in view to perform a theoretical performance assessment along the two aircraft concepts (SMR and HER) defined in the SRIA and the in Work Programme. It aims at compiling an inventory of relevant aeronautical advanced research activities and technology areas, not only from the aviation community but potentially also from other sectors if relevant.

Aeronautical literature is abundant in terms of publications of "disruptive aircraft concepts". These are stemming from world renown research centers like NASA (N3-X, STARC-ABL, PEGASUS,…) or academia MIT (Aurora D8 double bubble, …), ONERA (Dragon, NOVA, …), DLR (ADEC, EXACT, …), Bauhaus Luftfahrt (CENTRELINE), TU Delft (Flying-V) but also from industry in cooperation with airlines or academia (Boeing SUGAR-Volt, SUGAR-High, SUGAR-Freeze, TTBW), Airbus (Nautilius, Maverick, Zero-e, E-Thrust), Safran (Cobalt-Blue), Lockheed (Box-Wing), Easyjet, Wright Electric, ZeroAvia, and many more.

Many of those concepts are linked to more general research programmes (AATT – Advanced Air Transport Technology, CLEEN, Continuous Lower Energy Emissions and Noise, CHEETA Cryogenic High-Efficiency Electrical Technologies for Aircraft, etc.) or large-scale test facilities (i.e., NEAT, NASA Electrical Aircraft Testbed) funded by NASA, FAA or any other governmental agencies (DARPA, ARPA-e, Dpt. Of Energy, etc.).

Over the last decade, in Europe as well, a number of EU or national funded projects have addressed similar topics, either at overall aircraft design level and/or and propulsion level (PARSIFAL, AHEAD, APPU, ULTIMATE, CENTRELINE, IMOTHEP, FUTPRINT50, ENABLE-H2, etc.).

There is high interest in exploring as well other relevant initiatives around the world, both in terms of funded research programmes towards greener aircraft and climate neutral aviation in general. The recent interest in Hydrogen as an alternative energy source has triggered the launch of many research projects on Fuel Cells and Hydrogen technologies and this should part of the survey.

In relation to the various aircraft concepts, many of them state percentage improvements based on the integration of new technologies or disruptive propulsion or aircraft architectures versus a different reference aircraft chosen in each case. Propose a way forward and an approach, highlighting the assumptions and metrics used to reconcile the numbers, in line with the technology assumptions versus a well-defined reference is a mandatory exercise to allow fair comparison of the concepts, and the prospects of performance improvements for the main technologies.

There is high interest to categorize these concepts in terms of aerodynamics, structural, systems and propulsion technologies and their associated benefits at aircraft level. This shall be linked to a technology mapping exercise according to a proposed technology taxonomy and compared to Clean Aviation technology mapping. A preliminary performance assessment using proposed assumptions and criteria should be delivered along the two aircraft concepts listed in the Work Programme. This will allow the CAJU and the Technical Committee to get first impact assessment of the 1st phase of the programme objectives and to identify potential gaps to be addressed in the future, if any.