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IMPACT ASSESSMENT REPORT
Accompanying the document

**Proposal for a COUNCIL REGULATION establishing the Joint Undertakings under
Horizon Europe**

European Partnership for Clean Aviation

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Glossary

<i>Term or acronym</i>	<i>Meaning or definition</i>
ACARE	Advisory Council for Aviation Research and Innovation in Europe
ASD	Aerospace and Defence Industries Association of Europe, industry association
ATAG	Air Transport Action Group
ATM	Air traffic management
CAGR	Compound Annual Growth Rate
CEF	Connecting Europe Facility
CORSIA	ICAO's Carbon Offsetting and Reduction Scheme for International Aviation
EASA	European Union Aviation Safety Agency
EASN	European Aeronautics Science Network
EREA	Association of European Research Establishments in Aeronautics
EU ETS	European Emissions Trading System
GHG	Greenhouse gas
Horizon 2020	European Union research and innovation research framework programme 2014-2020
Horizon Europe	European Commission's proposed research framework programme for research and innovation to succeed Horizon 2020, from 2021 to 2027
H ₂	Hydrogen
IADP	Innovative Aircraft Demonstration Platform
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
ITD	Integrated Technology Demonstrators
JU	Joint Undertaking.
MRO	Maintenance, repair and overhaul
NACE	Statistical classification of economic activities in the European Community
NO _x	Nitrous Oxide
PM	Particulate matter
R&I	Research and innovation
RTO	Research and technology organisations
SAF	Sustainable aviation fuels
SO _x	Sulphur Oxides
SDG	Sustainable Development Goal
SESAR	Single European Sky Air Traffic Management Research
SME	Small and medium-sized enterprises
SRG	States' Representative Group
SRIA	Strategic Research and Innovation Agenda
TRL	Technology readiness level
ufPM	Ultrafine particulate matter

PART 1 - COMMON FOR ALL CANDIDATE INSTITUTIONALISED EUROPEAN PARTNERSHIPS

1. BACKGROUND AND CONTEXT TO EUROPEAN PARTNERSHIPS IN HORIZON EUROPE AND FOCUS OF THE IMPACT ASSESSMENT– WHAT IS DECIDED

1.1. Focus and objectives of the impact assessment

This impact assessment accompanies the Commission proposal for Institutionalised European Partnerships to be funded under Horizon Europe, the 2021-2027 Framework Programme for EU Research and Innovation (R&I).¹ It sets out to **help decide in a coordinated manner the right form of implementation for specific candidate initiatives** based on a common approach and methodology for individual assessments². It also provides a **horizontal perspective on the portfolio of candidate European Partnerships** to identify further efficiency and coherence gains for more impact.

European Partnerships are initiatives where the Union, together with private and/or public partners (such as industry, public bodies or foundations) commit to support jointly the development and implementation of an integrated programme of R&I activities. The rationale for establishing such initiatives is to achieve the objectives of Horizon Europe more effectively than what can be attained by other activities of the programme.³

Based on the Horizon Europe Regulation, European Partnerships may be set up using **three different forms**: “Co-funded”, “Co-programmed” and “Institutionalised”. The setting up of **Institutionalised Partnerships** involves new EU legislation and the establishment of dedicated implementing structures based on Article 185 or 187 of the Treaty on the Functioning of the EU (TFEU). This requires an impact assessment to be performed.

The Horizon Europe Regulation defines **eight priority areas**, scoping the domains in which Institutionalised Partnerships could be proposed⁴. Across these priority areas, **13 initiatives** have been identified as **suitable candidate initiatives** for Institutionalised Partnerships due to their objectives and scope. This impact assessment aims to identify whether 12 of these initiatives⁵ need to be implemented through this arrangement, and would not carry out their activities equally well with traditional calls of Horizon Europe or other lighter forms of European Partnerships under Horizon Europe. This means assessing whether each of these initiatives meets the necessity test set in the **selection criteria** for European Partnerships in the Horizon Europe Regulation, Annex III.

This assessment is done **without any budgetary considerations**, as the overall budget of the Multiannual Financial Framework of the EU – and hence of Horizon Europe – for the next financing period is not known at this stage.⁶

¹ Horizon Europe Regulation (common understanding), <https://data.consilium.europa.eu/doc/document/ST-7942-2019-INIT/en/pdf>

² Based on the European Commission Better Regulation framework (SWD (2017) 350) and supported by an external study coordinated by Technopolis Group (to be published in 2020).

³ For further details on these points, see below Section 1.2.2.

⁴ Set out in the Annex Va of the Horizon Europe Regulation (common understanding). <https://data.consilium.europa.eu/doc/document/ST-7942-2019-INIT/en/pdf>

⁵ Only 12 are subject to this impact assessment, as one initiative on High Performance Computing has already been subject to an impact assessment in 2017 (SEC(2018) 47).

⁶ EU budget commitments to the European Partnership candidates can only be discussed and decided following the political agreement on the overall Multiannual Financial Framework and Horizon Europe budgetary envelopes. The level of EU contribution for individual partnerships should be determined once there are agreed objectives, and clear commitments

1.2. The political and legal context

1.2.1. Shift in EU priorities and Horizon Europe framework

European priorities have evolved in the last decades, and reflect the social, economic, and environmental challenges for the EU in the face of global developments. In her Political Guidelines for the new European Commission 2019 – 2024⁷, the Commission President put forward six overarching priorities, which reach well beyond 2024 in scope⁸. Together with the Sustainable Development Goals (SDGs), these priorities will shape future EU policy responses to the challenges Europe faces, and thus also give direction to EU research and innovation.

As part of the Multi-annual Financial Framework (MFF) 2021-27 the new EU Framework Programme for Research and Innovation **Horizon Europe will play a pivotal role for Europe to lead the social, economic, and environmental transitions needed to achieve these European policy priorities**. It will be more impact driven with a strong focus on delivering European added value, but also be more effective and efficient in its implementation.⁹ Horizon Europe finds its rationale in the daunting challenges that the EU is facing, which call for “*a radical new approach to developing and deploying new technologies and innovative solutions for citizens and the planet on a scale and at a speed never achieved before, and to adapting our policy and economic framework to turn global threats into new opportunities for our society and economy, citizens and businesses.*” While Horizon Europe continues the efforts of strengthening the scientific and technological bases of the Union and foster competitiveness, a more strategic and impact-based approach to EU R&I investment is taken. Consequently, the **objectives of Horizon Europe** highlight the need to *deliver on the Union strategic priorities and contribute to the realisation of EU objectives and policies, contribute to tackling global challenges, including the Sustainable Development Goals by following the principles of the Agenda 2030 and the Paris Agreement.*¹⁰

In this context, **at least 35 % of the expenditure from actions under the Horizon Europe Programme will have to contribute to climate action**. Furthermore, a **Strategic Plan** is co-designed with stakeholders to identify **key strategic orientations for R&I support** for 2021-2024 in line with the EU priorities. In the Orientations towards the first Strategic Plan for Horizon Europe, the need to strategically prioritise and “*direct a substantial part of the funds towards the areas where we believe they will matter the most*” is emphasised. The Orientations specify, that actions under Pillar II of Horizon Europe “Global Challenges and European Industrial Competitiveness” will target only selected themes of especially high impact that significantly contribute to delivering on the political priorities of the Union. Most of the candidate European Partnerships fall under this Pillar.

from partners. Importantly, there is a ceiling to the partnership budgets in Pillar II of Horizon Europe (the legal proposal specifies that *the majority of the budget in pillar II shall be allocated to actions outside of European Partnerships*).

⁷ https://ec.europa.eu/info/strategy/priorities-2019-2024_en

⁸ 1.A European Green Deal; An economy that works for people; A Europe fit for the Digital Age; Promoting our European way of life; A Stronger Europe in the World; and 6.A New push for European Democracy

⁹ EC (2018) *A Modern Budget for a Union that Protects, Empowers and Defends. The Multiannual Financial Framework for 2021-2027*. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2018) 321 final

¹⁰ Article 3, Common understanding regarding the proposal for Horizon Europe Framework Programme.

1.2.2. Key evolutions in the approach to partnerships in Horizon Europe

Since their start in 1984, the successive set of Framework Programmes uses a variety of instruments and approaches to support R&I activities, address global challenges and industrial competitiveness. Collaborative, competition-based and excellence-driven R&I projects funded through Work Programmes are the most traditional and long-standing approach for implementation. Since 2002, available tools also include **partnerships**, whereby the Union together with private and/or public partners commit to jointly support the development and implementation of a R&I programme. These were introduced as part of creating the European Research Area (ERA) to align national strategies and overcome fragmentation of research effort towards an increased scientific, managerial and financial integration of European research and innovation. Interoperable and integrated national research systems would allow for better flows of knowledge, technology and people. Since then, the core activities of the partnerships consist of building critical mass mainly through collaborative projects, jointly developing visions, and setting strategic agendas.

As analysed in the **interim evaluation of Horizon 2020**¹¹, a considerable repertoire of partnership initiatives has been introduced over time, with eight forms of implementation¹² and close to 120 partnership initiatives running under Horizon 2020 - without clear exit strategies and concerns about their degree of coherence, openness and transparency. Even if it is recognised that these initiatives allow for setting long-term agendas, structuring R&I cooperation between otherwise dispersed actors, and leveraging additional investments, the evaluation points to the complexity generated by the proliferation of instruments and initiatives, and their insufficient contribution to policies at EU and national level.

Box 1 Key lessons from the interim evaluation of Horizon 2020 and R&I partnerships

- The **Horizon 2020 Interim Evaluation** concludes that the overall partnership landscape has become overly complex and fragmented. It identifies the need for rationalisation, to improve their openness and transparency, and link them with future EU R&I missions and strategic priorities.
- The **Article 185 evaluation** finds that these public-public partnerships have scientific quality, global visibility and networking/structuring effects but should, in the future, focus more on the achievement of policy impacts. From a systemic point of view, it found that the EU public-to-public cooperation (P2P) landscape has become crowded, with insufficient coherence.
- The **Article 187 evaluation** points out that Public-Private Partnership (PPP) activities need to be brought more in line with EU, national and regional policies, and calls for a revision of the Key Performance Indicators. As regards the **contractual PPPs (cPPPs)** their reviews identified challenges of coherence among cPPPs and the need to develop collaborations and synergies with

Over 80% of respondents to the Open Public Consultation (OPC) indicated that a significant contribution by future European Partnerships is 'fully needed' to achieve climate-related goals, to develop and effectively deploy technology, and for EU global competitiveness in specific sectors/domains. Views converged across all categories of respondents, including citizens, industry and academia.

¹¹ Interim evaluation of Horizon 2020, Commission Staff Working Document, SWD(2017)221 and 222 Interim evaluation of the Joint Undertakings operating under Horizon 2020 (Commission Staff Working Document, SWD(2017) 339); Evaluation of the Participation of the EU in research and development programmes undertaken by several Member States based on Article 185 of the TFEU, Commission Staff Working Document, SWD (2017)340

¹² E.g. initiatives based on Article 187 (Joint Technology Initiatives), Article 185 TFEU, Contractual Public-Private Partnerships (cPPPs), Knowledge & Innovation Communities of the European Institute of Innovation & Technology (EIT-KICs), ERA-NETs, European Joint Programmes, Joint Programming Initiatives.

The impact assessment of Horizon Europe identifies therefore the need to **rationalise the EU R&I funding landscape**, in particular with respect to partnerships, as well as to **re-orient partnerships towards more impact** and delivery on EU priorities. To address these concerns and to realise the higher ambitions for European investments, Horizon Europe puts forward **a major simplification and reform for the Commission’s policy on R&I partnerships**¹³. Reflecting its systemic nature which aims to contribute to EU-wide ‘transformations’ towards the sustainability objectives, Horizon Europe indeed intends to make a more effective use of these partnerships with a **more strategic, coherent and impact-driven approach**. Key related changes that apply to all forms of European Partnerships encapsulated in the Horizon Europe Regulation are summarised in the Box

Box 2 Key features of the revised policy approach to R&I partnerships under Horizon Europe based on its impact assessment

- ✓ **Simpler architecture & toolbox** by streamlining eight partnership instruments into 3 implementation forms (Co-Funded, Co-Programmed, Institutionalised), under the umbrella ‘European Partnerships’
- ✓ **More systematic and transparent approach** to selecting, implementing, monitoring, evaluating and phasing out all forms of partnerships (**criteria** for European Partnerships):
 - The selection of Partnerships is embedded in the strategic planning of Horizon Europe, thereby ensuring coherence with the EU priorities. The selection criteria require that partnerships are established with stronger ex-ante commitment and higher ambition.
 - The implementation criteria stipulate that initiatives adopt a systemic approach in achieving impacts, including broad engagement of stakeholders in agenda-setting and synergies with other relevant initiatives to promote the take-up of R&I results.
 - A harmonised monitoring & evaluation system will be implemented, and ensures that progress is analysed in the wider context of achieving Horizon Europe objectives and EU priorities.
 - All partnerships need to develop an exit strategy from Framework Programme funding. This new approach is underpinned by principles of openness, coherence and EU added value.
- ✓ **Reinforced impact orientation:**
 - Partnerships are established only if there is evidence they support achieving EU policy objectives more effectively than other Horizon Europe actions, by demonstrating a clear vision and targets (**directionality**) and corresponding long-term commitments from partners (**additionality**).
 - European Partnerships are expected to provide mechanisms – based on a concrete roadmap - to join up R&I efforts between a broad range of actors towards the development and uptake of innovative solutions in line with EU priorities, serving the economy and society, as well as scientific progress.
 - They are expected to develop close synergies with national and regional initiatives, acting as dynamic change agents, strengthening linkages within their respective ecosystems and along the value chains, as well as pooling resources and efforts towards the common EU objectives.

below.

Under Horizon Europe, a ‘European Partnership’¹⁴ is defined as *“an initiative where the Union, prepared with early involvement of Member States and/or Associated Countries, together with private and/or public partners (such as industry, universities, research organisations, bodies with a public service mission at local, regional, national or international level or civil society organisations including foundations and NGOs), commit to jointly support the development and implementation of a programme of research and innovation activities, including those related to market, regulatory or policy uptake.”*

The Regulation further specifies that European Partnerships shall adhere to the *“principles of Union added value, transparency, openness, impact within and for Europe, strong leverage effect on sufficient scale, long-term commitments of all the involved parties, flexibility in implementation, coherence, coordination and complementarity with Union, local, regional, national and, where relevant, international initiatives or other partnerships*

¹³ Impact assessment of Horizon Europe, Commission Staff Working Document, SWD(2018)307.

¹⁴ Article 8 and Annex III of the Horizon Europe Regulation (common understanding)

and missions.”

1.3. Why should the EU act

1.3.1. Legal basis

Proposals for Institutionalised European Partnerships are based on:

- 1) Article 185 TFEU which allows the Union to make provision, in agreement with the Member States concerned, for participation in research and development programmes undertaken by several Member States, including participation in the structures created for the execution of those programmes; or
- 2) Article 187 TFEU according to which the Union may set up joint undertakings or any other structure necessary for the efficient execution of Union research, technological development and demonstration programmes.¹⁵

1.3.2. Subsidiarity

The EU should act only in areas where there is demonstrable advantage that the action at EU level is more effective than action taken at national, regional or local level. Research is a shared competence between the EU and its Member States according to the TFEU. Article 4 (3) specifies that in the areas of research, technological development and space, the EU can carry out specific activities, including defining and implementing programmes, without prejudice to the Member States’ freedom to act in the same areas. The candidate initiatives focus on areas where there is a demonstrable added value in acting at the EU level due to the scale, speed and scope of the efforts needed for the EU to meet its long-term Treaty objectives and deliver on its strategic policy priorities and commitments. In addition, the proposed initiatives should be seen as complementary and reinforcing national and sub-national activities in the same area. Overall European Partnerships find their **rationale in addressing a set of systemic failures**¹⁶:

- Their primary function is to create a platform for a strengthened **collaboration** and knowledge exchange between various actors in the European R&I system and an enhanced **coordination** of strategic research agendas and/or R&I funding programmes. They aim to address **transformational failures** to better align agendas and policies of public and private funders, pool available resources, create critical mass, avoid unnecessary duplication of efforts, and leverage sufficiently large investments where needed but which are not achievable by single countries.
- The concentration of efforts and pooling of knowledge on common priorities to solve multi-faceted societal and economic challenges is at the core of these initiatives. Specifically, enhanced cross-disciplinary and cross-sectoral collaboration and an improved integration of value chains and ecosystems are among the key objectives of these instruments. In the light of Horizon Europe, the aim is to **drive system transitions and transformations towards EU priorities**.
- Especially in fast-growing technologies and sectors such as ICT, there is a need to **react to emerging opportunities** and address systemic failures such as a shortage in skills or critical mass or cross-sectoral cooperation along the value chains that would hamper attainment of future European leadership and/or strategic autonomy.
- They also aim to address **market failures** predominantly to enhancing industry

¹⁵ Both Articles are under Title XIX of the TFEU - Research and Technological Development and Space.

¹⁶ The Interim Evaluation of Horizon 2020 and the impact assessment of Horizon Europe provide qualitative and quantitative evidence on these points. Sections 1 and 2 of each impact assessment on candidate European Partnerships include more detail on the necessity to act at EU level in specific thematic areas.

investments due to the sharing of risks.

2. THE CANDIDATE EUROPEAN PARTNERSHIPS – WHAT NEEDS TO BE DECIDED

2.1. Portfolio of candidates for Institutionalised European Partnerships

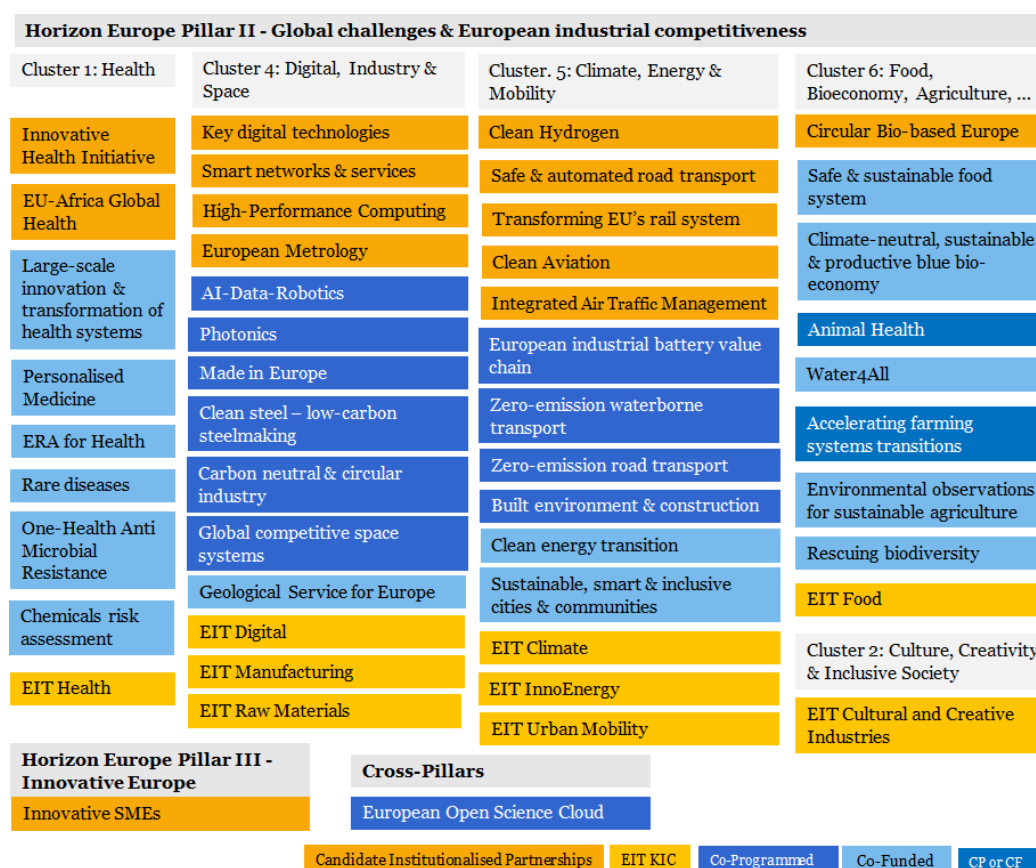
The new approach for more objective-driven and impactful European Partnerships is reflected in the way candidate Partnerships have been identified. It involved a co-design exercise aiming to better align these initiatives with societal needs and policy priorities, while broadening the range of actors involved. Taking into account the 8 areas for Institutionalised European Partnerships set out in the Horizon Europe Regulation¹⁷, a co-design exercise as part of the Strategic Planning process of Horizon Europe led to the identification of **49 candidates for Co-funded, Co-programmed or Institutionalised European Partnerships**¹⁸. Out of these, **13 were identified as suitable candidate Institutionalised Partnerships because of their objectives and scope**¹⁹. Whilst the Co-Funded and Co-Programmed Partnerships are linked to the comitology procedure (including the adoption of the Strategic Plan and the Horizon Europe Work Programmes), Institutionalised Partnerships require the adoption of legislation and are subject to an impact assessment. The Figure below gives an overview of all candidate European Partnerships according to their primary relevance to Commission priorities for 2019-2024.

¹⁷ Horizon Europe Regulation (common understanding), Annex Va.

¹⁸ Shadow configuration of Strategic Programme Committee for Horizon Europe. The list of candidate European Partnerships is described in “Orientations towards the Strategic Plan of Horizon Europe” - Annex 7

¹⁹ Only 12 are subject to this impact assessment, as one initiative on High Performance Computing has already been subject to an impact assessment in 2017 (SEC(2018) 47)

Figure 1 - Overview of the candidates for Co-Funded, Co-Programmed and Institutionalised European Partnerships according to Horizon Europe structure



Source: Technopolis group (2020)

There are only three partnerships for which implementation as an Institutionalised Partnership under Article 185 is an option, i.e. European Metrology, the EU-Africa Global Health partnership, and Innovative SMEs. Ten partnerships are candidates for Institutionalised Partnerships under Article 187. Overall, the initiatives can be categorised into ‘horizontal’ partnerships and ‘vertical’ partnerships.

The ‘horizontal’ partnerships have a central position in the overall portfolio, as they are expected to develop methodologies and technologies for application in the other priority areas, ultimately supporting European strategic autonomy in these areas as well as technological sovereignty. These ‘horizontal’ partnerships are typically proposed as Institutionalised or Co-programmed Partnerships, in addition to a number of EIT KICs, they cover mainly the digital field in addition to space, creative industries and manufacturing, but also the initiative related to Innovative SMEs. ‘Vertical’ partnerships are focused on the needs and development of specific application areas, and are primarily expected to support enhanced environmental sustainability thereby addressing European Green Deal’s objectives. They also deliver on policies for a more people-centred economy, through improved wellbeing of EU citizens and the economy.

2.2. Assessing the necessity of a European Partnership and possible options for implementation

Article 8 of the Horizon Europe Regulation stipulates that Institutionalised European Partnerships based on Article 185 and 187 TFEU shall be implemented only where other parts of the Horizon Europe programme, including other forms of European Partnerships would not achieve the objectives or would not generate the necessary expected impacts, and

if justified by a long-term perspective and high degree of integration. At the core of this impact assessment is, therefore, the need to demonstrate that the impacts generated through a Partnership approach go beyond what could be achieved with traditional calls under the Framework Programme – the Baseline Option. Secondly, it needs to assess if using the Institutionalised form of a Partnership is justified for addressing the priority.

For all candidate Institutionalised European Partnerships the options considered in this impact assessment are the same, i.e.:

- Option 0 – Baseline option – Traditional calls under the Framework Programme
- Option 1 – Co-programmed European Partnership
- Option 2 – Co-funded European Partnership
- Option 3 – Institutionalised Partnership
 - Sub-option 3a Institutionalised Partnerships based on Art 185 TFEU
 - Sub-option 3b Institutionalised Partnerships based on Art 187 TFEU

2.2.1. Option 0 - Baseline option – Traditional calls

Under this option, strategic programming for R&I in the priority area will be done through the mainstream channels of Horizon Europe. The related priorities will be implemented through **traditional calls** of Horizon Europe covering a range of actions, mainly R&I and/or innovation actions but also coordination and support actions, prizes or procurement. Most actions involve consortia of public and/or private actors in ad hoc combinations, while some actions are single actor (mono-beneficiary). There will be no dedicated implementation structure and no support other than what is foreseen in the related Horizon Europe Work Programme. This means that discontinuation costs/benefits of predecessor initiatives should be factored in for capturing the baseline situation, when relevant.

Under this option, strategic planning mechanisms in the Framework Programme will allow for a high level of flexibility for traditional calls to respond to particular needs over time, building upon additional co-creation input from stakeholders and programme committees involving Member States. The Union contribution to addressing the priority covers the full duration of the initiative, during the lifetime of Horizon Europe. Without a formal EU partnership mechanism, it is less likely that the stakeholders will develop a joint Strategic Research and Innovation Agenda (SRIA) and commit to its implementation or agree on mutual commitments and contributions outside their participation in funded projects.

2.2.2. European Partnerships

Under this set of options, three different forms of implementation are assessed: Co-funded, Co-Programmed, Institutionalised European Partnerships. These have **commonalities that cannot serve as a distinguishing factor in the impact assessment process**. They are all based on agreed objectives and expected impacts and underpinned by Strategic Research and Innovation Agendas/ roadmaps that are shared and committed to by all partners in the partnership. They all have to follow the same set of criteria along their lifecycle, as defined in the Horizon Europe Regulation (Annex III), including ex ante commitment from partners to mobilise and contribute resources and investments. The Union contribution is defined for the full duration of the initiative for all European Partnerships. The Horizon Europe legal act introduces few additional requirements for Institutionalised Partnerships, e.g. the need for a long-term perspective, strong integration of R&I agendas, and financial contributions.

Figure 2 - Key differences in preparation and implementation of European Partnerships

Type	Legal form	Implementation
Co-Programmed	Contractual arrangement/ MoU	Division of labour , whereby Union contribution is implemented through Framework programme and partners' contributions under their responsibility.
Co-Funded	Grant Agreement	Union provides co-funding for an integrated programme with distributed implementation by entities managing and/or funding national research and innovation programmes
Institutionalised based on Article 185/187 TFEU	Basic act (Council regulation, Decision by European Parliament and Council)	Integrated programme with centralised implementation

The main differences between the different forms of European Partnerships are in their preparation and in the way they function, as well as in the overall impact they can trigger. The Co-Programmed form is assessed as the simplest, and the Institutionalised form as the most complex to prepare and implement. The functionalities of the different form of Partnerships – compared to the baseline option – are presented in Figure 3. They relate to the types of actors Partnerships can involve and their degree of openness, the types of activities they can perform and their degree of flexibility, the degree of commitment of partners and the priority setting system, and their ability to work with their external environment (coherence), etc. These key distinguishing factors will be at the basis of the comparison of each option to determine their overall capacity to deliver what is needed at a minimised cost.

Figure 3 Overview of the functionalities provided by each form of European Partnerships, compared to the traditional calls of Horizon Europe (baseline)

Baseline: Horizon Europe calls	Option 1: Co-Programmed	Option 2: Co-Funded	Option 3a: Institutionalised Art 185	Option 3b: Institutionalised Art 187
Type and composition of actors (including openness and roles)				
Partners: N.A., no common set of actors that engage in planning and implementation <u>Priority setting:</u> open to all, part of Horizon Europe Strategic planning <u>Participation in R&I activities:</u> fully open in line with Horizon Europe rules	Partners: Suitable for all types: private and/or public partners, foundations <u>Priority setting:</u> Driven by partners, open stakeholder consultation, MS in comitology <u>Participation in R&I activities:</u> fully open in line with Horizon Europe rules	Partners: core of national funding bodies or governmental research organisations <u>Priority setting:</u> Driven by partners, open stakeholder consultation <u>Participation in R&I activities:</u> limited, according to national rules of partner countries	Partners: National funding bodies or governmental research organisation <u>Priority setting:</u> Driven by partners, open stakeholder consultation <u>Participation in R&I activities:</u> fully open in line with Horizon Europe rules, but possible derogations	Partners: Suitable for all types: private and/or public partners, foundations <u>Priority setting:</u> Driven by partners, open stakeholder consultation <u>Participation in R&I activities:</u> fully open in line with Horizon Europe rules, but possible derogations
Type and range of activities (including additionality and level of integration)				
<u>Activities:</u> Horizon Europe standards that allow broad range of individual actions <u>Additionality:</u> no additional activities and investments outside the funded projects <u>Limitations:</u> No systemic approach beyond individual actions	<u>Activities:</u> Horizon Europe standard actions that allow broad range of individual actions, support to market, regulatory or policy/ societal uptake <u>Additionality:</u> Activities/investments of partners, National funding <u>Limitations:</u> Limited systemic approach beyond individual actions	<u>Activities:</u> Broad, according to rules/programmes of participating States, State-aid rules, support to regulatory or policy/ societal uptake <u>Additionality:</u> National funding <u>Limitations:</u> Scale & scope depend on participating programmes, often smaller in scale	<u>Activities:</u> Horizon Europe standards that allow broad range of individual actions, support to regulatory or policy/societal uptake, possibility to systemic approach <u>Additionality:</u> National funding	<u>Activities:</u> Horizon Europe standards that allow broad range of individual actions, support to regulatory or policy/societal uptake, possibility to systemic approach (portfolios of projects, scaling up of results, synergies with other funds). <u>Additionality:</u> Activities/investments of partners/ national funding

Baseline: Horizon Europe calls	Option 1: Co-Programmed	Option 2: Co-Funded	Option 3a: Institutionalised Art 185	Option 3b: Institutionalised Art 187
Priority-setting process and directionality				
<u>Priority setting:</u> Strategic Plan and annual work programmes, covering max. 4 years. <u>Limitations:</u> Fully taking into account existing or to be developed SRRIA/ roadmap	<u>Priority setting:</u> Strategic R&I agenda/ roadmap agreed between partners & EC, covering usually 7 years, incl. allocation of Union contribution Input to FP annual work programme drafted by partners, finalised by EC (comitology) Objectives & commitments set in contractual arrangement	<u>Priority setting:</u> Strategic R&I agenda/ roadmap agreed between partners & EC, covering usually 7 years, incl. allocation of Union contribution Annual work programme drafted by partners, approved by EC Objectives & commitments set in Grant Agreement	<u>Priority setting:</u> Strategic R&I agenda/ roadmap agreed between partners & EC, covering usually 7 years, incl. allocation of Union contribution Annual work programme drafted by partners, approved by EC Objectives & commitments set in legal act	<u>Priority setting:</u> Strategic R&I agenda/ roadmap agreed between partners & EC, covering usually 7 years, incl. allocation of Union contribution Annual work programme drafted by partners, approved by EC (veto-right in governance) Objectives & commitments set in legal act
Coherence: internal (Horizon Europe) & external (other Union programmes, national programmes, industrial strategies)				
<u>Internal:</u> Coherence between different parts of the FP Annual Work programme can be ensured by EC <u>External:</u> Limited for other Union programmes, no synergies with national/regional programmes & activities	<u>Internal:</u> Coherence among partnerships & with parts of the FP Annual Work programme can be ensured by partners & EC <u>External:</u> Limited synergies with other Union programmes & industrial strategies. If MS participate, with national/ regional programmes & activities	<u>Internal:</u> Coherence among partnerships & with parts of the FP Annual Work programme can be ensured by partners & EC <u>External:</u> Synergies with national/ regional programmes & activities	<u>Internal:</u> Coherence among partnerships & with parts of the FP Annual Work programme can be ensured by partners & EC <u>External:</u> Synergies with national/ regional programmes & activities	<u>Internal:</u> Coherence among partnerships & with parts of the FP Annual Work programme can be ensured by partners & EC <u>External:</u> Synergies with other Union programmes and industrial strategies If MS participate, with national/ regional programmes & activities

2.2.2.1. Option 1 - Co-programmed European Partnership

This form of European Partnership is **based upon a Memorandum of Understanding or a Contractual Arrangement** signed by the Commission and the private and/or public partners. Private partners are represented by industry associations, which also support the daily management of the partnership. This type of partnership would allow for a large degree of flexibility for the activities, partners and priorities to continuously evolve. The commitments of partners are political efforts described in the contractual arrangement and the contributions from partners are provided in kind more than financially. The priorities for the calls, proposed by the Partnership's members for integration in the Horizon Europe's Work Programmes, are subject to further input from Member States (comitology) and Commission services. The Union contribution is implemented within the executive agency managing Horizon Europe calls for research and innovation projects proposals. The full array of Horizon Europe instruments can be used, ranging from research and innovation (RIA) types of actions to coordination and support actions (CSA) and including grants, prizes, and procurement.

2.2.2.2. Option 2 – Co-funded European Partnership

The Co-funded European Partnership is **based on a Grant Agreement** between the Commission and a consortium of partners, resulting from a specific call in the Horizon Europe Work Programme. This form of implementation only allows to address public partners at its core. Typically these provide co-funding to a common programme of activities established and/or implemented by entities managing and/or funding national R&I programmes. The recipients of the EU co-funding implement the initiative under their responsibility, with national funding/resources pooled to implement the programme with co-

funding from the Union. The expectation is that these entities would cover most if not all EU Member States. Calls and evaluations would be organised centrally, beneficiaries in selected projects would be funded at national level, following national funding rules.

2.2.2.3. Option 3 – Institutionalised European Partnership

This type of Partnership is the most complex and high-effort arrangement, and requires meeting additional requirements. Institutionalised European Partnership are **based on a Council Regulation (Article 187 TFEU or a Decision by the European Parliament and Council (Article 185 TFEU))** and are implemented by dedicated structures created for that purpose. These regulatory needs limit the flexibility for a change in the core objectives, partners, and/or commitments as these would require amending legislation. The basic rationale for this type of partnership is the need for a strong integration of R&I agendas in the private and/or public sectors in the EU in order to address a strategic challenge. It is therefore necessary to demonstrate that other forms of implementation would not achieve the objectives or would not generate the necessary expected impacts, and that a long-term perspective and high degree of integration is needed. For both Article 187 and 185 initiatives, contributions from partners can be in the form of financial and in-kind contributions. Eligibility for participation and funding follows by default the rules of Horizon Europe, unless a derogation is introduced in the basic act.

Option 3a - Institutionalised Partnerships based on Article 185 TFEU

Article 185 of the TFEU allows the Union to participate in programmes jointly undertaken by Member States and limits therefore the scope to **public partners** which are Member States and Associated Third Countries. This type of Institutionalised Partnership aims therefore at reaching the greatest possible impact through the integration of national and EU funding, aligning national strategies in order to optimise the use of public resources and overcome fragmentation of the public research effort. It brings together R&I governance bodies of most if not all EU Member States (legal requirement: at least 40% of Member States) as well as Associated Third Countries that designate a legal entity (Dedicated Implementation Structure) of their choice for the implementation. By default, participation of non-associated Third Countries is not foreseen. Such participation is possible only if it is foreseen in the basic act and subject to conclusion of an international agreement.

Option 3b - Institutionalised Partnerships based on Article 187 TFEU

Article 187 of the TFEU allows the Union to set up joint undertakings or any other structure necessary for the efficient execution of EU research, technological development and demonstration programmes. This type of Institutionalised Partnership brings together a stable set of **public and private partners** with a strong commitment to taking a more integrated approach and requires the set-up of a dedicated legal entity – a Union body, Joint Undertaking (JU) – that carries full responsibility for the management of the Partnership and implementation of the calls. Different configurations are possible:

- Partnerships focused on creating strategic industrial partnerships where, most often, the partner organisations are represented by one or more industry associations, or in some cases individual private partners;
- Partnerships coordinating national ministries, public funding agencies, and governmental research organisations in the Member States and Associated Countries;
- Or a combination of the two: the so-called tripartite model.

Participation of non-associated Third Countries is only possible if foreseen in the basic act and subject to conclusion of an international agreement.

2.3. Overview of the methodology adopted for the impact assessment

The methodology for each impact assessment is based on the Commission Better Regulation Guidelines²⁰ to evaluate and compare options with regards to their **efficiency, effectiveness and coherence**. This also integrates **key selection criteria for European Partnerships**.

Box 2 Summary of European Partnerships selection criteria²¹

- **Effectiveness** in achieving the related objectives and impacts of the Programme;
- **Coherence** and synergies of the European Partnership within the EU R&I landscape;
- **Transparency & openness** as regards the identification of priorities and objectives and the involvement of partners & stakeholders from the entire value chain, backgrounds & disciplines;
- Ex-ante demonstration of **additionality** and **directionality**;
- Ex-ante demonstration of the partners' **long term commitment**.

2.3.1. Overview of the methodologies employed

In terms of **methods and evidence used**, the impact assessments draw on an external study covering all candidate Institutionalised European Partnerships in parallel to ensure a high level of coherence and comparability of analysis, in addition to an horizontal analysis.²² For all initiatives, the understanding of the overall context of the candidate institutionalised European Partnerships relied on desk research, including among others the lessons learned from previous partnerships. This was complemented by the analysis of a range of quantitative and qualitative evidence, including evaluations of past and ongoing initiatives; foresight studies; statistical analyses of Framework Programmes application and participation data, and Community Innovation Survey data; analyses of science, technology and innovation indicators; reviews of academic literature; sectoral competitiveness studies and expert hearings. The analyses included a portfolio analysis, a stakeholder and social network analysis in order to profile the actors involved as well as their co-operation patterns, and an assessment of the partnerships' outputs (bibliometrics and patent analysis).

A cost modelling exercise was performed in order to feed into the efficiency assessments of the partnership options, as described below. Public consultations (both open and targeted) supported the comparative assessment of the policy options. For each initiative, up to 50 relevant stakeholders were interviewed by the external contractor (policymakers, business including SMEs and business associations, research institutes and universities, and civil organisations, among others). In addition, the analysis was informed by the results of the Open Public Consultation that ran between September and November 2019, the consultation of Member States through the Strategic Programme Committee and the online feedback received on the Inception Impact Assessments of the set of initiatives.

A more detailed description of the methodology and evidence base that were mobilised, completed by thematic specific methodologies, is provided in Annexes 4 and 6.

²⁰ European Commission (2017), Better Regulation Guidelines (SWD (2017) 350)

²¹ For a comprehensive overview of the selection criteria for European Partnerships, see Annex 6.

²² Technopolis Group (2020), Impact Assessment Study for Institutionalised European Partnerships under Horizon Europe, Final Report, Study for the European Commission, DG Research & Innovation

2.3.2. Method for identifying the preferred option

The first step of the assessments consisted in scoping the problems that the initiatives are expected to solve given the overall economic, technological, scientific and social context, including the lessons to be learned from past and ongoing partnerships on what worked well and less well. This supported the identification of the objectives of the initiative in the medium and long term with the underlying intervention logic – showing how to get there.

Given the focus of the impact assessment on comparing different forms of implementation, the Better Regulation framework has then been adapted to introduce “**key functionalities needed**” - making the transition between the definition of the objectives and what would be crucial to achieve them *in terms of implementation*. The identification of “key functionalities needed” for each initiative as an additional step in the impact assessment is based on the distinguishing factors between the different options (see Section 2.2.1).

In practical terms, each option is assessed on the basis of the degree to which it would allow for the key needed functionalities to be covered, as regards e.g. the type and composition of actors that can be involved (‘openness’), the range of activities that can be performed (including additionality and level of integration), the level of directionality and integration of R&I strategies; the possibilities offered for coherence and synergies with other components of Horizon Europe, including other Partnerships (internal coherence), and the coherence with the wider policy environments, including with the relevant regulatory and standardisation framework (external coherence). This approach guides the identification of discarded options while allowing at the same time a structured comparison of the options not only as regards their effectiveness, efficiency and coherence, but also against a set of other key selection criteria for European Partnerships (openness, transparency, directionality)²³.

In line with the Better Regulation Framework, the assessment of the effectiveness, efficiency and coherence of each option is made compared to the baseline. Therefore, for each of these aspects, the performance of using traditional calls under Horizon Europe is first estimated and scored 0 to serve as a reference point. This includes the discontinuation costs/benefits of existing implementation structures when relevant. The policy options are then scored compared to the baseline with a + and – system with a two-point scale, to show a slightly or highly additional/lower performance compared to the baseline. A scoring of 0 of a policy option means that it would deliver as much as the baseline option.

On the basis of the evidence collected, the intervention logic of each initiative and the key functionalities needed, the impact assessments first evaluate the **effectiveness** of the various policy options to deliver on their objectives. To be in line with the Horizon Europe impact framework, the fulfilment of the specific objectives of the initiative is translated into ‘expected impacts’ – how success would look like – differentiating between scientific, economic/ technological, and societal (including environmental) impacts. Each impact assessment considers to which extent the different policy options provides the ‘key functionalities needed’ to achieve the intended objectives. The effectiveness assessment does not use a compound score but shows how the options would deliver on the different

²³ The criterion on the ex-ante demonstration of partners’ long-term commitment depends on a series of factors that are unknown at this stage, and thus fall outside the scope of the analysis.

types of expected impacts. This is done to increase transparency and accuracy in the assessment of options²⁴.

A similar approach is followed to evaluate the coherence of options with the overarching objectives of the EU's R&I policy, and distinguishes between **internal** and **external coherence**. Specifically, internal coherence covers the consistency of the activities that could be implemented with the rest of Horizon Europe, including European Partnerships (any type). External coherence refers to the potential for synergies and/or complementarities (including risks of overlaps/gaps) of the initiative with its external environment, including with other programmes under the MFF 2021-27, but also the framework conditions at European, national or regional level (incl. regulatory aspects, standardisation).

To compare the expected costs and benefits of each option (**efficiency**), the thematic impact assessments broadly follow a cost-effectiveness approach²⁵ to establish to which extent the intended objectives can be achieved for a given cost. A preliminary step in this process is to obtain a measure of the expected costs of the policy options, to be used in the thematic assessments. As the options correspond to different implementation modes, relevant cost categories generally include the costs of setting-up and running an initiative. For instance, set-up costs includes items such as the preparation of a European Partnership proposal and the preparation of an implementation structure. The running costs include the annual work programme preparation costs. Where a Partnership already exists, discontinuation costs and cost-savings are also taken into account²⁶. The table below provides an overview of the cost categories used in the impact assessment and a qualitative scoring of their intensity when compared to the baseline option (traditional calls). Providing a monetised value for these average static costs would have been misleading, because of the different features and needs of each candidate initiative.²⁷ The table shows the overall administrative, operational and coordination costs of the various options. These costs are then put into context in the impact assessments to reflect the expected co-financing rates and the total budget available for each of the policy options, assuming a common Union contribution (cost-efficiency):

- The costs related to the baseline scenario (traditional calls under Horizon Europe) are pre-dominantly the costs of implementing the respective Union contribution via calls and project, managed by the executive agencies (around 4%, efficiency of 96% for the overall investment).
- For a Co-Programmed partnership, the costs of preparation and implementation increase only marginally compared to the baseline (<1%), but lead to an additional R&I investment of at least the same amount than the Union contribution²⁸ (efficiency of 98% for the overall investment).
- For a Co-Funded partnership, the additional R&I investment by Member States accounts for 2.3 times the Union contribution²⁹. The additional costs compared to the

²⁴ In the thematic impact assessments, scores are justified in a detailed manner to avoid arbitrariness and spurious accuracy. A qualitative or even quantitative explanation is provided of why certain scores were given to specific impacts, and why one option scores better or worse than others.

²⁵ For further details, see Better Regulation Toolbox # 57.

²⁶ Discontinuation costs will bear winding down and social discontinuation costs and vary depending on e.g. the number of full-time-equivalent (FTEs) staff concerned, the type of contract (staff category and duration) and applicable rules on termination (e.g. contracts under Belgian law or other). If buildings are being rented, the cost of rental termination also apply. As rental contracts are normally tied to the expected duration of the current initiatives, these termination costs are likely to be very limited. In parallel, there would also be financial cost-savings related to the closing of the structure, related to operations, staff and coordination costs in particular. This is developed further in the individual efficiency assessments.

²⁷ A complete presentation of the methodology developed to assess costs as well as the sources used is described in the external study supporting this impact assessment (Technopolis Group, 2020).

²⁸ Minimum contributions from partners equal to the Union contribution

²⁹ Based on the default funding rate for programme co-fund actions of 30%, partners contribute with 70% of the total investment.

baseline of preparing and implementing the partnership, including the management of the Union contribution implemented by the national programmes, can be estimated at 6% of the Union contribution (efficiency of 98% related to the overall investment).

- For an Article 185 initiative, the additional R&I investment by Member States is equal to the Union contribution³⁰. The additional costs compared to the baseline of preparing and implementing the partnership, including the management of the Union contribution implemented by the dedicated implementation structure, can be estimated at 7% of the Union contribution. (efficiency of 96% related to the overall investment).
- For an Article 187 initiative, the additional R&I investment by partners is equal to the Union contribution³¹. The additional costs compared to the baseline of preparing and implementing the partnership, including the management of the Union contribution implemented by the dedicated implementation structure, can be estimated at 9% of the Union contribution. (efficiency of 94% related to the overall investment).

Figure 4 - Intensity of additional costs compared with Horizon Europe Calls (for Partners, stakeholders, public and EU)

Cost items	Baseline: traditional calls	Option 1: Co-programmed	Option 2 Co-funded	Option 3a -Art. 185	Option 3b -Art. 187
Preparation and set-up costs					
Preparation of a partnership proposal (partners and EC)	0		↑↑		
Set-up of a dedicated implementation structure		0		Existing: ↑ New: ↑↑	Existing: ↑↑ New: ↑↑↑
Preparation of the SRIA / roadmap	0		↑↑		
Ex-ante Impact Assessment for partnership		0		↑↑↑	
Preparation of EC proposal and negotiation		0		↑↑↑	
Running costs (Annual cycle of implementation)					
Annual Work Programme preparation	0		↑		
Call and project implementation	0	0 In case of MS contributions: ↑	↑	↑	↑
Cost to applicants	Comparable, unless there are strong arguments of major differences in oversubscription				
Partners costs not covered by the above	0	↑	0	↑	↑
Additional EC costs (e.g. supervision)	0	↑	↑	↑	↑↑
Winding down costs					
EC		0			↑↑↑
Partners	0	↑	0	↑	↑

Notes: 0: no additional costs, as compared with the baseline; ↑: minor additional costs, as compared with the baseline; ↑↑: medium additional costs, as compared with the baseline; ↑↑↑: higher costs, as compared with the baseline.

The cost categories estimated for the common model are then used to develop a scorecard analysis and further refine the assessment of options for each of the 12 candidate Institutionalised Partnerships. Specifically, the scores related to the set-up and implementation costs are used in the thematic impact assessments to consider the scale of

³⁰ Based on the minimum requirement in the legal basis that partners contribute at least 50% of the budget.

³¹ Based on the minimum requirement in the legal basis that partners contribute at least 50% of the budget.

the expected benefits and thereby allow a simple “value for money” analysis (**cost-effectiveness**)³². In carrying out the scoring of options, the results of fieldwork, desk research and stakeholder consultation undertaken and taken into account.

For the **identification of the preferred option**, the scorecard analysis builds a hierarchy of the options by individual criterion and overall in order to identify a single preferred policy option or in case of an inconclusive comparison of options, a number of ‘retained’ options or hybrid. This exercise supports the systematic appraisal of alternative options across multiple types of monetary, non-monetary and qualitative dimensions. It also allows for easy visualisation of the pros and cons of each option. Each option is attributed a score of the adjudged performance against each criterion with the three broad appraisal dimensions of effectiveness, efficiency and coherence.

As a last step, the alignment of the preferred option with key criteria for the selection of European Partnerships is described, reflecting the outcomes of the ‘**necessity test**’.³³ The monitoring and evaluation arrangements are concluding the assessment, with an identification of the key indicators to track progress towards the objectives over time.

2.4. Horizontal perspective on candidate Institutionalised European Partnerships

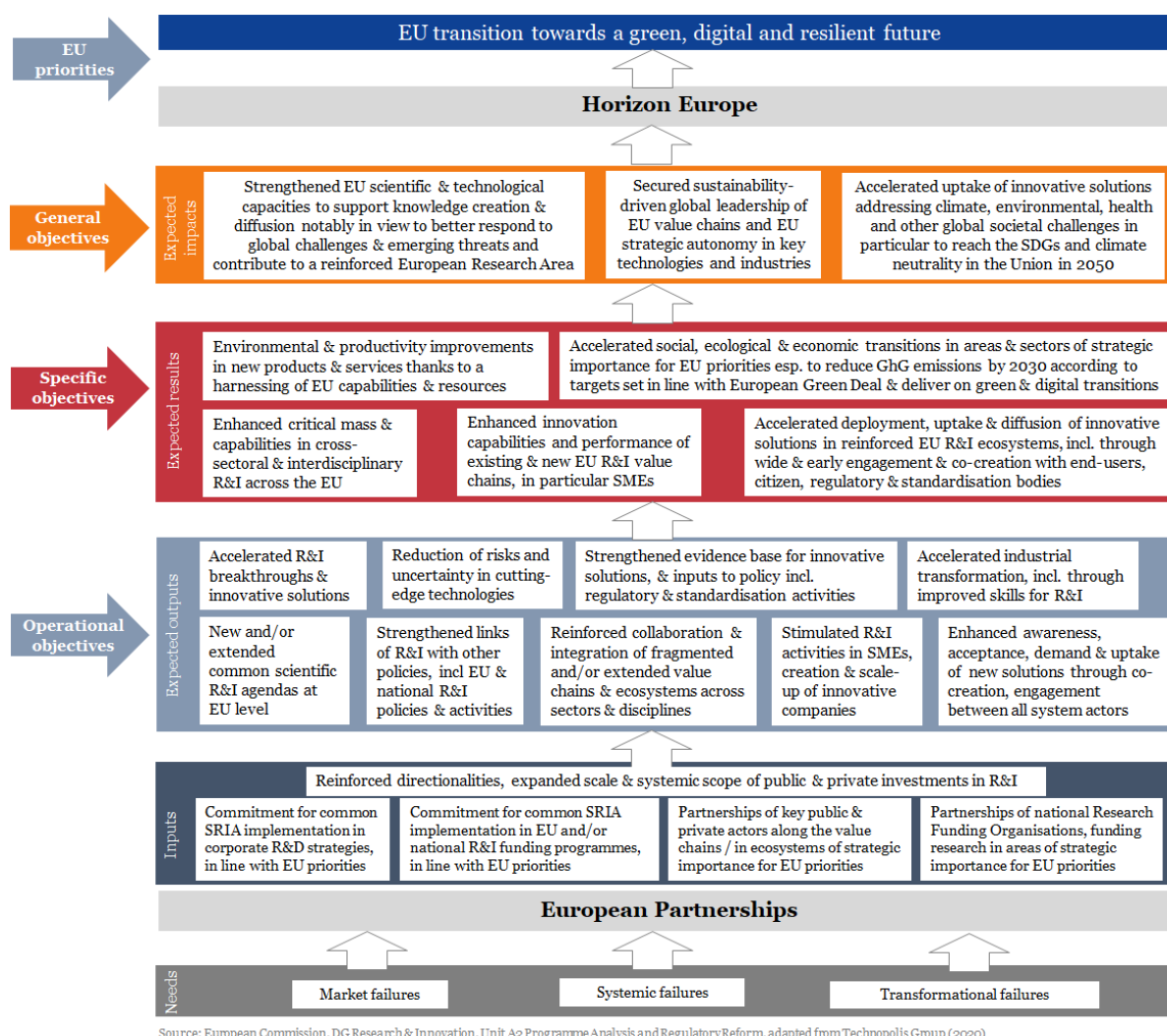
2.4.1. Overall impact orientation, coherence and efficiency needs

The consolidated **intervention logic** for the set of candidate Institutionalised European Partnerships in the Figure below builds upon the objectives as reported in the individual impact assessments.

³² More details on the methodology can be found in Annex 4.

³³ Certain aspects of the selection criteria will be further addressed/ developed at later stages, notably in the context of preparing basic acts (e.g. Openness and Transparency; Coherence and Synergies), in the Strategic Research and Innovation Agendas (e.g. Directionality and Additionality), and by collecting formal commitments (Ex-ante demonstration of partners’ long-term commitment).

Figure 5 – Overall intervention logic of the European Partnerships under Horizon Europe



When analysed as a package the 12 candidate Institutionalised European Partnerships are expected to support the achievement of the European policy priorities targeted by Horizon Europe by pursuing the following joint general objectives:

- Strengthening and integrating EU scientific and technological capacities to support knowledge creation and diffusion notably in view to better respond to global challenges and emerging threats and contribute to a reinforced European Research Area;
- Securing sustainability-driven global leadership of EU value chains and EU strategic autonomy in key technologies and industries; and
- Accelerate the uptake of innovative solutions addressing climate, environmental, health and other global societal challenges contributing to Union strategic priorities, in particular to reach the Sustainable Development Goals and climate neutrality in the Union in 2050.

In terms of specific objectives, they jointly aim to:

- Enhance the critical mass and scientific capabilities in cross-sectoral and interdisciplinary research and innovation across the Union;
- Accelerate the social, ecological and economic transitions in areas and sectors of strategic importance for Union priorities, in particular to reduce greenhouse gas

emissions by 2030 according to the targets set in line with the European Green Deal, and deliver on the green and digital transition;

- c) Enhance the innovation capabilities and performance of existing and new European research and innovation value chains, in particular SMEs;
- d) Accelerate the deployment, uptake and diffusion of innovative solutions in reinforced European R&I ecosystems, including through wide and early engagement and co-creation with end-users, citizen and regulatory and standardisation bodies;
- e) Deliver environmental and productivity improvements in new products and services thanks to a harnessing of EU capabilities and resources.

In terms of their operations, taking an horizontal perspective on all initiatives allows for the identification of further possible collective efficiency and coherence gains for more impact:

- **Coherence for impact:** The extent and speed by which the expected results and impacts will be reached, will depend on the scale of the R&I efforts triggered, the profile of the partners involved, the strength of their commitments, and the scope of the R&I activities funded. To be fully effective, it comes out clearly that future partnerships need to operate over their whole life cycle in full coherence with their environment, including potential end users, regulators and standardisation bodies. This relates also to the alignment with relevant EU, national or regional policies and synergies with R&I programmes. This needs to be factored in from the design stage to ensure a wide take-up and/or deployment of the solutions developed, including their interoperability.
- **Collaboration for impact:** Effectiveness could also be improved collectively through enhanced cross-disciplinary and cross-sectoral collaboration and an improved integration of value chains and ecosystems. An adequate governance structure appears in particular necessary to ensure cross-fertilisation between all European Partnerships. This applies not only to initiatives where similar R&I topics are covered and/or the same stakeholders involved or targeted, but also to the interconnections needed between the ‘thematic’ and the ‘vertical’ Partnerships, as these are expected to develop methodologies and technologies for application in EU priority areas. Already at very early stages of preparing new initiatives, Strategic Research and Innovation Agendas and roadmaps need to be aligned, particularly for partnerships that develop enabling technologies that are needed in other Partnerships. The goal should be to achieve greater impacts jointly in light of common challenges.
- **Efficiency for impact:** Potential efficiency gains could also be achieved by joining up the operational functions of Joint Undertakings that do not have a strong context dependency and providing them through a common back-office³⁴. A number of operational activities of the Joint Undertakings are of a technical or administrative nature (e.g. financial management of contracts), or procured from external service providers (e.g. IT, communication activities, recruitment services, auditing) by each Joint Undertaking separately. If better streamlined this could create a win-win situation for all partners leading to better harmonization, economies of scale, and less complexity in supervision and support by the Commission services.

2.4.2. *Analysis of coherence of the overall portfolio of candidate initiatives at the thematic level*

Looking at the coherence of the set of initiatives at the thematic level, the “**digital centric**”

³⁴ See Annex 6 for an overview of key functions/roles that could be provided by a common back office.

initiatives have a strong focus on supporting the digital competitiveness of the EU ecosystem. Their activities are expected to improve alignment and coordination with Member States and industry for the development of world-competitive EU strategic digital technology value chains and associated expertise. Addressing the Key Digital Technologies, the 5G and 6G connectivity needs as part of a Smart Networks and Services initiative and the underlying supercomputing capacities through a European High Performance Computing initiative present potential for synergies that can be addressed through cooperative actions (e.g. joint calls, coordinated support activities, etc.). They may as well profit from and contribute to Partnerships envisaged for Photonics, AI, data, robotics, Global competitive space system and Made in Europe, together with the EIT Digital. Synergies between these initiatives and several programmes (Digital Europe and Connecting Europe as well as cohesion programmes) are needed in areas where EU industry has to develop leadership and competitiveness in the global digital economy. They are expected to impact critical value chains including on sectors where digital is a strong enabler of transformation (health, industrial manufacturing, mobility/transport, etc.).

The **transport** sector face systemic changes linked to decarbonisation and digitalisation. Large scale R&I actions are needed to prepare the transition of these complex sectors to provide clean, safer, digital and economically viable services for citizens and businesses. Past decades have shown that developing and implementing change is difficult in transport due to its systemic nature, many stakeholders involved, long planning cycles and large investments needed.

A systemic change of the air traffic network through an Integrated Air Traffic Management initiative should ensure safety and sustainability of aviation, while a Clean Aviation initiative should focus on the competitiveness of tomorrow's clean aircraft made in Europe. The initiative for Transforming Europe's Rail System would comprehensively address the rail sector to make it a cornerstone in tomorrow's clean and efficient door-to-door transport services, affordable for every citizen as well as the most climate-friendly mode of transport for freight.

Connected and Automated Mobility is the future of road transport, but Europe risks falling behind other global regions which have strong players and large harmonised markets. The initiative Safe and Automated Road Transport would bring stakeholders together, creating joint momentum in digitalising road transport and developing new user-based services. Stronger links and joint actions will be established between initiatives to enable common progress wherever possible.

The Clean Hydrogen initiative would be fundamental in that regard. Synergies would also be sought with those partnerships driving digital technological developments To deliver a deep decarbonisation of highly emitting industrial sectors – such as the steel, transport and chemical industries – would require the production, distribution and storage of **hydrogen** at scale. The candidate hydrogen initiative would have a central positioning in terms of providing solutions to the challenges for sustainable mobility and energy, but also is expected to operate in synergies with other industry related initiatives.

The initiative would interact in particular with initiatives on the zero emission road and water transport, transforming Europe's railway system, clean aviation, batteries, circular industry, clean steel and built environment partnerships. There are many opportunities for collaboration for the delivery and end-use of hydrogen. However, the Clean Hydrogen initiative would be the only partnership focused on addressing hydrogen production technologies.

Metrology, the science of measurement, is an enabler across all domains of R&I. It supports the monitoring of the Emissions Trading System, smart grids and pollution, but also

contributes to meeting demands for measurement techniques from emerging digital technologies and applications. More generally, emerging technologies across a wide range of fields from biotechnologies, new materials, health diagnostics or low carbon technologies are giving rise to demands requiring a world-leading EU metrology system.

The initiative for a **Circular Bio-based Europe** is intended to solve a shortage of industry investments in the development of bio-based products, whose markets do not have yet certain long-term prospects. The **Innovative Health Initiative** and **EU-Africa Global Health** address the lack of investments in the development of solutions to specific health challenges. The initiative on **Innovative SMEs** supports innovation-driven SMEs in participating in international, collaborative R&I projects with other innovative firms and research-intensive partners. As a horizontal initiative, it is expected to help innovative SMEs to grow and to be successfully embedded in global value chains by developing methodologies and technologies for potential application in the other partnership areas or further development by the instruments of the European Innovation Council.

The description of the interconnections between all initiatives for each Horizon Europe cluster is provided in the policy context of each impact assessment, and further assessed in the coherence assessment for each option.

PART 2 - THE CANDIDATE EUROPEAN PARTNERSHIP FOR CLEAN AVIATION

1. INTRODUCTION: POLITICAL AND LEGAL CONTEXT

Aviation brings major positive social and economic benefits. It connects people, countries and cultures, it enables trade, and generates tourism. Aviation underpins the freedom of movement of persons and goods, one of the European Union founding principles. It connects European citizens and businesses with each other and with the world. Beyond transportation of people and goods, aviation plays a pivotal role in the emergency services, search and rescue, disaster relief, maritime surveillance, police, and border control operations.

The disadvantage is that aviation comes with an environmental cost. Emissions generated by the growing fleet of aircraft, flying with fossil fuels, are rising in line with increasing air traffic.

Reducing fuel consumption has an environmental as well as an economic benefit. Researchers have been successfully reducing fuel consumption by optimising engines and improving the aerodynamic performance of aircraft. Unfortunately, these incremental improvements cannot keep pace with the growth in air traffic, and further large gains within the current technology portfolio seem more and more improbable.

Challenged by the growing environmental concerns, researchers are envisaging several disruptive alternatives to the standard civil aircraft configuration. These include alternative energy sources such as hydrogen or electricity stored in batteries, which could lead to new types of propulsion, innovative aerodynamic configurations reducing air friction, and advanced IT systems that optimise operations.

Such new aircraft technologies come under the term 'Clean Aviation', which is the research and innovation pillar for achieving carbon neutral aviation in the EU by 2050. The complexity of this endeavour lies in the selection and maturing of the most promising technologies, and their demonstration (i.e. integration and testing) in realistic aircraft configurations.

The journey to a climate neutral aviation system is well beyond the private sector's capability and capacity to invest on its own. Equally, no single country in Europe has the financial, technological and industrial capability to affect the transformation, nor the ability to promote and support the required changes to global rules and operative frameworks, which are necessary to implement those solutions.

This document focuses on assessing the most effective, efficient and coherent way of implementing an initiative which would focus on joint European research and innovation activities on Clean Aviation under Horizon Europe.

1.1. Emerging challenges in the field

Aviation is valuable for social and economic development, brings the world closer together and drives global growth and prosperity. While precise data differs slightly depending on the source and calculation methods, all analysis shows significant and sustained growth of both aviation traffic and its ecological footprint.

COVID-19: This growth has been abruptly impacted by the current, on-going COVID-19³⁵ crisis. Thus, it is worth noting that much of the information and data in this impact assessment dates from before the global onset of the COVID-19 crisis. While previous pandemic outbreaks have demonstrated the resilience of the sector to bounce back relatively swiftly, it must be recognised that the COVID-19 crisis is of unprecedented scale and magnitude. A full recovery is not expected before 2025-30.

The expected impact of COVID is explained in more detail in annex 6.2. The evolution of this crisis is being closely monitored by the Commission to ensure that the Clean Aviation initiative reaches its objectives despite the changed economical context.

The aviation sector, which is probably one of the most affected by the crisis, has been the recipient of various national aid packages. The Commission's recent proposals for a post COVID-19 recovery package focus on the European Green Deal as part of the EU's post-pandemic response, with the aim of bridging the gap between economic crisis response and transforming Europe into a sustainable and climate neutral economy.



Stakeholders involved in the CS3PG (the private side's preparatory group for Clean Aviation) underline that the initiative should maintain a clear strategic direction towards climate neutrality, instead of turning towards short-term solutions in response to the current crisis.

The proposed Clean Aviation initiative should not aim to resolve COVID-19 related difficulties but aim at providing a clear strategic direction for the aviation sector and its efforts to become climate neutral.

Environmental concerns:³⁶ ³⁷Over the past decades, the aviation sector has successfully transformed the way Europeans travel and has brought significant socio-economic benefits for people and businesses. Airlines transport over four billion passengers annually, with revenue passenger kilometres totalling nearly eight trillion³⁸. Air transport carries around 35% of world trade by value and less than 1% by volume.

In 2016, aviation was accountable for 3.6% of the total EU-28 greenhouse gasses emissions and for 13.4% of the emissions from transport³⁹. By 2040, CO₂ and NO_x (nitrogen oxides) emissions are predicted to increase by at least 21% and 16% respectively.

Further growth in aviation would result in a further increase of the adverse impact of carbon dioxide and non-carbon dioxide emissions, as well as from noise, if worldwide investments in new clean and sustainable technologies do not drastically increase. Movements such as "Stay Grounded"⁴⁰ and "Flight Shame"⁴¹ alone could halve the growth in air traffic, according to a survey by the bank UBS⁴².

³⁵ A brief discussion on COVID-19 and its impact on aviation R&I is in annex 6.2.

³⁶ The environmental impact of aviation is discussed in annex 6.3.

³⁷ <https://www.easa.europa.eu/eaer/climate-change/aviation-environmental-impacts>

³⁸ https://aviationbenefits.org/media/166344/abbb18_full-report_web.pdf

³⁹ <https://www.easa.europa.eu/eaer/executive-summary>

⁴⁰ <https://stay-grounded.org/>

⁴¹ <https://www.theguardian.com/money/2019/jun/09/flight-airline-travel-rail-family-environment>

⁴² <https://www.ubs.com/global/en/investment-bank/in-focus/2019/electric-planes.html>

If the aviation sector fails to take effective technology-based measures to address its climate impact, it may be confronted with a range of market based measures which could undermine its growth.

Health concerns: Public health issues, linked to the release of gaseous pollutants, air pollutants and noise emissions, primarily near airports, are a cause of increasing health concerns on the top of disrupted sleep and stress. A report from Queen Mary, University of London⁴³ summarises the strength of evidence for aircraft noise effects on cardiovascular health, sleep disturbance, annoyance, psychological well-being, and effects on children's cognition and learning. The EU has recently confirmed these causal links by embedding them into binding legislation⁴⁴.

1.2. EU relative positioning in the field

The EU is a global leader in this field⁴⁵, with Airbus and the US company, Boeing, operating largely as a duopoly in the global commercial aircraft market. Half of the global commercial aircraft fleet is designed and manufactured by a European company.

Research and innovation is a fundamental building block for European competitiveness and global leadership in the aviation ecosystem. In 2018, the Aerospace and Defence Industries Association of Europe (ASD) estimated that the European aeronautics industry invested EUR 9 billion in R&D annually, although this figure includes product development, which is significantly more expensive than technology development envisaged by the Clean Aviation initiative.

As regards the R&D investments in the field, EU companies are well-positioned compared to the rest of the world according to the 2019 Industrial R&D Scoreboard. The top 39 companies of the aerospace and defence sector in terms of R&D investment invested close to EUR 20 billion in R&D in 2018 worldwide, where EU companies represent 46% of the investments, slightly more than the USA.

In terms of scientific performance, the EU-28 shows a good performance compared to the rest of the world based on scientific publications in the field of aerospace engineering. Based on Scopus data, EU-28 publications represents 23% of all publications in the field with close to 40,000 publications between 2014 and 2019, involving close to 60,000 authors. Worldwide the most prolific country is China with more than 50,000 publications, followed by the United States (40,000).

In terms of technological performance, between 2010 and 2016 the EU overall has maintained a stable higher performance compared to the USA.

In terms of aviation R&I performance and in particular on **patents and scientific publications**, Europe shows strong leadership, especially in peer-reviewed publications and references with high impact factor.

⁴³https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/446311/noise-aircraft-noise-effects-on-health.pdf

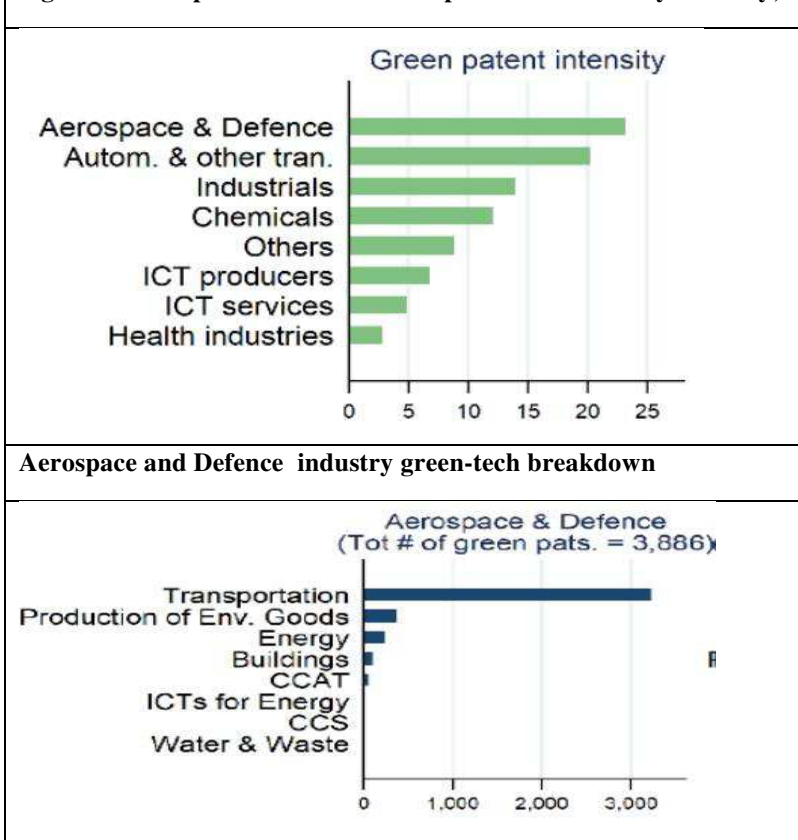
⁴⁴ Commission Directive 2020/367 ... as regards the establishment of assessment methods for harmful effects of environmental noise
[\[https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2020.067.01.0132.01.ENG&toc=OJ%3AL%3A2020%3A067%3ATOC\]](https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2020.067.01.0132.01.ENG&toc=OJ%3AL%3A2020%3A067%3ATOC)

⁴⁵ An overview of the positioning of the European industry in aviation is available in annex 6.3.

- Out of the 50 journals on aerospace engineering⁴⁶ worldwide, 26 are based in Europe, including a clear lead in the total citations over the last three years.
- In terms of patents, leading European aeronautics companies hold an extensive portfolio (Airbus⁴⁷: 37,000, Safran⁴⁸: 38,000, Thales⁴⁹: 15,000).

When looking in the EU industrial R&D Scoreboard at the share of green patenting with respect to the total technological inventions of the biggest R&D investors worldwide, the highest share of green over total patents is revealed by companies operating in transport-related industries, including aerospace and defence (23.2%), totalising almost 3,900 green over more than 17,000 patents in the period 2012-2015, and automobiles and other transports (20.1%). These companies concentrate their green inventions in green transportation technologies. From the top 25 green inventors among the top R&D investors, green patents represent 28% of the patents of the company United Technologies (USA), 20% of the patents filed by Airbus (EU), and 34% of the patents filed by Rolls Royce (UK).

Figure - Green patent intensities of top R&D investors by industry;



Note: Share (left panel) and number of green patents (right panel) by industry (ICB) and environmental technology (CPC), 2012-2015. Caption: CCS = "Carbon Capture and Storage", ICT = "Information and Communication Technologies" CCAT =

Finally, a report from Intereconomics on the impact of Horizon 2020 on innovation in Europe confirms (table 3⁵⁰) that Europe has technological advantages in aerospace.

Hence, Europe is in an excellent position to contribute to a clean aviation on condition that all the available R&I resources are mobilised for this research and innovation effort.

⁴⁶ <https://www.scimagojr.com/journalrank.php?category=2202&area=2200&type=all>

⁴⁷ <https://www.airbus.com/careers/working-for-airbus/innovations-of-tomorrow.html>

⁴⁸ <https://www.safran-group.com/media/safran-third-ranked-patent-filings-france-7th-year-row-20180406>

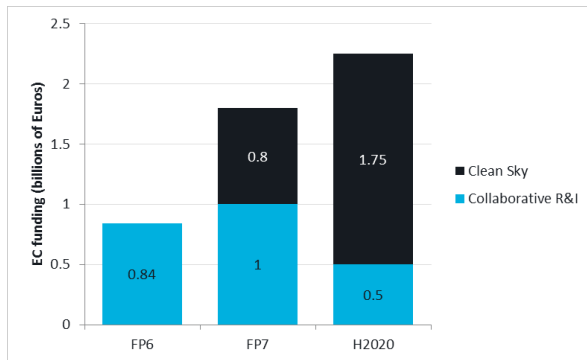
⁴⁹ <https://www.thalesgroup.com/en/group/journalist/press-release/thales-once-again-amongst-top-100-global-innovators-clarivate>

⁵⁰ <https://www.intereconomics.eu/contents/year/2015/number/1/article/the-impact-of-horizon-2020-on-innovation-in-europe.html>

Box 3 Support for the field in the previous Framework Programmes⁵¹ – key strengths & weaknesses identified.

Below is a summary of different sources of evidence on the performance of Clean Sky 2, which includes the mid-term evaluation⁵² but also inputs from the study for this impact assessment.

The Clean Sky initiatives⁵³



Dedicated R&I activities related to transport and aviation in particular have been supported since 1994 (FP4) through the Framework Programmes. This covers traditional (collaborative) projects but also support provided through the Clean Sky Joint Undertakings (CS1 and CS2) under Horizon 2020.

The Clean Sky Joint Undertaking is a partnership between the EU and the aviation

industry set up in 2008, with a total budget of EUR 1.6 billion for CS1 and EUR 4bn for CS2 and focussing on delivering technologies for reducing aircraft emission.

More than 75% of the EU aviation research funding in Horizon 2020 was provided through CS2, whereas under FP7, CS1 only accounted for just under 50% of the total EU research funding.

The maximum EU contribution to CS2 is EUR 1.7 billion, to be funded from Horizon 2020⁵⁴. The private members of the JU are expected to contribute resources of at least EUR 2.2 billion over the life span of the JU. Of this amount, private members have to incur costs of at least EUR 965 million in implementing additional activities outside the work plan of the Clean Sky Joint Undertaking. Details on the way the Joint Undertaking functions are available in annex 2.7 and annex 2.8.

What has or is being achieved so far?

Numerous promising climate neutral solutions have been researched under former public and private research and innovation programmes, either in the EU (starting from the 4th research and development programme), national or regional programmes. A number of those technologies, that reached high maturity levels in the Clean Sky and Clean Sky 2 research programmes, have been assessed in the Technology Evaluator under FP7-Clean Sky and it was found that if taken-up in new aeroplanes, they have the potential to reduce emissions up to 30% compared to a state-of-the-art aircraft available on the market in the year 2000.

⁵¹ Annex 6.8 provides an introduction to the H2020 aviation research landscape

⁵² <https://ec.europa.eu/research/evaluations/pdf/cs2.pdf>

⁵³ The Clean Sky public-private partnerships are detailed in annex 6.7. A more complete overview of the European aviation research is available in annex 6.5.

⁵⁴ Article 3(1) of Regulation (EU) No 558/2014

Technological advances in aviation have significantly impacted aviation emissions; current aircraft are about 80% more fuel efficient, per passenger kilometre, than aeroplanes in the 1960's.

The Interim Evaluation⁵⁵ of the Joint Undertakings operating under Horizon 2020⁵⁶ concluded that JU-based public-private partnerships (PPPs) have demonstrated efficiency improvements in comparison to FP7, despite a few identified shortcomings to be addressed.

While it is too soon to draw conclusions for CS2 (which runs until 2024), preliminary assessments show that it is well on track to achieve its objectives of demonstrating and validating technologies reducing CO₂ and NO_x emissions by 20 to 30% compared to state-of-the-art aircraft entering into service as from 2014⁵⁷. A growing number of publications and patent applications support the good progress of the main demonstrators⁵⁸. Unfortunately, the introduction of those technologies into aeroplanes on the market is anything but certain, because this is largely determined by market forces.

CS2 has been successful in attracting over 800 participants – including industry, research and technology organisations (RTOs), academia, and many SMEs – with a good geographical distribution. However, funding is concentrated within a limited number of industrial leaders, core partners and their associated supply chain with a large part of the funding (40%) earmarked upfront for the Leaders⁵⁹ and Core Partners (30%) and only the remaining 30% available through open calls.

What are the key areas for improvement⁶⁰ & unmet challenges?

The Interim Evaluation of CS2⁶¹, published in 2017, raises various questions, summarised below and outlined in more detail in annex 2.10 (see also the study by Steer and Technopolis supporting which⁶² identified a set of issues from the experience of the CS2 JU).

The summary of the issues across both reports is:

Concentration of funding

- Project participation rates are distributed in favour of a relatively limited number of organisations. A large share of the funding is reserved to Leaders and Core Partners. There is a risk that SMEs or EU-13⁶³ Member States participants may find it difficult to join it, as project participation in the CS2 JU is concentrated among a relatively limited number of players reflecting the composition of Leaders and Core Partners.

⁵⁵ More information on the Interim Evaluation, its recommendations and the initial Clean Aviation response are available in Annex 6.7.3

⁵⁶ Commission SWD - Interim Evaluation of the Joint Undertakings operating under Horizon 2020, {SWD (2017) 339 final}

https://ec.europa.eu/research/evaluations/pdf/20171009_a187_swd.pdf

⁵⁷ https://www.cleansky.eu/sites/default/files/inline-files/CS-GB-2019-06-27%20AAR%202018_published.pdf

⁵⁸ Clean sky 2 Annual Activity report 2019

⁵⁹ The structure of the Clean Sky and Clean Sky 2 programmes are explained in Annex 6.7

⁶⁰ A brief overview of the Clean Aviation responses to clean sky 2 perceived shortcomings is available in annex 6.11

⁶¹ <https://ec.europa.eu/research/evaluations/pdf/cs2.pdf>

⁶² Technopolis Group, Steer (2020, forthcoming), Impact Assessment Study for Institutionalised European Partnerships under Horizon Europe -Candidate Institutionalised European Partnership on Clean Aviation

⁶³ Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia

- The imbalance between the relatively small budget for collaborative aviation R&I, over the last decade, compared to the large budget for demonstration, has adversely affected the availability and spectrum of lower technology readiness levels (TRL)⁶⁴ technologies to the European aviation research chain.

Operations

- Aspects of the design and implementation of the CS2 JU have limited effectiveness: certain aspects of its governance arrangements such as the role of the States' Representative Group, which is not always as well attended as could be and its opinions are only advisory.
- The lack of structural involvement of the European Union Agency for Safety Aviation (EASA) in CS and CS2 may have a negative impact on the “time to market”, which benefits from the assessment of potential safety risks and environmental standards related to certification of new products and technologies. Safety topics and certification issues regarding environmental protection may also have been excluded from the scope of CS2 R&I by narrow industrial interests.
- Similarly, the CS2 JU complex membership structure is constraining the R&I effort. There is arguably a need for greater flexibility and for reduction in the administrative burden. There are also some communication improvements that could be made.
- It is not always easy to establish what the precise outcomes of CS1 and CS2 have been.

Policy coordination

- There is a lack of multi-level policy coordination, e.g. between the EU and Member States' level, whilst horizontal coordination between research, technology and innovation policies is good in the European aviation sector.
- Although some Member States have quite elaborated aviation research programmes, one of the weaknesses of the European research landscape is that there is no systematic alignment, and no single roadmap, of the various aviation related research programmes leading to overlaps, ineffective investment and sometimes to duplications.
- Overall, the CS2 programme has not contributed to the alignment of national and EU aviation research programmes – apart from creating some synergies with EU regional funds⁶⁵ as outlined in the CS2 2018 Annual Activity Report. In addition, efforts to develop more electric systems as well as composite aero structures were often duplicated by partners, while opportunities for synergies were not exploited.

In addition, the interim evaluation of CS2 recommended increased transparency and energising academic participation to better spread the newly acquired knowledge.

1.3. EU policy context beyond 2021

Aviation research has been of particular interest for the EU since the fourth framework programme. However, the political context has evolved drastically in the last five years with all Member States of the EU having signed and ratified the Paris Agreement, and the EU committing to contributing to delivering the Sustainable Development Goals (SDGs).

⁶⁴ https://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2016-2017/annexes/h2020-wp1617-annex-ga_en.pdf
(Annex G for a definition of Technology Readiness Levels)

⁶⁵ https://www.cleansky.eu/sites/default/files/inline-files/CS-GB-2019-06-27%20AAR%202018_published.pdf

In order to contribute to EU policies, as well as increasing the integration of aviation research into relevant policies, the forthcoming Clean Aviation initiative must take into account the surrounding environment and the regulatory framework.

Policy communications provide the direction the initiative should follow:

- In 2018, the European Commission published “A Clean Planet for All”⁶⁶, the strategic long-term vision of the EU for a prosperous, modern, competitive, and climate-neutral economy by 2050.
- The European Green Deal⁶⁷ puts a high emphasis on preventing climate change and protecting the health of citizens especially children. It identifies, through research and innovation, a way to drive the transformation to modernise the EU’s economy and society and re-orient them towards a just and sustainable future and becoming the world’s first climate-neutral continent by 2050.
- The COVID-19 recovery package⁶⁸ is presented as an opportunity to redesign a sustainable, inclusive economy, revitalising industry, preserving vital biodiversity systems, and tackling climate change.

The European Green Deal Communication specifically mentions aviation, suggesting market-based measures such as a revision and strengthening of the EU Emissions Trading Scheme (ETS⁶⁹) which could trigger aviation stakeholders to develop more environmental friendly practice.

The European Green Deal Communication further aims at the improvement of air quality near airports by tackling the emissions of pollutants by aeroplanes and airport operations, and the modernisation of Trade Defence Instruments.

The European Green Deal will also re-orient the lending policy of the European Investment Bank⁷⁰. European Investment Bank (EIB) financing and InvestEU can be effective multipliers in areas of the supply chain where access to commercial finance is limited. An important option could be ‘green finance’ for airlines: enabling earlier and more aggressive rollout of new aircraft in their fleets.

The implication for an R&I initiative on Clean Aviation is that breakthrough technologies based on green energy sources become more attractive for the market, in turn motivating the acceleration of clean aviation research.

The EU is investigating the use of EU and/or global emissions trading schemes to foster further improvements in air quality, as well as greater use of sustainable aviation fuels that have lower emissions.

The ECOFIN Council on 5 December 2019⁷¹ gave its support to an update of the legal framework for energy taxation (including aviation, taking into account their specificities and

⁶⁶ European Commission (2018), A Clean Planet for all, COM(2018)773

⁶⁷ https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf

⁶⁸ https://ec.europa.eu/info/strategy/recovery-plan-europe_en

⁶⁹ https://ec.europa.eu/clima/sites/clima/files/factsheet_ets_en.pdf

⁷⁰ https://ec.europa.eu/commission/presscorner/detail/en/qanda_20_24

⁷¹ <https://www.consilium.europa.eu/media/41646/st14851-en19.pdf>

existing exemptions and international dimension), which will contribute to wider economic and environmental policy objectives⁷².

- **Regulations** put the boundaries for the initiative to operate while supporting sustainability-driven innovation in the sector. Two directives regulate aviation noise, mainly at airports. Directive 2000/14/EC on noise emitted by non-transport outdoor equipment, and Directive 2002/49/EC on noise mapping. These two pieces of legislation are currently under revision in order to be aligned with the recent World Health Organisation guidelines. The implication for an R&I initiative on Clean Aviation are similar as for previous point.

In Horizon Europe, the aviation research is part of the research and innovation activities under Cluster 5 “Climate, Energy and Mobility” under pillar 2. Aviation has been identified as one of the industry sectors with the highest need for new technological solutions to contribute to meeting the goals of the Paris Agreement, such as sustainable mobility and health.

The proposed mandate and scope of the Clean Aviation initiative is to focus exclusively on highly disruptive new technologies with the greatest potential to contribute to the ambitious European Green Deal objective of full decarbonisation by 2050;

The Horizon Europe collaborative calls for proposals should, in turn, concentrate on lower TRL research, including topics covered by the new industrial strategy⁷³ and the European digital agenda⁷⁴;

This two-pronged approach enables a very focussed Clean Aviation initiative alongside a highly complementary collaborative research programme.

Other aspects of the aviation sector’s comprehensive decarbonisation strategy (e.g. incremental improvements in energy efficiency of engines and aircraft design, drop-in sustainable aviation fuels) should be supported by industry’s own R&D budgets, or by national resources.

A **set of policies are relevant** to be considered as regards the field of clean aviation, in particular:

Trade policies: Both the EU and the USA have been found at fault by the WTO dispute settlement system⁷⁵ for continuing to provide certain unlawful subsidies to their aircraft manufacturers.

Industrial policies: This includes the linkages between European strategic value chains that have been identified⁷⁶ and integrated industrial aviation activities with great potential to contribute to Europe’s green and digital transformation and to improve Europe’s industrial competitiveness.

⁷² More information is available in the external studies, performed on behalf of the European Commission, which are linked with the EU-ETS and new sustainable energy carriers for aviation towards 2050.

⁷³ https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/european-industrial-strategy_en

⁷⁴ https://ec.europa.eu/info/sites/info/files/communication-shaping-europes-digital-future-feb2020_en_4.pdf

⁷⁵ <https://trade.ec.europa.eu/doclib/press/index.cfm?id=2068>

⁷⁶ Report of the Strategic Forum for Important Projects of Common European Interest, EC, DG GROW.

Competition policies: Considering that, in 2019, the global aerospace and defence mergers and acquisitions increased by 62% to EUR 86 billion⁷⁷, when compared with 2018, it is of importance to safeguard the intellectual property rights (IPR) of the European aviation supply chain as a result of EU-funded pre-competitive R&I.

Energy policies: In line with the Energy Union objectives for transport towards achieving deep emissions reductions, aviation R&I paths will need to contribute to the required integrated system approach for overall aircraft efficiency.

Transport policies: In line with the objectives of the European Strategy on Sustainable and Smart Mobility, towards achieving 90% reduction in emissions by 2050, due consideration should be taken of all four principles that will guide transport's contribution to the European Green Deal:

- Making the transport system as whole more sustainable;
- Making sustainable alternative solutions available to EU citizens and businesses;
- Respecting the polluter-pays principle in all transport modes;
- Fostering connectivity and access to transport for all.

In addition, the policy context is also influenced by the European Aviation Strategy⁷⁸ (including the objectives towards a Single European Sky) as well as all initiatives towards a transparent and effective phase 4 trading period (2021-2030)⁷⁹ of the EU Emissions Trading System (i.e. ending fossil-fuel subsidies, revising the Energy Taxation Directive, addressing current tax exemptions, and reducing the quantity of free allowances allocated to airlines).

Health policies: In post-COVID-19 times, attention needs to be paid to communicable diseases in all public transport vehicles and their infrastructures. European aviation R&I needs to take account of related mitigation and preparedness actions, with an eye towards the next outbreak. Technological and societal solutions should be in-line with the national and European health plans, ECDC⁸⁰ and ICAO revised guidelines. Preliminary considerations are laid out in Annex 6.2.4.

The initiative has to operate in synergy with its environment to support the adoption of clean technologies. In particular supporting horizontal synergies and efficiencies beyond Horizon Europe, other instruments and initiatives can take the partnership's activities further and strengthen its impact:

- The Connecting Europe Facility (CEF) can facilitate market uptake where deployment is strongly dependent on infrastructure development.
- As is currently developing, the link to the European Innovation Council (EIC) can provide significant opportunities for transferring R&I results delivered by SMEs into the next phase of development and market deployment.
- Other European Partnerships might be a source of solutions or of markets for Clean Aviation solutions:
 - For technology solutions: e.g. the Clean Hydrogen initiative
 - For improved digitalisation: e.g. the Key Digital Technologies initiative

⁷⁷ <https://www.pwc.com/us/en/industries/industrial-products/library/aerospace-defense-quarterly-deals-insights.html>

⁷⁸ <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM:2015:598:FIN>

⁷⁹ https://ec.europa.eu/clima/policies/ets/revision_en

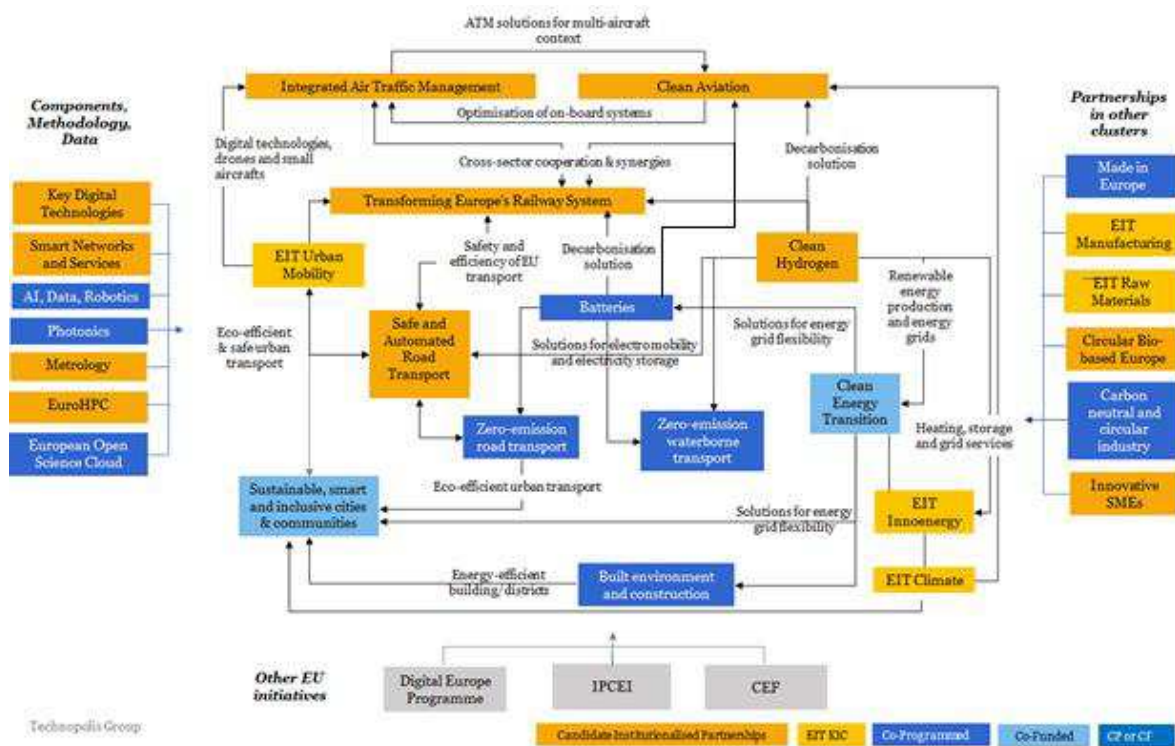
⁸⁰ <https://www.ecdc.europa.eu/en/covid-19-pandemic>

- For improved deployment: e.g. the Integrated Air Traffic Management initiative

A separate institutionalised partnership (to succeed the SESAR Joint Undertaking) is proposed to optimise air traffic control and co-ordination between national authorities in this area. A mapping of the potential links between the different initiatives put forward as candidate European Partnerships under this cluster is provided in the Figure below. These potential links are explained in annex.

Overall, an initiative on Clean Aviation would have a set of potential interconnections with other partnerships. This highlights the five possible candidate initiatives and the synergies between them and with other initiatives. Four of these can be considered as ‘application’ sector partnerships with the other (Clean Hydrogen) being more ‘technology’ orientated. The central position of batteries and hydrogen, as enablers of zero emission transport and the clean energy transition, is also clear from the analysis. Likewise, there are synergies with the other technology-related partnerships, particularly in the digital area, and those that are manufacturing or materials-orientated. This also highlights the twin challenges of digitisation and decarbonisation for the future energy/mobility sectors.

Potential interconnections between partnership initiatives in the Climate, Energy and Mobility cluster of Horizon Europe



2. PROBLEM DEFINITION

2.1. What are the problems?

Given the scale of the challenges ahead for achieving the European Green Deal in aviation, the current scientific, technological and economic positioning of Europe in the field, and the

overarching EU policy context, a set of problems have been identified where there is a need for EU research and innovation in the field of Clean Aviation.

2.1.1. Growing ecological footprint of aviation associated to unclear path to climate neutrality

The growing demand for air-transport of passengers and goods, expected to swiftly pick up again after COVID, is insufficiently offset by incremental technological and operational improvements, as well as market-based measures, to reduce the environmental externalities of aviation. This is not consistent with the EU's objective of climate neutrality by 2050 and EU citizens' expectations.

The technological path towards climate neutrality is not obvious in aviation, and established solutions in other sectors cannot simply be transferred, due to severe constraints like weight and/ or performance (e.g. batteries⁸¹), safety or scalability issues.

Some of the most interesting research paths identified so far – clean hydrogen (for which there are currently no established large green supplies) and electrification with batteries – will require huge investments not only for powering new aircraft but also for renewing airports and infrastructure worldwide to enabling this shift of technology.

All this has global consequences on climate change, serious health implications especially for people living near airports, and it puts the prosperity of the European aviation industry in danger. This could have wider effects on mobility and connectivity which are important for the European integration project.

A Clean Aviation initiative should concentrate on disruptive technologies with high potential to accelerate the development of climate neutral aviation technologies for the earliest possible deployment in view of the European Green Deal targets for 2030 and 2050. Within the context of the deadlines set by the European Green Deal, selecting the most promising technologies should include an assessment on how fast these could be brought to the market.

2.1.2. Insufficient deployment of EU R&I aviation solutions putting EU European industrial leadership & technological sovereignty at risk

The current incremental pace of innovation is largely set by the global context in which European aviation is operating. Europe is manufacturing roughly 50% of all civil aircraft worldwide and has a very good performance in terms of green patenting in aviation. Looking at the European aviation value chain as a whole, it is designing and manufacturing each significant part of a civil aircraft.

While the ability to design, prototype and patent every aspect of a radical innovative design in combination with the strong policy drive (and linked public support) puts Europe in an excellent position to contribute to clean aviation, it should not be forgotten that only a competitive European industry can put the necessary focus on the needed technological breakthroughs to achieve climate neutrality while upcoming international competitors are competing on price, not quality.

⁸¹ With current technology, the weight of the batteries required for normal flight operations of an airliner would have the order of magnitude of 100+ tons and exceed the maximum take-off weight. (source: Airbus)

Potential clients weigh the purchase costs, performance advantages, operational and expected maintenance costs of the various aircraft on offer. This way, an innovative design may price itself out of the market compared to much cheaper, less advanced aircraft.

One technological challenge is to significantly accelerate technology development and tap into technologies emerging from other sectors with potential for adoption in aviation while ensuring that this does not lead to a higher sales price.

In fact, the “market” for breakthrough technologies has largely been created by the European Green Deal. Without this strong policy drive and support, it would be impossible, even with the resources of the combined European aviation industry, to justify developing civil aircraft using alternative energy sources such as hydrogen and/or through electrification with batteries.

In addition, there are no shortcuts on safety in aviation. Safety is a fundamental objective embedded in any aviation R&I effort. The prior indication that an innovative climate neutral solution has reasonable chances to be certified by the regulatory bodies is of major importance to drive research and innovation.

As an illustration, the two main demonstrators in terms of Clean Sky 2 achievements (the BLADE wing design, and the CROR open rotor) aiming at increasing the environment performance of aircraft have not been taken up by the market on the ground that they were not certified.

The aviation sector is a highly internationally regulated market, characterised by very long lifecycles. Emerging technological R&I solutions to reduce the environmental impact of the aviation industry (e.g. electrified aircraft, hydrogen), require long development and demonstration cycles compared to other modes of transports. Access to the global market for the European industry, and for very innovative products, is heavily dependent upon the corresponding standardisation efforts, and on ensuring world-wide regulatory convergence in the field of certification and common rule making. As with all global regulation and standardisation, this is often a complex and lengthy process.

In addition to the research, product development and related certification prohibiting cost, the huge investments required by airports to store hydrogen, or supply electricity to the aircrafts would prevent any such breakthrough technology from reaching the market.

The current certification regulatory framework does not sufficiently allow for the early certification of more promising climate neutral solutions. Certification – although its value and necessity is not questioned – tends to delay market introduction of innovations.

2.1.3. Fragmented R&I capacity of the European aviation value chains prevents to develop climate neutral technologies within the Green deal delays

The European Green Deal deadlines of 2030 and 2050 pose a challenge on their own and introduce a sense of urgency in a sector used to work with very long life-cycles and carefully planned introduction of new technologies on the market.

The initiative will have to pay particular attention towards analysing options for the most promising technologies, to tap into the most knowledgeable sources for individual R&I issues and to define and continuously refine the most efficient critical path towards the delivery of the envisaged demonstrators.

Without such careful analysis, and sufficient attention for review, testing and certification throughout the R&I process to ensure that cleaner aviation remains safe, secure and efficient the introduction of the radically new technologies required to achieve the green deal targets could be impossible.

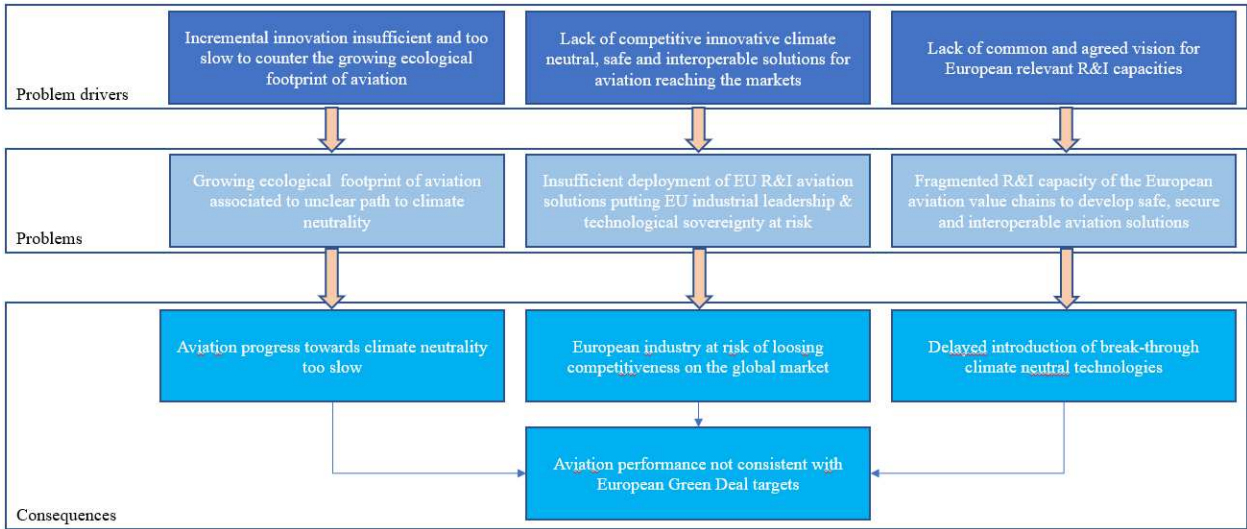
In view of the limited resources compared to the highly ambitious targets of the Clean Aviation initiative, synergies with national aviation R&I programmes will be key to achieving the objectives. The absence of systematic cooperation with these programmes reduces efficiency of aviation research overall, potentially with solutions to occurring problems hidden at a national level, only partially investigated, or investigated in parallel in different countries.

This fragmentation in aviation R&I actions could be addressed by policy actions seeking alignment of the national and European schemes for R&I.



Many of the stakeholders responding to the **Open Public Consultation** confirmed the importance of these issues. A substantial majority of business organisations, business associations, academic and research institutions, public authorities and EU citizens strongly recognise the impact that long development and innovation cycles and high associated costs of demonstration are having on the growing ecological footprint, whilst all parties also recognise that a future initiative in the area must also make significant contributions to EU global competitiveness.

These themes were echoed during the **interviews**, with several stakeholders (from across industry, Member States, academics and research institutes) also highlighting the long development and innovation cycles and high associated costs as contributing to the growing ecological footprint, and that a transformative change was required to achieve sustainability in the industry, despite the practicalities of this being unclear at this stage. Most stakeholders noted the importance of EU industrial leadership in the field, especially in the face of increasing competition from China and Russia. Many business stakeholders also expressed the need for the industry to deliver cost-efficient products that would be affordable for their airline customers.



2.2. What are the problem drivers?

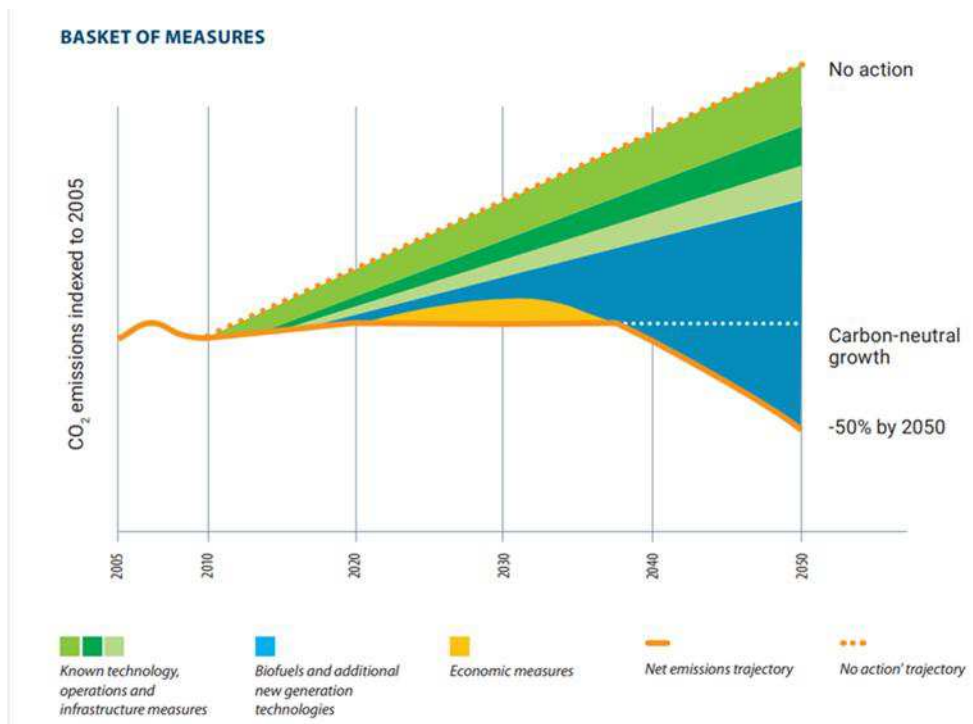
2.2.1. Incremental innovation insufficient and too slow to counter the growing ecological footprint of aviation

Whilst advancements in technology reduce the average fuel consumption and emissions per passenger by -1.5 % per annum, the 4.4% average annual passenger growth more than counteracts this, resulting in fuel consumption and emissions rising by approximately +2.9% per annum or doubling every 25 years⁸². Without transformative interventions in next generation aircraft, the aviation industry's CO₂ emissions will be approximately 136% higher in 2050 compared to 2020⁸³.

As shown in the Figure below, ICAO's schematic CO₂ emission reduction roadmap highlights the effects of different measures on the aviation industry from 2020. It shows (in green) that improvements to current aircraft technologies, infrastructure and operating procedures are not sufficient to achieve carbon-neutral growth in the context of growing levels of air traffic.

ICAO's schematic CO₂ emissions reduction roadmap for the aviation industry

Source: Eurocontrol (2019), Think Paper #4, Decarbonisation Issues



⁸² Source: European Commission, PRIMES scenario, https://ec.europa.eu/clima/policies/strategies/analysis/models_en

⁸³ European Commission (2018), Global Energy and Climate Outlook 2018: Sectoral mitigation options towards a low-emissions economy – see:

http://publications.jrc.ec.europa.eu/repository/bitstream/JRC113446/kj1a29462enn_geco2018.pdf

Instead radically new technologies and sustainable aviation fuels are required (blue zone in the drawing below) to address the substantially increased level of EU aviation CO₂ emissions (+95% from 1990 to 2016)⁸⁴.

Economic measures could decrease the demand and thus control the growth of emissions. These would, however, also reduce airline profitability leading to reduced investments in new aircraft and technologies. If such activities were not coordinated at a global level, competitors from outside Europe who are less impacted by these measures would get a competitive advantage compared to European companies.

They would, therefore, need to be carefully designed to incentivise airlines to invest faster in greener technologies or accelerate the demand for sustainable aviation fuels for which there are, currently, no proper alternatives for long-haul flights.

In light of the above graph, incremental technology gains will not lead to climate neutrality.

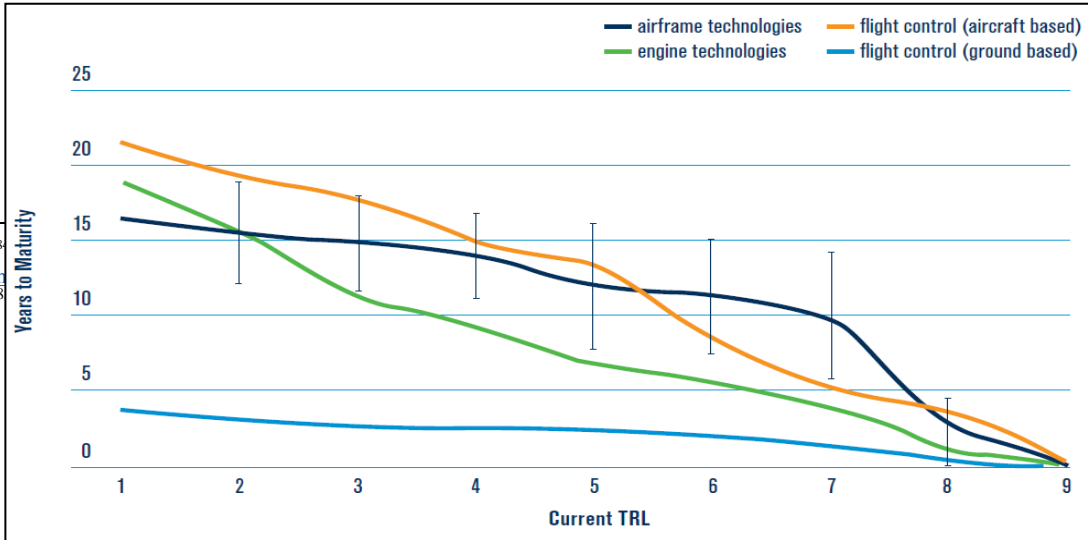
2.2.2. *Lack of competitive innovative climate neutral, safe and interoperable solutions for aviation reaching the markets*

Commercial aircraft combine a wide range of different, complex, and interacting components for aerodynamics, propulsion, navigation, and communication. The components’ integration is crucial for safe and effective aircraft performance. As one example of this complexity, Airbus has more than 12,000 suppliers worldwide. The main parts of the popular A320 series⁸⁵ are constructed in seven countries with final assembly in three factories in three different countries one three different continents.

The complex interaction of components makes it very hard to predict if a new design will (under all possible) real-world circumstances behave exactly as predicted, based on theoretical and computational models. This is already true for the traditional civil aircraft configuration, and it certainly applies when moving into the uncharted territory of alternative propulsion (hydrogen, batteries) systems, innovative aerodynamic (blended wing) designs, and the accelerated introduction of digitalised systems. Testing of aircraft functionality and safety is therefore a crucial but timely and costly part of the R&I process.

From conception phase (TRL 1) through all the steps of maturing the technologies to “fit-to-fly” (TRL 9) typically takes between 10 and 20 years (see Figure below), including substantial financial investment. The consequences of bringing design errors to the market could include the loss of life, disruption of the aviation and tourist sector as a whole by grounded planes, economic disaster for the aeronautical supply chain, and potential bankruptcy of the integrator.

Time to mature aircraft technologies



This is the reason why aircraft manufacturers are very careful when introducing new technologies and, more often than not, limit themselves to the gradual roll-out of incremental improvements.

The Commission Staff Working Document on better regulations for innovation-driven investment at EU level⁸⁶ underlines that cost, time and uncertainty related to certification are important factors in preparing new aviation products and services. Certification can indeed add three to five years of additional delay after an accumulated 10 years of investments costs (accumulating credit/debt) also postponing sales.

Due to high costs associated with the production process of aircraft, manufacturers seek to receive certification for their aircraft quickly and the early involvement of regulators in research and the deployment of emerging technologies can reduce time to market significantly.

An extra dimension is the long life-span of aircraft once on the market⁸⁷. Although the life-span of a commercial aircraft is declining, it is still fairly common for civil aircraft to be used for a period between 20 to 30 years or longer. It may be expected that the COVID-19 outbreak will lead to an increase in those average life spans of civil aircraft and slower replacement of older, less environmentally friendly aeroplanes by the newest models.

The European Union Aviation Safety Agency (EASA⁸⁸) benefits in the implementation of its tasks from early knowledge sharing between regulators and industry (while ensuring regulator independence), as aspects of the design, production, and servicing of aircraft become more dispersed⁸⁹. To be noticed though that acceleration of safety critical technologies (such as aircraft-based flight control) without timely, proper, and independent oversight can lead to fatal outcomes.

Unable to compete on price with upcoming new aircraft manufacturers, the maintenance of Europe's leadership position in the global aeronautical market in an increasingly competitive environment depends on R&I leading to technological excellence in turn leading to cost efficiency, offering a far better performance to airlines compared to cheaper products from upcoming manufacturers.

To sustain Europe's leadership position and thus make green aircraft globally available, the Clean Aviation initiative has to focus on those new technologies that brought to market could maintain the European competitive lead over the competing products from international competitors.

⁸⁶ <https://op.europa.eu/en/publication-detail/-/publication/404b82db-d08b-11e5-a4b5-01aa75ed71a1/language-en/format-PDF/source-79728021>

⁸⁷ http://www.boeing.com/assets/pdf/commercial/aircraft_economic_life_whitepaper.pdf

⁸⁸ A short contribution on the role of EASA in research and innovation is available in annex 6.6.

⁸⁹ EASA (2019), Emerging Technologies and Aircraft Certification – accessible at http://congress.cimne.com/emus2019/frontal/doc/PL_Abstract/PL_Abstract_Waite_Expert.pdf

2.2.3. *Lack of common and agreed vision for European relevant R&I capacities*

The Flightpath 2050 (ACARE's Vision for Aviation) only provides a general umbrella but in practice, a coordinated roadmap and workload share are not available. In addition, Flightpath 2050 environmental ambitions have to be revised and made more ambitious in relation to the European Green Deal.

Under H2020 and on the European level, cooperation between the two aviation Joint Undertakings (Clean Sky and SESAR) is based upon a memorandum of understanding between the two Joint Undertakings. This cooperation is limited to an exchange of information and preventing overlapping research projects. Coordination is also limited between the European collaborative research programme for aviation, and the Clean Sky demonstrator programmes.

Next to the European aviation research and innovation programmes there are national aviation R&I programmes with significant budgets such as those of Germany (LuFo), France (CORAC) and the UK (ATI), with a budget of between EUR 2-3 billion for a period of five years.

However, an external study shows that these programmes were not sufficiently coordinated, neither at national level nor at European level. In some cases, national interest in local employment and technology, led to non-complementary policies, with a possible duplication of activities.

Under Horizon 2020, Clean Sky 2 made some limited efforts seeking better alignment with European Structural and Investment Funds. Results achieved indicate that a better alignment of the R&I efforts between European and national levels could lead to significant efficiency gains.

Some of the most promising technologies to achieve climate neutrality in aviation are the core business of other sectors. The obvious examples are hydrogen and batteries, but also digitalisation could have a significant impact on the environmental performance of the sector.

The insufficient tracking of technological developments in other sectors may lead to aviation being unaware of potentially interesting research or unable to transfer and take up potentially useful technologies developed elsewhere into its own R&I path.

In addition, those other sectors may be unaware of the specificities of aviation (such as limiting weight, be able to function under extreme heat/cold and at altitude, safety) to be taken into account in their own research. It should be carefully analysed how the experience and know-how of these sectors could be translated to aviation.



Responses to the **Open Public Consultation** widely agreed on the nature of the problem drivers. Most of stakeholders agreed strongly that innovation and development cycles in the industry are both too long and too costly and these views were held in similar proportions across all stakeholder groups. Stakeholders also noted the presence of regulatory barriers in the context of standards and disruptive technology development, although these considerations were felt less strongly than those regarding the innovation cycles. A majority of stakeholders also noted that the lack of global integrated standards undermines the benefits of R&I activities developed at an EU level, thus affecting European competitiveness.

Similar views were also emphasised by most **interviewed stakeholders**, particularly supporting the views that the development cycles in the industry are both long and costly, and that regulatory barriers⁹⁰ need to be suitably addressed to not cause further delay to development cycles. There was a strong consensus, in the absence of policy intervention, that it would not be possible to achieve the long-term strategy and level of stakeholder participation required to achieve the goal of climate neutrality by 2050.

2.3. How will the problem(s) evolve?

The lack of a framework to secure the necessary long-term commitments, reduce the financial risks, and combine the R&I capacity in Europe may result in the delay or cancellation of expensive demonstrators or system integration projects based on decades of research at low and later high TRLs which would significantly reduce the impact of R&I in aviation, and delay achieving the green deal targets. The reshuffling of priorities in response to COVID-19 by the European Industry may have an additional negative influence.

Without policy intervention creating such frameworks, the gap between technological progress and the European Green Deal's ambitions will widen, leaving only market based measures such as additional taxes on fuel, expanding the ETS system etc. to achieve the European Green Deal's ambitions and reducing air traffic, with significant negative social and economic consequences, and reducing the competitive lead of the European industry. In this it should be taken into account that technology maturation requires an exponential increase in resources, rather than a linear one, because the more integration towards the final product/system is achieved, the more complexity needs to be addressed. The kind of demonstration and integration, projects needed before moving towards product development are very costly, and risky for the industry involved.

As explained above, without any policy action, it is anticipated that an increased gap will form between the demand for mobility and the achievement of the climate neutrality target.

The Figure below outlines the potential evolution of the problem if there is no intervention. It uses two sets of numbers, the first set based on the EC PRIMES Reference Scenario⁹¹ whilst the second comes from EC estimations⁹². Those forecasts have been produced before the COVID-19 crisis and may be now overestimated. However, aviation will most likely recover at some point and reconnect with the current trends.

Potential evolution of the problems if there is no intervention

Parameter	Position from 2022	Source	Commentary on starting point and evolution during period of Horizon Europe
Air passenger traffic growth	Ranges between +2.2% per annum	EC (PRIMES) EC (Inception)	Different sources of traffic forecasts anticipate different rates of air passenger growth: the EC

⁹⁰ A brief explanation on these perceived regulatory barriers is annexed

⁹¹ The EU Reference Scenario is one of the European Commission's key analysis tools in the areas of energy, transport and climate action. It allows policy-makers to analyse the long-term economic, energy, climate and transport outlook based on the current policy framework.

https://ec.europa.eu/energy/sites/ener/files/documents/20160713%20draft_publication_REF2016_v13.pdf

⁹² https://ec.europa.eu/info/law/better-regulation/initiative/11904/publication/5722372/attachment/090166e5c639d431_en

	to +4.4% per annum	Impact Assessment)	PRIMES Reference scenario estimates that air passenger will grow an average of 2.2% per annum, whilst the EC IIA estimates that it will grow 4.4% per annum. External forces and/or regulation may alter demand for air travel.
Average evolution of fuel consumption per passenger	-1.5% per annum	EC (PRIMES)	Fuel consumption decreased at an average rate of 1.5% per annum. Without intervention, it is assumed that this trend will continue short term. Long term, disruptive new technologies will be required for when the current technologies reach their maximum performance.
CO₂ emissions by 2050 compared to 2020	Ranges between +0.6% per annum to +2.8% per annum (depending on the air traffic forecast source)	Calculated from EC (PRIMES) and EC (Inception Impact Assessment)	The joint impacts of air passenger traffic growth and fuel consumption per passenger results in fuel consumption and emissions rising between 0.6% and 2.8% per annum. Taking the worst-case scenario, CO ₂ emissions will rise by a further 22% during Horizon Europe. If there is no intervention by 2050 this may rise to 137%
Funding of civil aeronautics research and development activities (outside of Clean Sky) by public and private stakeholders	EUR9 billion per annum	ASD	Currently approximately 7% of the civil aeronautics industry turnover is spent on research and development activities. Without intervention, no change is predicted
Years necessary to achieve TRL 1 to 9	Between 10 and 20 years	IATA	No change is predicted. However, a significant acceleration will be necessary to meet the Green Deal requirements and deadlines, for instance by earlier preparation of certification.

Source: Steer analysis

In summary, without policy intervention leading to transformative technology, traffic growth will offset CO₂ emissions reduction resulting in 22% increased consumption of kerosene by 2027. A worst-case extrapolation to 2050, results in a 136% increase in kerosene consumption, compared to 2020.

The European aviation sector will be at greater risk of losing competitiveness in the global market. In turn this could negatively affect investments in research and innovation for greener technologies, which would be detrimental to the achievement of the European Green Deal's objectives.

As the objective of the European Green Deal are global in nature, a slower path towards clean aviation in the EU could also reduce incentives for other manufacturers to develop greener technologies.⁹³ Unless the European Green Deal's targets become, at least de facto, global industry standards.

The continued fragmented R&I capacity of the European aviation value chains will have to develop safe, secure and interoperable aviation solutions.

⁹³ Indeed, upcoming non-EU manufacturers tend to primarily compete on costs and may place less emphasis on greening aviation.

The combined effects will mean that aviation performance will not be consistent with EU climate targets and that the contribution of European aviation to the growth of the economy and employment will be below potential.

The evolution of the problem will also be driven by the overall aviation strategies that will be put in place at the EU level and MS' level, and to a lesser extent at the international level, on the regulatory framework, and the provision of economic incentives or loans.



Stakeholders interviewed tended to support the view that intervention was required in order to bridge the gap between academic based innovations and their commercial application (the ‘valley of death’)⁹⁴, which was more prevalent before Horizon 2020. Stakeholders providing feedback to the inception impact assessment tended to support the view that problems would persist in the absence of policy intervention

3. WHY SHOULD THE EU ACT?

3.1. Subsidiarity: Necessity of EU action

The rationale for EU intervention follows directly from the previous discussion of the problems. The primary justification for EU public intervention in aviation R&I is to harmonise, optimise and coordinate resources at ecosystem level from all European countries towards climate neutrality in aviation – an ambitious target that cannot be achieved by neither one aeronautics company nor single country alone. As underlined above, there is a need for a holistic R&I approach towards climate neutrality.

Furthermore, all research needs should be coherent with market measures, incentives as well as a robust and modern regulatory and standardisation framework, which can only be designed in the EU context and through international cooperation. This framework should be coherent and aligned with environment and climate policies, trade, defence, space, air traffic management, certification and standardisation schemes which are under the remit of the EU.

In addition, European research with open competitive calls allows participants to break away from their natural suppliers and develop new partnerships with different types of organisations (academia, research centres, industry etc.) including those from EU countries without traditional aviation industry but potentially bringing novel approaches.

The rationale for EU intervention includes risk sharing, considering the high costs of developing and demonstrating innovative technological solutions, which cannot be carried out by individual companies alone.

In the context of the specific characteristics of the aviation sector, the costs and risks of new developments depend on effective cooperation at European scale. Cooperation between different stakeholders is important, both in the development stages as well as during the maturing of innovative technologies.

⁹⁴ The ‘Valley of Death’ was referred to in several stakeholder interviews and is a metaphor often used to describe the gap between academic-based innovations and their commercial application in the marketplace.

3.2. Added value of EU action

With a clear climate policy and clear objectives for 2030 and for 2050, there is a strong need for directionality of European investments as well as additionality. EU action would complement the national schemes to provide a clearer policy approach, especially as innovations are urgently needed to realise the climate action plan and objectives.

The European Commission is ideally placed to strive towards cooperation between the national aviation R&I programmes and the Clean Aviation initiative, avoiding duplication of effort and combining resources towards achieving the European Green Deal's targets.

At the same time, it takes the initiative on many aviation related policy measures and can ensure that policy measures, legislation and R&I efforts are aligned.

Further, The European Commission is an ad-hoc observer in many ICAO⁹⁵ bodies (Assembly and other technical bodies) focusing on aviation safety, security, environment, air traffic management and air transportation.



Among stakeholders responding to the **Open Public Consultation** there was widespread recognition of the problem of fragmentation and lack of effective coordination of R&I activity, underpinning the case for intervention at the European level.

Stakeholders participating in the **interviews** and providing feedback on the **inception impact assessment** were also generally fully supportive of EU action to address these and other aspects of the problem. Member States and businesses agreed that the pan-European nature of the industry coupled with uncoordinated support for R&I at national level justified EU action.

4. OBJECTIVES: WHAT IS TO BE ACHIEVED?

4.1. General objectives of the initiative

Based on the identified problems, the initiative's main objective would be to contribute to **reduce the ecological footprint by accelerating the development of climate neutral aviation⁹⁶ technologies for earliest possible deployment, therefore significantly contributing to the achievement of the general goals of the European Green Deal, i.e.: a 50% to 55% emissions reduction by 2030, and climate neutrality by 2050⁹⁷.**

The focus on climate neutrality, in line with the Commission's top priority, is justified because other environmental aspects can be covered by the collaborative research programme (outside the partnership), and because a push towards climate neutrality requires a strong mobilisation of the whole community around the most promising technologies, which is less the case for other environmental aspects.

⁹⁵ https://ec.europa.eu/transport/modes/air/international_aviation/european_community_icao_en

⁹⁶ Clean Aviation is complemented by a collaborative research effort that deals with other aviation research priorities.

⁹⁷ The main objective complements several of the Sustainable Development Goals (SDGs) supported by the Climate, Energy and Mobility Cluster, including SDG 3 (Good Health and Well-being), SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action).

The second general objective would be to ensure that aeronautics-related research and innovation activities **contribute to the global sustainable competitiveness** of EU aviation, while ensuring that remains a safe, secure, reliable, cost-effective, and efficient means of passenger and freight transportation. Without a strong European supply chain, Europe has no leverage to pursue to ambitious environmental policy.

The third objective would be to **further advance the European R&I capacity** to accelerate and optimise the R&I process. This objective is similarly aligned with several SDGs, especially SDG 9 (Industry, Innovation and Infrastructure).

It should be noted that addressing market and regulatory barriers is not in the research remit of any future initiative but remains vital for achieving the general objectives.



There was strong support from stakeholders responding to the open public consultation to making significant contributions towards achieving the EU's climate-related goals. The vast majority of business organisations (both large organisations and SMEs), business associations, academic and research institutions, public authorities and EU citizens considered that any future European Partnership should respond effectively to achieving European policy goals and recognised that this is hindered by development cycles in the industry that were both lengthy and costly. Most of these groups also confirmed the importance of meeting societal needs and contributing to both EU climate related goals and UN Sustainable Development Goals through the effective deployment of new technology, whilst also maintaining European competitiveness in the market.

Stakeholders interviewed, whether from industry, research institutes, academics or other types of organisations were generally very supportive of the proposed objective of achieving climate neutrality by 2050. It was felt that that objective, whilst ambitious, was more encompassing of the effects of aviation and also allowed a more long-term solution to be realised.

Virtually all stakeholders providing feedback on the **inception impact assessment** also noted their support for the previous objective⁹⁸ of achieving deep-decarbonisation in the industry.

4.2. Specific objectives of the initiative

The following specific objectives have been defined for the R&I efforts under the Clean Aviation initiative:

- **to demonstrate disruptive aircraft technological innovations able to decrease net emissions of greenhouse gasses by no less than 30% by 2030, compared to 2020 state-of-the-art technology;**

The primary objective is to achieve climate neutrality by 2050, with an intermediate step towards 2030. Together with the large-scale deployment and use of new, net-zero or fully decarbonised sustainable aviation fuels such as power-to-liquid synthetic fuels, methane and/or hydrogen, the operating fleet in 2050 could achieve a 90+% improvement in carbon efficiency compared to today's fleet. The sector can meet the Air Transport Action Group's (ATAG) goal to halve total CO₂ emissions in 2050 compared to 2005 levels, while maintaining its forecast growth.

⁹⁸ The objective was changed from deep-decarbonisation to climate neutrality after the inception impact assessment was issued.

The Clean Aviation initiative should **focus on disruptive technologies** that also allow the earliest possible deployment with the greatest potential to contribute to the ambitious European Green Deal targets for 2030 and 2050.

Three key R&I ‘thrusts’ will drive the energy efficiency and the emissions reductions of future aircraft.

- **Hybrid electric and full electric architectures** – driving research into novel (hybrid) electrical power architectures and their integration; and maturing technologies towards the demonstration of novel configurations, on-board energy concepts and flight control.
- **Ultra- efficient aircraft architectures** – to address the short, medium and long-range needs with innovative aircraft architectures making use of highly integrated, ultra-efficient thermal propulsion systems and providing disruptive improvements in fuel efficiency. This will be essential for the transition to low/zero emission energy sources (synthetic fuels, non-drop in fuels such as hydrogen), which will be more energy intensive to produce, more expensive, and only available in limited quantities.
- **Disruptive technologies to enable hydrogen- powered aircraft** – to enable aircraft and engines to exploit the potential of hydrogen as a *non-drop-in* alternative *zero carbon fuel*, in particular liquid hydrogen.

Exclusions:

- Other aspects of the aviation sector’s comprehensive decarbonisation strategy (eg incremental improvements in energy efficiency of engines and aircraft design, drop-in sustainable aviation fuels) should be supported by industry’s own R&D budgets, or by national resources. Operational measures, such as optimised green trajectories and air traffic management will also contribute in achieving climate neutrality and may be covered by another initiative following the current SESAR Joint Undertaking.
- Alternative energy sources that gradually complement or replace kerosene play a pivotal role in achieving climate neutrality in aviation. These energy sources include sustainable aviation fuels⁹⁹ (SAF), batteries and hydrogen. SAF are already available on the market and are therefore excluded from the research activities of a Clean Aviation initiative.
- **Ensure the market readiness of innovative, climate neutral, safe and interoperable solutions for aviation**

The second specific objective is to ensure that the technological innovations are available in time to permit the launch of disruptive new products and services by 2035 – with the aim of replacing 75% of the operating fleet by 2050 – and developing an innovative, reliable, safe and cost-effective European aviation system that is able to meet the objective of climate neutrality by 2050.

⁹⁹ Sustainable Aviation Fuel (SAF) is a clean substitute for fossil jet fuels. Rather than being refined from petroleum, SAF is produced from sustainable feedstocks such as waste oils from biological origin, agri residues or non-fossil CO₂

An independent Impact Monitor mechanism should ensure continuous strategic monitoring and steering, and ensure objectives are met.

The continuous assessment of intermediate project deliverables should guarantee that the developed technologies meet their full innovation potential, or allow re-orienting the research and innovation activities towards the most promising technologies.

Modelling, testing, evaluation, and assessment will play a vital role within the clean aviation initiative in validating technologies and increase their change to reach the market:

- To select the most promising technologies with the highest potential to have significant impact on climate change and to assess the impact that the implementation of those technologies on the market would have.
- To evaluate project progress and assess how practical research results confirm the impact forecasts, potentially leading to re-orienting the projects.
- To identify knowledge gaps and shortcomings and define targeted projects to tackle these.
- To support safety certification in cooperation with an independent EASA to mitigate safety concerns and accelerate the research life cycle and the introduction of technologies in the market later on.

Thorough testing and demonstration (in-flight) of new technologies should guarantee that they are sufficiently matured, reliable and affordable to be integrated in novel aircraft designs and ensure that they are taken up by the market.

The impact monitor could play a role in preparing for international standards and certification of novel technologies.

- **To expand and foster integration of the aviation research and innovations value chains, including academia, research organisations, industry, and small and medium sized enterprises, also by exploiting synergies with other, related, national and European programmes**

The independent Impact Monitor will be used to support dialogue with internal and external counterparts regarding environmental aspects, policies, required infrastructures and critical success factors for the transition to a climate neutral aviation. The Impact Monitor mechanism could also be used to assess other parts of Horizon Europe relevant to the partnership, such as traditional calls.

Building upon the work done under Clean Sky 2, the initiative will increase efforts to exploit synergies with other initiatives and programmes with a special focus on areas offering a high potential such as hydrogen, batteries and digital that could bring new knowledge to the aviation sector.

Discussions on the best mechanisms for exploiting synergies with other partnerships, or with collaborative research in aviation are still on-going.



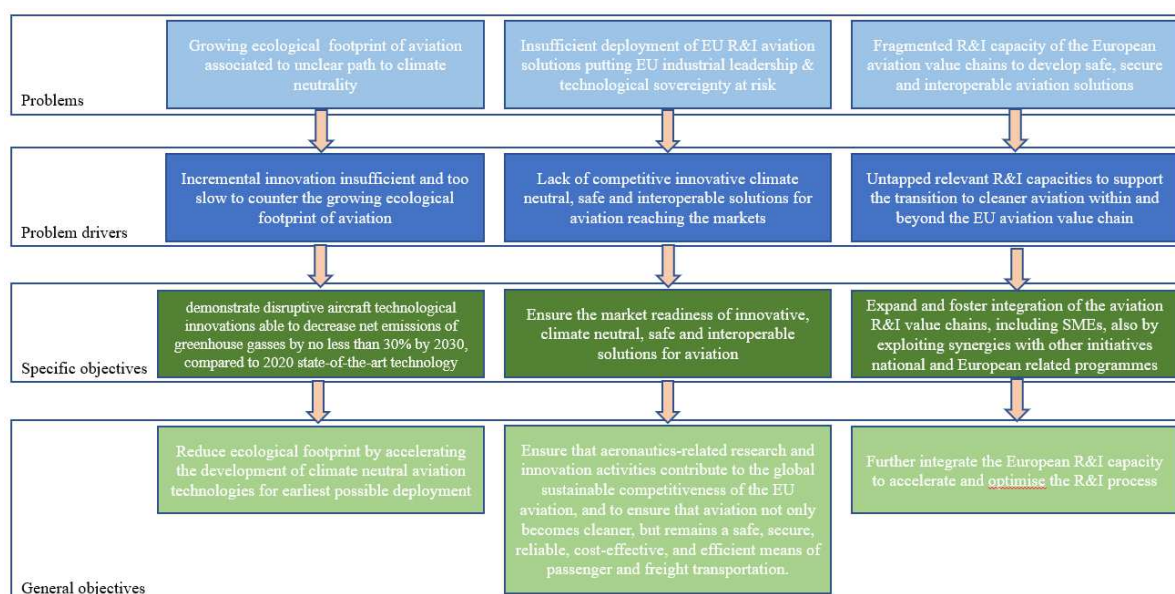
Respondents to the open public consultation – including business organisations of different sizes, business associations, academic and research institutions, public authorities, and EU citizens – largely endorsed the view that a European Partnership

should be responsive to societal needs and should make a significant contribution to achieving the UN SDGs and EU climate-related goals. The vast majority also agreed that more focus should be placed on bringing about a transformative change towards sustainability through the development and effective deployment of technology, whilst also making significant contributions towards EU global competitiveness.

Stakeholders interviewed supported to focus higher proportions of the budget on larger aircraft, as resultant developments have larger impacts versus other aircraft. All stakeholders interviewed supported the inclusion of regulators throughout the development process, albeit in an observational capacity, to assist in addressing market barriers to entry.

Stakeholders providing feedback to the **inception impact assessment** were generally very supportive of the objectives identified in the document, in particular the need to explore, mature and demonstrate new technologies, whilst also ensuring competitiveness of the European aeronautics industry.

4.3. Intervention logic for the initiative



How would success look like?

Should the initiative deliver on its specific objectives, it is expected that it would translate in practice into the following impacts:

Expected Scientific impacts

- Acceleration of the development of know-how and the process of maturing technologies and knowledge transfer for key new technologies and ‘differentiators’;
 - Increased ability to theoretically model and compute the effects of new technologies.
 - Increased scientific knowledge of climate impact and atmospheric effects and so enable optimised interventions in the aviation system.
- Increased diffusion of scientific excellence and high-quality knowledge in the field of aeronautics among research staff from universities, research institutes or private companies;
 - New high-value skills and new engineering capacities for future generations of the European workforce.

- Increased collaboration with other sectors and integration of areas of fundamental research that are not traditionally within the aeronautical scientific ecosystem;
- Strengthened innovation pipeline by creating better directionality of research;



All academic and research institutions responding to the **open public consultation** were highly in favour of the potential partnership being used for the advancement of science. This was supported by most businesses and other stakeholder groups too. The views on its role in development of new scientific knowledge and capabilities were similarly highly positive among all stakeholder groups.

Similar opinions were expressed by stakeholders engaging in the **interviews**, particularly academic and research institutions. During these interviews many academic and research institutions mentioned that more research resulting from the partnership should be published.

Stakeholders responding to the **inception impact assessment** were generally supportive as well of the view that an initiative under Horizon Europe would have important scientific impacts.

Expected economic/ technological impacts

If successful, the proposed initiative has the potential to achieve direct and indirect economic and technological impacts affecting several areas of the EU economy and society, namely:

Direct impact

- New safe, climate neutral and efficient airborne transport modes such as regional aircraft that have the potential to reduce traffic congestion in highly populated areas, and connect remote regions;
- Increased competitiveness of European aeronautics industry through cost-efficiency improvements throughout the entire supply-chain;
 - This would also be a catalyst for a further reduction in environmental impacts. Together, these impacts would contribute to the achievement of SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action);
 - Growth in aviation industry and wider employment;
- New sustainable business models for innovative aircraft technology for future aircraft and fleet retrofits, exploiting next generation digitalisation/automation technologies;
- The emergence of new branches of the aviation industry, such as new sources of propulsion, systems or airframes which will enhance European competitiveness.
 - Strategic partnerships with non-aviation sectors to make use of emerging technologies (e.g. drop-in and non-drop-in fuels, fuel cells, batteries, artificial intelligence, electronics, and materials).

Indirect impact

- A multitude of spin-offs that will benefit Europeans through exploitation of critical areas such as disaster response, emergency interventions, space and security;
- International co-operation prowess, leadership and shared socio-cultural values.
- Strengthened demand for sustainable forms of energy for aviation;
- Increased demand and opportunity for sustainable air mobility leading to job creation;



Most stakeholders consulted as part of the **open public consultation** scored the resulting economic and technological impacts from the partnership as being very relevant. The following impacts received high relevance scores: increased industrial leadership and uptake of new technologies; the acceleration of key technologies through selected demonstrators; as well as the creation of high-skilled jobs in the low-carbon economy.

In addition to supporting above views, several **interviewed stakeholders** highlighted the importance of encouraging participation from a wide group of stakeholders, including those outside the traditional aviation industry, to assist with the development of innovative technologies. As mentioned previously, there was a consensus that regulatory bodies (such as EASA) should also have early knowledge of all developments to ensure that the regulation process did not ultimately delay the introduction of new technologies.

Stakeholders responding to the **inception impact assessment** generally confirmed that an initiative under Horizon Europe could be expected to deliver substantial economic and technological benefits, whilst ensuring competitiveness of the European aeronautics industry.

Expected societal impacts

- Clean Aviation will significantly contribute to the delivery of Europe's climate neutrality by 2050 by pioneering new solutions in the aeronautics disciplines and readying them for market introduction.
 - Considerable impact on reducing climate change, considering that the European aeronautics industry is a world leader in the field and produces +/- 50% of all civil aircraft (SDG 13 Climate Action).
 - Reduction of noise and improved air quality around airports with positive and immediate impact on the health of citizens in support of SDG 11 (Sustainable Cities and Communities).
 - Positive impact on the health and well-being of EU citizens, starting with those living in the vicinity of airports (pollution and noise reduction) as well as for other part of the world. SDG 3 (Health and Well Being)
- Further increase safety and security levels, in cooperation with the European Union Aviation Safety Agency (EASA) by deeply transforming present operations with the help of innovation;
- Fulfil customers' and the general public's expectations of a globally competitive European industry;
- Improving mobility and connectivity of European citizens with safe, reliable, affordable and resilient air travel options.



The majority of the respondents to the **open public consultation** have mentioned the importance of societal benefits and view the reduction in CO₂ emissions and the improvement in public health as being particularly relevant impacts associated with the future partnership.

The vast majority of **interviewees** maintained the view that safety in European aviation was of paramount importance, but also mentioned that developments from new technologies would ensure the longevity and relevance of the European aeronautics industry, whilst also resulting in reductions of gas and noise emissions, which in turn would contribute to improved societal impacts.

4.4. What is needed to achieve these objectives – Key Functionalities needed

Given the focus of the impact assessment on comparing different forms of implementation, the identification of “key functionalities needed” allows making the transition between the definition of the objectives and what would be crucial to achieve them in terms of implementation. These functionalities relate to the type and composition of actors that have to be involved, the type of range of activities that should be performed, the degree of directionality needed and the linkages needed with the external environment.

4.4.1. *Type and composition of the actors to be involved*¹⁰⁰

The inclusion¹⁰¹ of the largest possible number of stakeholders from across the value chain, from different sectors, backgrounds and disciplines, and EU Member States is essential for an initiative for Clean Aviation research and innovation to leverage all the relevant expertise and capabilities. In particular:

The European industry, including SMEs, to develop and ensure the uptake of the most promising climate neutral solutions.

Academic and research organisations to translate disruptive ideas, possibly coming from other sectors, to the aviation context.

The Commission and Member States to ensure alignment and synergies between the EU, national and regional priorities and funding programmes and for a broader political coordination of national and international policies to achieve impact.

An increased involvement of **Member States** in the deployment and uptake of the most promising climate neutral technologies at EU level will promote synergies and economy of scale with the national R&I programmes as well as increase the alignment of the national educational schemes to match the future needs for corresponding skills and jobs.

EASA to provide guidance on certification related matters, and in assessing the environmental impact of the proposed solutions.

The broader stakeholder community (e.g. airports) that will ultimately roll-out and implement the new aircraft at an early stage should allow anticipating practical considerations such as needed infrastructural works from an early stage.

Note: International participation should be considered in compliance with the Horizon Europe rules for associating countries to the Horizon Europe.

The Figure below summarises the stakeholders that need to be involved and indicates the capabilities that they can bring.

Type and composition of actors that need to be involved

¹⁰⁰ This functionality relates to the criterion “Involvement of partners and stakeholders from across the entire value chain, from different sectors, backgrounds and disciplines, including international ones when relevant and not interfering with European competitiveness”.

¹⁰¹ Annex 6.9 shows the high interest of stakeholders from various backgrounds (industry, SME, academia, research organisations) for participating in the Clean Aviation initiative.

	Aeronautics Industry	Universities and research institutions	Member States	End-users (Airline and airports)	EASA	Technology-based organisations outside aviation
Long term perspective	✓	✓	✓	✓	✓	✓
Flexibility and disruptive thinking	✓	✓				✓
Expertise in aircraft operations		(✓)		✓	✓	
Understanding of passengers, aviation workers and citizens needs			✓	✓	✓	
Understanding of current R&I	✓	✓	✓			✓
In-kind support	✓	✓			✓	✓
Financial contribution	✓		(✓)			✓

4.4.2. *Type and range of activities needed*

Given the very ambitious objectives, a **strategic vision** for the initiative is essential for the prioritisation and focus. It is important that the initiative sets out and maintains (reality checks) a comprehensive strategic research and innovation agenda including milestones and deliverables.

Increased focus on the most promising breakthrough technologies and a limited set of high TRL (4 to 6+), integration, demonstration and validation demonstrators. These high TRL activities may be supported on a case-by-case basis with limited low TRL (1-3) research activities that are directly linked to the demonstrators.

Increased **openness and transparency** through open calls and actively seeking for potential partners from outside the traditional aviation sector.

Reinforced **public involvement** in the governance of the initiative should avoid a tendency within the private sector for a ‘share the cake’ approach instead of a real strategic orientation towards higher performance and lower climate footprint. This includes a feedback to relevant policy initiatives.

Enhanced governance responsibility for the demonstrator and project progress.

Independent monitoring, progress and impact assessment directly reporting to the governing board. These assessments will also contain aspects related to the post-research stage, in verifying the feasibility of bringing technologies to the market considering the unequivocal deadlines (2030 and 2050) set out in the European Green Deal.

Actively **exploiting synergies** and coordination of R&I activities, especially with the proposed air-traffic management partnership under Horizon Europe (the current SESAR Joint Undertaking).

4.4.3. *Priority setting system and level of directionality required*

A common vision and a Strategic Research and Innovation Agenda is under development, taking into consideration the diverging business agendas and the post-covid-19 aviation crisis. To address the future challenges, Horizon Europe proposes a holistic approach that is based on two main sets of activities.

Firstly, a Clean Aviation initiative that will focus on the acceleration of the development, validation and integration of climate-neutral technologies, towards market uptake and with strong long-term commitment of industry but also academia and research organisations.

A Strategic Research and Innovation Agenda (SRIA) will focus on the activities foreseen in the context of the Clean Aviation initiative. The programme and its content will be clearly described and ring-fenced. Links to, and expected inputs from other research programmes (other partnerships, collaborative research or otherwise) shall be indicated in a summarised form for later elaboration and a close coordination between Clean Aviation, the Commission and these other areas/partnerships is envisaged.

Exclusions:

- Sustainable aviation fuels research is outside the scope of the Clean Aviation initiative (as it is dealt with in the energy-related partnerships, missions and other instruments). However, technological development needed for their use is within the scope. Technical and system level impacts for drop-in can be justified if an essential element of the demonstrator logic. Technology development and initial demonstration efforts for non-drop-in, notably liquid hydrogen, are in scope and of interest.
- Low-TRL research generally are out of the scope of the Clean Aviation initiative unless it concerns the accelerated development of essential low-TRL activities which are directly linked to development, integration and validation of the demonstrator elements and/or their future transition to a market offering.
- Critical enablers i.e. technologies that would lead to essential features of the demonstrator in terms of its successful transition to a viable product can be in scope if motivated properly.

Secondly, collaborative research will bring together all stakeholders, but primarily research establishments, academia and SMEs will mature low-TRL technologies (including climate neutral ones) which could benefit from subsequent acceleration and deployment in the second fifteen-year cycle.

- The bulk of low-TRL aviation research needs an adequate collaborative research programme in Cluster 5. Low-TRL R&I in the collaborative part of Cluster 5 of Horizon Europe will complement the Clean Aviation initiative's SRIA.
- A strong and effective mechanism will be developed together with the Commission for the effective and efficient transfer of knowledge and research outcomes in areas of relevance to the Clean Aviation initiative, and to enhance exploitation through the

absorption in the demonstration programme areas within the Clean Aviation initiative.

- The Commission, through its presence in both the Clean Aviation initiative and in defining the work programmes for collaborative research, will ensure the complementarity between both.

A key added-value of Horizon Europe will be the increased synergies between EU, national and regional levels and the timely development of transformative and disruptive climate neutral aviation pathways. Lessons learned from the current Clean Sky 2 programme include:

- The European strategic R&I agenda needs to be well-focused and designate a few disruptive research paths, since targets cannot be achieved with purely evolutionary paths as it was in the two Clean Sky programmes;
- stronger synergies as well as coherent and timely alignment with national/regional R&I programs;
- better planning and better connection to Pillars I and III of Horizon Europe, as well as other relevant partnerships.

Public oversight, and regular reviews of projects, should ensure that focus on the green deal ambitions is not lost in favour of less disruptive approaches that could fit better the research and commercial agenda of the industry. This entails political commitment from both Member States' and the Commission to ensure that the work (such as infrastructure) needed to support the new technologies on the market is done.

4.4.4. Coherence needed with the external environment

Issues related to the policy, regulatory and financial inadequacies framework have to be addressed in parallel and/or factored in so that the initiative is enabled to achieve its objectives and effectively contribute to the climate policies and targets from a broader perspective. This could be addressed by future developments of the regulatory framework and aviation relevant policies and strategies.

Achieving climate neutrality will partly depend on adopting and integrating new, environmentally friendly energy sources such as sustainable aviation fuels, electricity (batteries) or hydrogen. Links to relevant R&I partnerships and programmes active in these areas will be very important.

The European Commission and Member States should ensure better synergies between the EU, national and regional funding programmes to allocate sufficient resources to the ambitious Clean Aviation projects.

In addition, ties with the broader policy initiatives is crucial to support the achievement of the objectives of an initiative on Clean Aviation by facilitating market uptake.

This could include building upon other European programmes such as:

- European Investment Bank (EIB) loans¹⁰²: EIB loans and guarantees may provide funding for relevant market uptake of projects. One of the current priorities of the EIB is

¹⁰²<https://www.eib.org/en/press/all/2019-313-eu-bank-launches-ambitious-new-climate-strategy-and-energy-lending-policy>

climate and environment, including sustainable transport. Additional support should be in line with WTO rules.

- Cohesion Policy Funds: includes the European Regional Development Fund (ERDF) and Cohesion Fund (CF), which aim to increase economic and social cohesion and reduce imbalances and disparities between the regions of the European Union, may also provide support, including indirect, the further development of the aeronautics industry in certain Member States.
- Connecting Europe Facility¹⁰³ (CEF): CEF is an EU funding instrument to promote growth, jobs and competitiveness via targeted infrastructure investment at EU level. It is important for encouraging the deployment of these technologies, in particular airports' fuel/ electrification infrastructure, and green door-to-door air transports corridors.
- As well as building upon national and regional funding such as the French research national programme (CORAC), as well as the German federal aeronautical research programme *Luftfahrtforschungsprogramm* (LuFo) underlining the need to an increased involvement of Member States in the aviation partnership.

The impact on airport and air traffic management infrastructure and operations will also need to be considered, as new aircraft technologies may result in new operational requirements for airlines, airports, and air traffic management providers.

5. WHAT ARE THE AVAILABLE POLICY OPTIONS?

This section describes the specific functionalities that could be provided under the baseline scenario of traditional calls and the different options of different types of European partnerships.

5.1. What is the baseline from which options are assessed

The baseline scenario used in this impact assessment is a situation without a Partnership and only traditional calls of Horizon Europe. Given that there is a predecessor Joint Undertaking as well as other funding sources in the area, these will continue generating effects even if there is no new Partnership. In particular it is expected that these already existing initiatives will still create effects on maturing technologies addressing environmental concerns up to TRL 6. This is taken into account in the effectiveness assessment.

In parallel, the baseline situation means that the current implementation structure of the Article 187 would be closed, which bears winding down and social discontinuation costs. There would also be financial cost-savings related to the closing of the structure, related to operations, staff and coordination costs in particular. This is taken into account in the efficiency assessment.

Table 1: Key characteristics of the baseline situation - Horizon Europe calls

	What is feasible under this option - Functionalities of option
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¹⁰³ https://ec.europa.eu/transport/modes/air/airports_en

Enabling appropriate profile of participation	<ul style="list-style-type: none"> • The Commission would need to prepare the Strategic Research and Innovation Agenda (SRIA) by consulting a wide range of actors covering the complete aeronautics value and supply chain, and in addition consult key associations such as ACARE, ASD and so on, as well as the broader aviation community (airports, airlines ...) possibly through their federations. • A well-defined process would be needed to ensure that the programme committees of Member States/ Associated Countries were properly informed about R&I priorities, including key demonstration programmes. • The specification of calls over the period of the Framework Programme could reflect the need for an evolving profile of participation, with different consortia forming at different stages to take different types of activity forward.
Supporting implementation of R&I agenda	<ul style="list-style-type: none"> • Implementation would rely on standard infrastructure underpinning the open calls procedure, drawing on resources of relevant Commission Executive Agencies and systems, benefiting from economies of scale. • Administrative costs for the European Commission would be significantly reduced. • Calls for proposals would be published in the work programmes of Horizon Europe. • Transparency and open publication of results would ensure their availability to interested parties. • Dissemination of knowledge and share of practice would happen predominantly among partners within the calls consortia.
Ensuring alignment with R&I agenda	<ul style="list-style-type: none"> • Work programmes would need to reflect the requirement for R&I activity across TRLs, with input from representatives of all relevant stakeholders. • Specification of calls for activity at higher TRLs, particularly demonstration programmes, would need input from industry. • Calls would need to be compatible with CS 2 Joint Undertaking ITDs/ IATD¹⁰⁴ to ensure continuity where appropriate • R&I activity would focus on the short to medium term needs of the industry. • Commission input into specification and oversight of calls would help to ensure alignment with overarching policy objectives but integration with other programmes would require additional coordination. • Selection of high TRL projects would require provision of external expert (and independent) advice to the Commission (as has been done in the past in FP5, FP6, etc.)
Securing effective leveraging of resources	<ul style="list-style-type: none"> • Progress of R&I effort would depend largely on EU funding, with no mechanisms to ensure binding industry commitment and additional contributions. However, depending on the R&I scope and co-financing rules, some contributions from industry support could be expected at project level. • Demonstration programmes would require significant in-kind support and collaboration from industry, but there are some unknowns as to whether critical mass could be reached.
Key differences compared to the current situation	<ul style="list-style-type: none"> • The programme and project management tasks performed by the JU should be performed elsewhere and a separate Technology Evaluator and impact assessment mechanism has to be defined. • Portfolio of individual projects with reduced strategic integration and demonstration leading to less maturation of the technologies. • Potentially very promising Clean Sy 2 outcomes would not find a habitat to be further developed. • Clean Sky 2 knowledge and experience pool disappears, and is not further exploited.

5.2. Option 1 - Co-programmed European Partnership

Table 2: Key characteristics of Option 2 – Co-Programmed European Partnership

¹⁰⁴ ITD: Integrated Technology Demonstrator. IADP: Innovative Aircraft Demonstrator Platform

	What is feasible under this option - Functionalities of option
Enabling appropriate profile of participation	<ul style="list-style-type: none"> • The partnership would enable participation by key stakeholders as partners – to commit and contribute to the specification and delivery of the common strategic R&I agenda. • The strategic R&I agenda is developed prior to the partnership to ensure that partners know what they sign up to and the wider community is aware of the ambitions. • It would need to consult with a wide range of stakeholders to ensure that the R&I agenda, and ultimately the work programme, was aligned with industry and market needs. • At the same time, it would offer the flexibility to change the profile of participation over time, with new partners joining to support new areas of activity in response to emerging results and changing priorities.
Supporting implementation of R&I agenda	<ul style="list-style-type: none"> • Implementation would rely on standard administrative infrastructure underpinning the open calls procedure, drawing on resources of relevant Commission executive agencies and IT systems. • Calls for proposals would be published in the work programmes of Horizon Europe. • Transparency and open publication of results would ensure their availability to interested parties. • Partners are responsible for drafting input to the work programmes, and for implementing their additional activities, notably to support the take-up of results (these are agreed in the SRIA and annual work programmes)
Ensuring alignment with R&I agenda	<ul style="list-style-type: none"> • Work programmes would need to reflect the requirement for R&I activity across TRLs, with input from the various partners to achieve an appropriate balance of activity directed towards different markets. • The partnership would be responsible for ensuring that priorities for calls were specified in line with R&I priorities, including demonstration programmes. • Specification of calls would need to be informed by CS2 JU ITDs/IATDs to ensure continuity where appropriate • R&I activity would be likely to focus on the medium to long-term needs of the industry. • Commission co-steering role and Programme Committee responsible for mobility would need to ensure alignment with overarching policy objectives and coordination with related programmes.
Securing effective leveraging of resources	<p>Aspirations for partner contributions would be clearly defined at the outset. Commitments from partners would be defined at the outset, with private sector partners expected to match at least half of partnership resources through in-kind contributions.</p> <p>Industry commitments would be best efforts, defined in the contractual arrangement. Expected in-kind contributions from the private sector would be identified in the work programme.</p>

5.3. Option 2 – Institutionalised European Partnership

Table 3: Key characteristics of Option 2 – Institutionalised European Partnership (Article 187 TFEU)

	What is feasible under this option - Functionalities of option
Enabling appropriate profile of participation	<ul style="list-style-type: none"> • The partnership would enable participation of key stakeholders as partners – to commit and contribute to the specification and delivery of the SRIA. • The strategic R&I agenda is developed prior to the partnership to ensure that partners know what they sign up to. • The implementation of the agenda would not need further consultation, as the structure, thanks to its technical, economical and industrial knowledge and acquired expertise, allows self-management.

	What is feasible under this option - Functionalities of option
	<ul style="list-style-type: none"> • It would provide a forum or even a platform for consulting stakeholders on R&I priorities and the work programme, ensuring that they are aligned with industry, research and market needs and with the agenda of other partnerships and sectoral programmes. • Participation would be less flexible than under other options, but it might nevertheless be possible to change the profile of participation over time, with new partners joining to support new areas of activity in response to emerging challenges and evolving priorities.
Supporting implementation of R&I agenda	<ul style="list-style-type: none"> • A dedicated administrative structure would be established to coordinate the specification of R&I activity, manage implementation and report on the results (with administrative expenditure limited to 4% of the budget and subject to an indicative 40:60 allocation between the Commission and private partners). • Dissemination of knowledge and share of practices would happen among the stakeholders of the community, and through additional diffusion activities managed by the partnership structure. • Calls for proposals would be published broadly by the administrative structure. • Transparency and open publication of results would ensure their availability to interested parties.
Ensuring alignment with R&I agenda	<ul style="list-style-type: none"> • The partnership would be responsible for specifying a work programme fully in line with the R&I priorities identified by the industry to fulfil the European policy needs. • The work programme would reflect the medium- and long-term needs of industry, the research organisations and society in adopting clean aviation solutions. • The work programme can build on, but not be constrained by, the current CS 2 JU ITDs/IADPs to ensure continuity where appropriate. • Commission participation in the partnership governance arrangements and approval of the work programme would help to ensure alignment with overarching policy objectives and enable integration with other programmes.
Securing effective leveraging of resources	<ul style="list-style-type: none"> • Funding requirements would be clearly defined at the outset, with private sector partners required to provide between 50% and up to 75% of partnership resources through in-kind and/or financial commitments. • Given more limited funding than in the past, critical R&I priorities would need to be identified at the outset.

5.4. Options discarded at an early stage

For an initiative on Clean Aviation, industry involvement is vital to ensure that research results are further developed and reach the market as fast as possible. This requires an alignment of the Clean Aviation research agenda and the substantial research budgets of major market participants such as Airbus¹⁰⁵, Rolls-Royce¹⁰⁶, and SAFRAN¹⁰⁷ that spend respectively EUR 3.2 billion, EUR 1.5 billion, and EUR 1.1 billion annually on research and product development¹⁰⁸.

Partnerships, created under Article 185 of the TFEU, do not include private partners, only Member States. A co-funded partnership relies on public bodies with research funders (or governmental research organisations) and other public organisations at the core of the

¹⁰⁵ https://annualreport.airbus.com/pdf/Complete_Annual_Report.pdf

¹⁰⁶ <https://www.rolls-royce.com/investors/annual-report-2016.aspx#group-at-a-glance>

¹⁰⁷ <https://www.safran-group.com/media/safran-2016-annual-results-20170224>

¹⁰⁸ Note that these figures include product development beyond TRL6

consortium. Co-funded partnerships rely on pooling and/ or coordinating national programmes and policies with EU policies and investments. Member States become the ‘owners’ of the priorities and take sole responsibility for its funding. The industry R&I can only be addressed without formal commitments and financial contributions.

For these reasons, these two options have been discarded at an early stage and are not considered suitable for a Clean Aviation initiative where a public-private cooperation is vital to achieving the intended objectives.

6. HOW DO THE DIFFERENT POLICY OPTIONS COMPARE

Based on the objectives pursued by the initiative and the key functionalities identified to be able to achieve them, each option for implementation is assessed in terms of effectiveness, efficiency and coherence compared to the baseline scenario of traditional calls. The analysis is primarily based on the degree to which the different options would cater for the key needed functionalities. All options are compared to the baseline situation of traditional calls, which is thus consistently scored 0 to serve as reference point.

6.1. Effectiveness

To be in line with the Horizon Europe impact framework, the fulfilment of the specific objectives of the initiative is translated into ‘expected impacts’ – what success would look like – differentiating between scientific, economic/ technological, and societal (including environmental) impacts. This section considers to which extent the different policy options would allow delivering these expected impacts – confronting what is needed (functionalities) with what each form of implementation can provide in practice.

Scientific impacts

The **baseline option** could easily manage fundamental R&I activities (and could be complementary to any type of partnership). It is more directed towards low TRL and academic research and is of less interest to industry players who focus on closer to market research.

It is however unlikely to contribute to the emergence of high TRL solutions and close to market integrated demonstrators that require large scale integration and a coordinated research effort involving many partners and combining the research results of many projects.

This option does not provide for a framework or ecosystem of actors. However, this option could deliver improvements for low and medium TRL applications by a large number of individual small projects if a clear work programme is established.

Option 1 could deliver more impact than the baseline option when it comes to higher TRL applications, where a strong community with all actors is needed in order for all potential partners to liaise on complex projects. It would therefore have a similar or good potential compared to the baseline with scores between 0 and + according to the different types of scientific impacts.

Its better structure would facilitate knowledge exchange between the academic and industrial world.

Option 2 is the most effective option for well-focused integration, demonstration and validation activities in aviation. This option should be complemented with additional collaborative research under Cluster 5, which will bring together all stakeholders, but primarily research establishments, academia and SMEs towards inventing and maturing low-TRL technologies (including climate neutral ones). The management structure can adapt and coordinate the programme orientation based on early individual research results. Its score would therefore be a high potential compared to the baseline with ++ on this aspect.

Economic/ technological impacts

The **baseline option** could contribute to achieve technological impacts but on a very long-term scale, following the current very long life cycle in aviation research. The lack of a community structure beyond the project consortia might limit the sharing and diffusion of experience among the key actors involved and thus limit the coordination and collaboration necessary to integrate the research outcomes.

This option will not significantly support the scaling up of ready-to-market applications as there is no mechanism to facilitate bridging from R&D to market deployment and it is assessed as more difficult for SMEs to access funding. Hence, it will have little impact on the development of new climate neutral transport modes or on creating, on the competitiveness of the industry or on creating new branches of that industry.

This option would probably be less efficient in creating new networks, or to align European, national and company research programmes. In addition, it may not achieve involving the larger aviation community in preparation of market uptake, or in defining priorities for a strategic research and innovation agenda.

Option 1 has a better impact as it provides elements of the governance structure, but does not yet offer the complete governance and management structure required to build large scale demonstrators. Its potential would therefore be between similar and good compared to the baseline (scores of 0/+).

In light of the above, **Option 2** appears as the most effective, provided a concrete commitment from industry not only to develop climate neutral technologies, but also to ensure that the most promising climate neutral solutions would subsequently benefit from a market uptake.

A strategic research and innovation agenda (SRIA) with a clear view on certification needs and implementation measures will be an essential part of the establishment of the Clean Aviation partnership.

A call of expression of interest under the forthcoming research and innovation programme would help identifying the few building blocks where this acceleration of the most promising climate neutral solutions and deployment should be concentrated under the future Partnership.

The future initiative shall have improved, simplified and well performing governance and monitoring capability able to swiftly re-orient the programme where needed. Option 2 would thus be scored as high compared to the baseline with ++.

Societal (including environmental) impacts

The **baseline option**, given the short-term perspective of the calls, and the focus on low TRL research without much attention for technology integration and demonstration, would mainly lead to individual technology improvements. This conflicts with the sense of urgency introduced by the Green Deal that requires a focus on demonstrating integrated solutions close to market and reach concrete impacts by already 2030. Compared to the usual very long development cycles in aviation this is a very short period.

While **option 1** offers some improvements (Scores 0/+) it will require the binding commitments that would be made by the industry in the **Option 2** to enable higher level of market-focused development and demonstration projects and hence a substantially higher level of market take-up, which is essential for meeting the requirements of the European Green Deal.

It would however miss the advanced programme and project management oversight offered by an institutionalised partnership office, making it much more difficult to ensure the correct level of involvement of EASA, and the early detection of risks and issues with projects and demonstrators. This would lead to a loss of effectiveness, and a risk for loss of focus on the most promising technologies and demonstrators. This would inevitably lead to a reduced capacity to reach the green deal climate targets by the deadlines set and would not fulfil the expectations of society.

Option 2 appears to be the only option focussing on the demonstration of the most promising climate neutral technologies with a concrete view (and industry commitment) on their further development into products on the market. Safety would be ensured by involving EASA in the initiative. This would have the envisaged impact on climate neutrality and improvement of citizens’ health the initiative aims at.

As demonstrated by the CS and CS2 experience, and recognised in the CS2 mid-term evaluation, Option 2 benefits strongly from its Programme Office that coordinates and executes a very large range of tasks for which ad-hoc and case by case solutions would have to be found under Option 1. This leads to significant gains in effectiveness.

Option 2 is thus scored as having a high potential compared to the baseline with scores of ++.

The capacity to reduce emissions and achieve climate neutrality within the time limits set is directly dependent on the ability to accelerate the integration and demonstration of innovative technologies which requires an advanced programme management.

Table 5: Overview of the options’ effectiveness compared to the baseline

	Baseline: Horizon Europe calls	Option 1: Co- programmed	Option 2: Institutionalised Article 187 TFEU
Scientific impact			
Acceleration of the development of know-how and the process of maturing technologies and knowledge transfer for key new technologies and ‘differentiators	0	+	++
Increased diffusion of scientific excellence and high-quality knowledge in the field of aeronautics among research staff from universities, research institutes or private companies	0	+	+
Increased collaboration with other sectors and integration of areas of fundamental research that are not traditionally within the aeronautical scientific ecosystem	0	+	++

	Baseline: Horizon Europe calls	Option 1: Co- programmed	Option 2: Institutionalised Article 187 TFEU
Strengthened innovation pipeline by creating better directionality of research;	0	+	++
Economic/technological impact			
New safe, climate neutral and efficient airborne transport modes such as commuter/regional aircraft that have the potential to reduce traffic congestion in highly populated areas, and connect remote regions	0	+	++
Increased competitiveness of European aeronautics industry through cost-efficiency improvements throughout the entire supply-chain	0	0	++
New sustainable business models for innovative aircraft technology for future aircraft and fleet retrofits, exploiting next generation digitalisation/automation technologies	0	0	++
The emergence of new branches of the aviation industry, such as new sources of propulsion, systems or airframes which will enhance European competitiveness	0	0	++
Societal impact			
Clean Aviation will significantly contribute to the delivery of Europe's climate neutrality by 2050 by pioneering new solutions in the aeronautics disciplines and readying them for market introduction.	0	+	++
Further increase safety and security levels, in cooperation with the European Union Aviation Safety Agency (EASA) by deeply transforming present operations with the help of innovation;	0	+	++
Fulfil customer and general public expectations of a globally competitive European industry	0	0	++
Improving mobility and connectivity of European citizens with safe, reliable, affordable and resilient air travel options	0	0	++

Notes: Score ++ : Option presenting a *high* potential compared to baseline; Score +: Option presenting a *good* potential compared to baseline; Score 0: Potential of the baseline.

6.2. Efficiency

In order to compare the policy options consistently in terms of their efficiency, a standard cost model was developed for the external study supporting the impact assessment for the set of candidate Institutionalised Partnerships. The model and the underlying assumptions and analyses are set out in the Common Part of this Impact Assessment, Section 2.3.2 and in the methodology, in Annex 4. A dedicated Annex 3 also provides more information on who is affected and how by this specific initiative in line with the Better Regulation framework. The scores related to the costs set out in this context allow for a “value for money” analysis (cost-effectiveness) in the final scorecard analysis in Section 6.4.

In addition, for this specific initiative under the baseline scenario of traditional calls, there would be winding down and social discontinuation costs for the existing implementation structure of the current Article 187 initiative.

There would also be longer term financial cost-savings related to the closing of the structure, related to operations, staff and coordination costs in particular. These can be estimated at EUR 6 million per year of operation. Overall, it is estimated that the overall longer term cost savings from using traditional calls instead of an Article 187 initiative would exceed the costs incurred for winding down operations. This overall situation is set as the starting point for the comparison of options. The score of this baseline scenario (traditional Horizon Europe calls) is set to 0 to be used as a reference point.

On this basis, the scores for the costs of the different options range from a value of 0, in case an option does not entail any additional costs compared to the baseline, to a score of (-) when an option introduces limited additional costs when compared to the baseline and a score of (-)(-) when substantial additional costs are expected in comparison with the baseline. In case the scores are lower than for the baseline scenario, (+) and (+) (+) are used.

It is considered that while there is a clear gradation in the overall costs of the policy options, the cost differentials are less marked when one takes into account the expected co-financing rates and the total budget available for each of the policy options, assuming a common Union contribution. From this perspective, there are only one or two percentage points that split the most cost-efficient policy options – the baseline (traditional calls) and the Co-Programmed policy options – and the least cost-efficient – the Institutionalised Partnership option. Indeed, in terms of cost-efficiency, the Co-Programmed Partnership (Option 1) is 2 percentage points more efficient than the baseline and an Article 187 Partnership is 2 percentage points less cost-efficient than the baseline. However, it should be taken into account that winding down the existing Joint Undertaking would have a negative impact on the finalisation of the research agenda of the CS2 programme with key staff leaving before programme finalisation. The objective of the CS2 research programme have a strong link with the European Green Deal’s objectives of Clean Aviation independent of the implementation options chosen for the proposed future initiative.

A score of 0 is therefore assigned for **cost-efficiency** to the Co-Programmed options and a score of (-) for the Institutionalised Partnership policy option¹⁰⁹.

Looking at cost-efficiency on the broader perspective of attracting higher level of investments from stakeholders, Option 2 may appear much more cost-efficient. The reason is a much higher total investment in European R&I by the private partners and a more concrete spin-off towards full product development by those private partners leading to new products on the market. This also ensures contribution of the initiative to the Green Deal.

In comparison with CS2, the administrative cost (hence the maximum saving possible when not taking this option) is limited to EUR 80 million compared to a total managed research budget of EUR 4 billion (including additional activities).

Looking at cost-efficiency within context of the effectiveness of achieving meaningful research results with the highest (and fastest) possible value for society and contribute timely to achieving the European Green Deal it should be noted that option 2 scores much higher than any other option.

Although difficult to quantify, a slight loss in effectiveness by choosing option 0 or 1 would lead to much higher costs, and more importantly reduced impact, than potential savings.

In addition, only Option 2 contains all the characteristics as regards partner composition, commitment, governance needed to manage a hugely complex and large research and innovation agenda on time.

Matrix on ‘overall costs’ and ‘adjusted cost scoring’

¹⁰⁹ The baseline (traditional calls) is scored 0, as explained above.

	Baseline: Horizon Europe calls	Option 1: Co-programmed	Option 2: Institutionalised Article 187 TFEU
Administrative, operational and coordination costs	0	(-)	(-)(-)
Administrative, operational and coordination costs adjusted per expected co-funding (i.e. cost-efficiency)	0	0	(-)

Notes: Score 0 = same costs as for the baseline; score (-) = limited additional costs compared with the baseline; score (-)(-) = substantial additional costs compared with the baseline.

6.3. Coherence

6.3.1. Internal coherence

In this section we assess the extent to which the policy options show the potential of ensuring and maximising coherence with other actions, programmes and initiatives under Horizon Europe, in particular European Partnerships (internal coherence).

Strong synergies should be established between the two proposed aviation partnerships, Integrated Air Traffic Management¹¹⁰ and Clean Aviation, and several other proposed initiatives. This should ensure compatibility between the solutions developed by Clean Aviation, and the advanced ATM approaches developed under the Integrated Air Traffic Management initiative. For example, one of the main objectives is the environmental optimisation of air traffic operations in the European airspace. This optimisation requires optimisation in aircraft design and comprehensive meteorological data including different atmospheric parameters. Aligned roadmaps for new aircraft designs and operations, ATM and use of meteorological data will enable the instantaneous calculation of the climate impact caused by the engine emissions released at any point in the four-dimensional space (latitude, longitude, altitude, time).

Cooperation, and the alignment of research agendas, between partnerships is a key condition for success. For instance, the hydrogen initiative and the batteries initiative (potentially delivering alternative energy sources to aviation) could have a huge impact as enablers of zero-emission aviation, if their deliverables respond to the needs of the aviation sector (see Figure in Section 1.4).

Creating synergies would benefit all these initiatives. It is worth mentioning that more-electric aircrafts will require advancements in high-voltage electric power systems, which at high altitudes pose additional safety risks that have to be addressed and technological solutions to be validated. That's why aircraft requirements have to be taken into consideration at initial stages of proposed solutions.

Depending on the selection of the most promising technologies, and the practical research and innovation requirements expressed in the strategic research and innovation agenda, closer cooperation with other initiatives may be envisaged. An overview is available in annex 2.6.

For the **baseline option**: synergies and coherence between Clean Aviation and other initiatives would require an additional level of coordination. Exploiting potential synergies would be hampered by the difference in focus (low TRL versus high TRL) and the more limited scope of lower TRL projects. The baseline option is more appropriate for

¹¹⁰ <https://www.sesarju.eu/approach/environment>

collaborative research/incremental improvements whereas the initiative would focus on disruptive technologies and high TRL demonstrators.

For **Option 1**: The Co-Programmed option would be able to provide this coherence, notably in the context of work programme preparation. The European Commission could ensure coordination at the level of research agendas. Option 1 is not considered optimum to address the complex R&I chains typical for aviation.

For **Option 2**: The institutionalised partnership would allow for greater internal coherence than the two other options, expanding the possibilities of coordination and exploitation of synergies offered by the Co-Programmed option by the existence of the central coordination level, managed by the programme office and supported by the European Commission. This would also enable the development of a shared vision and better exploitation of synergies from joint programmes and calls, in areas such as hydrogen and battery technology,

6.3.2. *External coherence*

In this section we assess the extent to which the policy options show the potential of ensuring and maximising coherence with their external environment, including EU-level programmes and initiatives beyond the Framework Programme and/or national and international programmes and initiatives, but as well as with overarching framework conditions, such as regulation, standardisation, etc. (external coherence).

The **baseline** option and the **co-programmed** partnership are assessed to be less effective than an institutionalised partnership in creating the required systemic effects. This is due to their weaknesses in addressing the international community, ensuring adequate coordination with other programmes, third countries and international organisations, aligning with their own R&D agendas and low carbon roadmaps, and for facilitating market uptake support to be put in place.

The **institutionalised partnership** option, through its programme office, has a dedicated structure that provides a large value in organising systematic links with stakeholders, for establishing a structured dialogue with MS (SRG) or to exploit synergies with ERDF. This is the more important because synergies and sequencing with other EU, national, and regional R&I programmes will help in creating a critical mass to support breakthrough technologies in clean aviation.

In case other initiatives with large potential for synergies (e.g. hydrogen) would become an Article 187 partnership, then there could be a fluent cooperation between the various programme offices.

In addition, it will promote economies of scales, non-duplication and best practices with and among national and regional programs; promote participation of less active countries; and bridge the gap between R&I and national policies on new skills and jobs.

This applies also for setting ambitious standards and performance targets. Working with Member States and international standardisation bodies, the European Commission identifies areas where standards and performance targets could have the greatest impact towards aviation climate neutrality and could propose the development of other standards if needed.

Research provides results, and in this case enables climate neutrality, only when it leads to innovations that enter the market. Trends in EU policies such as the review of the energy

taxation framework, aircraft certification processes, carbon taxation schemes, the Air Quality Directives, as well as the Emissions Directives may create barriers to innovation or on the contrary stimulate research and innovation towards climate neutral aviation by 2050.

For maximising results, research and innovation must be part of a much broader EU strategy encompassing EU programmes, national and international policies.

To ensure continued progress, barriers to innovation as well as accelerators need to be addressed holistically in all EU policies in close cooperation with stakeholders¹¹¹.

All the synergies should be aligned in a shared, integrated and comprehensive roadmap. Combining resources and funding will produce a substantial leverage effect and help reach the objective of climate neutral aviation.

Figure 6 Overview of the options’ potential for ensuring and maximizing coherence

	Option 0: Horizon Europe calls	Option 1: Co-programmed	Option 2: Institutionalised Article 187 TFEU
Internal coherence	0	0/+	++
External coherence	0	+	++

Notes: Score ++ : Option presenting a *high* potential compared to baseline; Score +: Option presenting a *good* potential compared to baseline; Score 0: Potential of the baseline.

6.4. Tabular comparison of options and identification of preferred option

Figure 7 Overall scorecard of the policy options for all criteria

	Items	Baseline Traditional calls	Option 1: Co-programmed	Option 2: Article 187
Effectiveness	Scientific impact			
	Acceleration of the development of know-how and the process of maturing technologies and knowledge transfer for key new technologies and ‘differentiators	0	+	++
	Increased diffusion of scientific excellence and high-quality knowledge in the field of aeronautics among research staff from universities, research institutes or private companies	0	+	+
	Increased collaboration with other sectors and integration of areas of fundamental research that are not traditionally within the aeronautical scientific ecosystem	0	+	++
	Strengthened innovation pipeline by creating better directionality of research;	0	+	++
	Economic/technological impact			
	New safe, climate neutral and efficient airborne transport modes such as commuter/regional aircraft that have the potential to reduce traffic congestion in highly populated areas, and connect remote regions	0	+	++
	Increased competitiveness of European aeronautics industry through cost-efficiency improvements throughout the entire supply-chain	0	0	++
	New sustainable business models for innovative aircraft technology for future aircraft and fleet retrofits, exploiting next generation digitalisation/automation technologies	0	0	++

¹¹¹ the Advisory Council for Aviation Research and Innovation in Europe (ACARE), and the Association of European Research Establishments in Aeronautics (EREA), as well as key national organisations, e.g. the *Direction Générale de l’aviation civile* in France, BMWi in Germany, CDTI in Spain, MISE in Italy, etc.

	The emergence of new branches of the aviation industry, such as new sources of propulsion, systems or airframes which will enhance European competitiveness	0	0	++
	Societal impact			
	Clean Aviation will significantly contribute to the delivery of Europe's climate neutrality by 2050 by pioneering new solutions in the aeronautics disciplines and readying them for market introduction.	0	+	++
	Further increase safety and security levels, in cooperation with the European Union Aviation Safety Agency (EASA) by deeply transforming present operations with the help of innovation;	0	+	++
	Fulfil customer and general public expectations of a globally competitive European industry	0	0	++
	Improving mobility and connectivity of European citizens with safe, reliable, affordable and resilient air travel options	0	0	++
Coherence	Internal coherence	0	+	++
	External coherence	0	+	++
Efficiency	Overall cost	0	-	--
	Cost-efficiency	0	0	-

Notes: Scores for effectiveness and coherence: Score ++ : Option presenting a *high* potential compared to baseline; Score +: Option presenting a *good* potential compared to baseline; Score 0: Potential of the baseline Scores for efficiency: Score 0 = same costs as for the baseline; score (-) = limited additional costs compared with the baseline; score (-)(-) = substantial additional costs compared with the baseline

Overall, the implementation of the Clean Aviation initiative through an institutionalised partnership established under Article 187 of TFEU is the preferred option as it would best ensure that private and public sectors remain fully engaged in the development and implementation of a long-term strategy for clean aviation R&I.

It is also consistent with the aim of leveraging industrial financial and in-kind resources, strive towards synergies with national programmes, and create ties with the broader policy initiatives to support to facilitate market uptake. This way, the impact of funding provided by the Commission is maximised.

This form of partnership would continue to provide a stable framework for encouraging the participation of organisations from all concerned sectors (including those outside the traditional aviation industry), securing and allocating resources, managing a wide range of RD&I projects favouring high TRL and creating synergies with other partnerships and initiatives within and outside the Climate, Energy and Mobility Cluster.

It is also considered appropriate to develop a strategy for Clean Aviation that is fully aligned with European Green Deal priorities, and especially the European climate commitment, and with several sustainable development goals.

As documented in the CS2 mid-term evaluation, elements of the CS2 procedural structure are constraining the R&I effort. One objective in Horizon Europe is to optimise the structure of the partnership, in reply to the mid-term evaluation recommendations. This is seen as a key condition for having an Art. 187 partnership. Without such optimisation, a co-programmed partnership could become the better option.

Conclusion:

Three options have been considered **under the Clean Aviation** initiative: traditional calls, a co-programmed partnership and an Article 187 institutionalised partnership. The other

options, a co-funded partnership and an Article 185 partnership, were discarded at an early stage because Clean Aviation builds upon a strong and long-term commitment of industry.

The traditional calls (baseline option) would support a substantial effort for the **exploration of novel solutions**, but it would miss the long-term planning, and large long-term industry commitment, leading to high TRL technology demonstrators required for achieving the Green Deal. In addition, those novel solutions would take far too long to reach TRL 6 stage to be useful for achieving the European Green Deal’s climate neutrality targets on time.

In order to achieve large-scale integrated demonstrators there is a need for a management structure providing in-house programme management capacities, which would allow for close monitoring and swift adaptation of the research and innovation priorities in the course of the programme implementation.

A **co-programmed partnership** would be an improvement compared to traditional calls but would require a very heavy programme management and would lack flexibility.

The dedicated programme office foreseen under the **Article 187 institutionalised partnership** is vital for programme management of large-scale integrated demonstrators. In fact, one of the perceived weaknesses of Clean Sky 2 is that the programme office should have even better governance and programme/ project management capabilities.

In addition, the Article 187 institutionalised partnership ensures long-term commitment of the industry around the European Green Deal climate neutrality target as well as a precise timeline (up to 55% emission reduction by 2030, climate neutrality by 2050), which is vital for the envisaged research which is directly contributing to the European Green Deal climate neutrality target.

The following comparison between the preferred option and the current partnership existing in the area taking into account lessons from past evaluations.

What continues	What is different
<p>Strategic research and innovation agenda as basis for research and innovation activities.</p> <p>Dedicated structure of programme office managed by executive director</p>	<p>The European Green Deal sets a very clear ambition with corresponding target dates. This gives a much stronger focus compared to CS 2.</p> <p>Focus on disruptive research instead of incremental changes.</p> <p>Commitment of industry beyond research and towards market introduction</p> <p>Selection of a very limited number of most promising technologies, with high potential for market introduction, and a business plan on how to get there.</p> <p>Much simplified programme structure with projects selected by open calls instead of pre-allocation of budgets.</p> <p>Better involvement of Member States and the Scientific Community.</p> <p>Strong focus on analysis, project progress monitoring and</p>

	impact assessment.
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Annex 6.11 gives an overview of the weaknesses of the H2020 CS2 Joint Undertaking and how these could be addressed when establishing a new Article 187 Partnership.

7. THE PREFERRED OPTION

In the below table, the alignment of the preferred option of Institutionalised European Partnership under Article 187 TFEU with the selection criteria for European Partnerships defined in Annex III of the Horizon Europe Regulation is depicted.

Seeing that the design process of the candidate Institutionalised Partnerships is not yet concluded and several of the related topics are still under discussion, the criteria of additionality/directionality and long-term commitment are covered in terms of *expectations* rather than ex-ante demonstration.

Alignment with the selection criteria for European Partnerships

Criterion	Alignment of the preferred option
Higher level of effectiveness	<p>An institutionalised partnership would be more effective in achieving the objectives of the initiative within the timeframe set by the Green Deal.</p> <p>This the more important considering the global impact of the European aviation industry, and the global environmental challenges to be addressed.</p> <p>An institutionalised partnership would be considerably more effective in addressing global challenges and delivering research and innovation objectives, in securing EU competitiveness and,</p> <p>The institutionalised partnership would also be effective in securing sustainability (the final goal of “clean aviation”), in strengthening the European Research and Innovation Area, in securing the competitiveness of our industry, and where relevant, in contributing to international commitments (e.g. on standards).</p>
Coherence and synergies	<p>A dedicated management structure similar to the Programme Office in current CS 2 would operate on basis of but with an optimised governance structure, bringing the CS 2 mid-term evaluation recommendations to practice.</p> <p>Projects would be selected by open calls, on the basis of the Strategic Research and Innovation Agenda.</p> <p>Under the supervision of the European Commission, the institutionalised partnership could ensure where possible synergies with relevant strategies and programmes developed by other partnerships and initiatives, in particular in areas such as Clean Hydrogen, Integrated Air Traffic Management and Battery Technology. It would strive towards active coordination and exploiting synergies with national aviation research programmes.</p> <p>This would enable the gradual development of a shared vision and better exploitation of synergies from joint programmes and calls.</p>
Transparency and openness	<p>An institutional partnership would ensure that the outputs of R&I programmes are transparent and available to stakeholders inside and outside the aeronautics industry. The framework governing participation would allow any organisation meeting defined criteria to participate, with a proportion of funded activity subject to open calls.</p> <p>An institutionalised partnership would be better placed to identify priorities and objectives in terms of expected results and impacts, in involving partners and stakeholders from across the entire aviation value chain, from different sectors, backgrounds and disciplines, including international ones when relevant and not interfering with European competitiveness.</p> <p>SMEs would have the most appropriate support from the partnership, similar to CS 2.</p>

Criterion	Alignment of the preferred option
	<p>An institutional partnership would ensure that the outputs of RD&I programmes are transparent and available to stakeholders inside and outside the aviation community.</p> <p>The approach of using open calls would allow any organisation meeting defined criteria to participate, in an open and transparent way. This framework could provide support and guidance, help networking and build up consortia when addressing complex projects throughout the whole value chain</p>
Additionality and directionality	<p>Only a partnership would be able to secure the necessary industry commitments. The partnership should start on basis of a strategic research and innovation agenda for aeronautical-related R&I and establish a set of common objectives governing the direction, outputs and timeframe of R&I activity under Horizon Europe. This SRIA should, at best, fit within a larger EU aviation policy and strategy.</p> <p>An institutionalised partnership would be very well placed to maintain an Strategic Research and innovation agenda, and adapt it on basis of research results and progressive insights.</p> <p>The active and long term involvement of private as well as public partners would ensure flexibility of implementation and permit to adjust to changing policy, societal and/or market needs, and increase policy coherence between regional, national and EU level.</p>
Long-term commitment	<p>In the case of institutionalised European Partnerships, established in accordance with article 187 TFEU, the financial and/or in-kind, contributions from partners other than the Union, will at least be equal to 50% and may reach up to 75% of the aggregated European Partnership budgetary commitments</p>

7.1. Operational Objectives

Clean Aviation low and zero emissions technologies will allow fuel efficiency gains of one-third to one-half in 2050, compared to today's fleet.

To deliver on the identified objectives, an initiative in this area must enable aircraft, engines and systems to utilise the full potential of low or zero carbon fuels, including potential disruptive innovations such as hydrogen. Together these outcomes will accelerate the transition towards climate-neutrality.

The ambition of the Clean Aviation Partnership is to ensure that breakthrough technology advancements allow **new aircraft developments by 2030**, with maximum progress towards climate neutral aviation, while meeting socio-economic expectations and providing benefits for European society and businesses. It will go well beyond previous framework programme R&I, and will accelerate the transition towards a climate neutral system by enabling all-new aircraft platforms and configurations, and taking a system-wide approach. To deliver on its objectives, the initiative must aim to bring about decisive steps in new aircraft performance demonstrated and **on offer to airlines and operators by 2030 and available by 2035**. The focus will be on pursuing two pivotal aircraft demonstration efforts for the validation of selected technologies. **Ultra-efficient short-medium range aircraft** coupled with the use of sustainable aviation fuels, and **hybrid electric regional and short-range aircraft** will deliver major steps, together with optimised green trajectories and operations and with accelerated transition to low or zero carbon fuels. Clean Aviation will develop in parallel the technologies to deliver full climate-neutrality by 2050, by bringing key technologies to a maturity that can allow appropriate scaling across the full spectrum of aircraft segments and flight operations, including long-haul travel.

The technical details are worked out in an (approved) Strategic Research and Innovation Agenda¹¹² (SRIA) prepared by the private sector in response to the Clean Aviation initiative.

¹¹² http://clean-aviation.eu/files/Clean_Aviation_SRIA_16072020.pdf

The primary focus of the demonstration efforts will be on the hybrid electric regional and the ultra-efficient short-medium range aircraft concepts, with a stepwise development and demonstration strategy.

This allows for opportunities for technology spin-off to other aircraft categories (commuter and vertical lift applications, long range applications) and for a broad-based participation in the programme, and a much broader and deeper penetration of the overall air transport system with important additional environmental and climate-related benefits.

Note: The SRIA contains a table (page 20) indicating the targets set by the aviation sector for achieving impact linked to the Green Deal with 2030 and 2050 deadlines, confirming the ambition to reach climate neutrality by 2050.

An **Impact Monitor** mechanism and work programme will be included in the Partnership’s work breakdown structure to ensure regular strategic monitoring and steering, and ensure objectives are met. The performance levels in targeted the aircraft types to be demonstrated in Clean Aviation are below.

7.2. Monitoring indicators

We have identified a number of short, medium and long-term monitoring indicators to enable the progress of the partnership towards meeting its objectives to be tracked. However, it is indicated that the development of technologies within EU-funded R&I is limited to TRL 6 activities and additional product development and integration is necessary before first flight and entry into service. Furthermore, the societal impact of the aviation R&I is apparent and quantifiable at least ten years after TRL 6. Having these in mind, the monitoring indicators are shown in the below table.

Monitoring indicators in addition to the Horizon Europe key impact pathway indicators

	Short-term (typically as of year 1+)	Medium-term (typically as of year 3+)	Long-term (typically as of year 5+)
Scientific impact	Alignment of European fundamental and collaborative aeronautics research with medium/long term industry objectives. Cross-fertilisation with other S&T initiatives from relevant areas in Pillar I and II of HE.	Number of times that journal citations generated by the partnership are cited in the global literature Number of occupied and advertised jobs in aeronautical-related R&I Number of PhD thesis, inventions and patents.	Number of patents registered by the aeronautical industry and research organisations located in Europe
Technological / economic impact	Number of programmed projects involving organisations outside the aeronautical industry Number of programmed projects with a documented strategy identifying the potential application of results	Number of programmed projects leading to validated demonstration of new applications of technology Number of years for programmed projects to reach TRL 6 Level and intensity of the	Performance of engine ground demonstrators and/or flying test beds for emissions and noise. Reliability and cost reduction achieved from manufacturing technologies and the projected integration.

	Short-term (typically as of year 1+)	Medium-term (typically as of year 3+)	Long-term (typically as of year 5+)
	to defined market needs	aeronautical-related R&I (in percentage of turn-over) Number of joint ventures or suppliers ready to invest further in the development and integration beyond TRL 5-6	Number of programmed projects with high potential for market take-up Projected value of exports generated by the European aeronautical sector (note this will be significantly beyond year 5+) Projected direct and indirect employment generated by the European aeronautical sector
Societal impact	Number of programmed projects developing technological solutions towards climate neutrality	Level and intensity of the aeronautical-related R&I (in percentage of turn-over) Education and training of students and staff in new technological field	Maintain and/or increase European competitiveness and employment. Level of matching funds from National or International funding mechanisms required to integrate, integrate and certify developed technologies. Changes in air quality and well-being (note this will be significantly beyond year 10+)
Incl. Environmental / sustainability impact	Number of programmed projects focusing on large civil aircraft Number of programmed projects focusing on sustainable aviation fuels integration	Number of programmed projects focusing on alternative energies or technologies. Potential and scalability successfully demonstrated and quantified	Changes in CO ₂ , non- CO ₂ emissions and noise generated by the aviation industry in Europe and globally (note this will be significantly beyond year 10+)

Source: Steer analysis

7.3. Evaluation framework

The evaluation of the Partnership will be done in full accordance with the provisions laid out in Horizon Europe Regulation Article 47 and Annex III, with external interim and ex-post evaluations feeding into the overall Horizon Europe evaluations. As set in the criteria for European Partnerships, the evaluations will include an assessment of the most effective policy intervention mode for any future action; and the positioning of any possible renewal of the partnership in the overall European Partnerships landscape and its policy priorities. In the absence of renewal, appropriate measures will be developed to ensure phasing-out of framework programme funding according to conditions and timeline agreed, ex-ante, with the legally committed partners.