

PERSPECTIVES FOR AERONAUTICAL RESEARCH IN EUROPE



CHAPTER 1

58 Recommendations for Aeronautics Research in Horizon Europe

Final Report

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Chapter 1 - 58 Recommendations for Aeronautics Research in Horizon Europe

1.1 Set of Recommendations

The PARE First Year report has served as the background and justification for a set of “68 PARE Recommendations on Aeronautics in Horizon Europe” that combines:

- The 23 ACARE Goals as stated in the document Flight Path 2050 that is the basis of PART I of this report;
- The 35 PARE Objectives that support their implementation as presented in PART II of this report.

This ensemble may be seen as an advisory input into the preparation of the aeronautical themes for the EU research program Horizon Europe as a follow-on to the current Horizon 2000.

It also serves as a summary and introduction to the contents of this Report since each of the 68 Recommendations includes a concise justification and refers for further details to the relevant section of the First Year PARE Report.

The list of recommendations is based on the first draft of the First Yearly Report of the CSA “Perspectives for Aeronautical Research in Europe” (PARE) that provides the detailed background and justification. The list of recommendations can serve as a detailed “executive summary”, highlighting the main issues, and serving as a subject index indicating in which Chapter and Section of the PARE Report the relevant aspects are discussed. The List of Recommendations for Aeronautics in Horizon Europe is structured like the PARE report that is based upon.

There are interfaces and partial overlaps among the 23 ACARE Goals in PART I and the 35 PARE Objectives in PART II. The recommendations are structured so that they mostly cover one topic at a time, without overlaps. Even avoiding repetitions, the number of recommendations is significant, so a ranking scheme is used.

The highest rank (***/three asterisks) concerns broad issues with a major impact on the future of aviation in which critical concerns have to be tackled. The lowest rank (no asterisks) concerns subjects for which the current rate of progress is adequate but should not be overlooked. The two intermediate ranks (one and two asterisks) make the transition.

Since this set of recommendations is based on the first draft of a yearly report of a project started 25 months ago, it is certainly open for improvement, bearing in mind that it is entirely based on open sources of information. The PARE report is open access at: <https://www.pareproject.eu/publications>.

Structure of the recommendations

Each of the 23 ACARE goals and 35 PARE Objectives is taken as the basis for 58 sets of recommendations ordered by number. All sets of recommendations use the following format:

- a. **Statement:** text of the ACARE goal or PARE objective;
- b. **Recommendation(s):** brief statement of the actions to be taken.
- c. **Rationale:** current situation and future prospects motivating the recommendation;
- d. **Stakeholders:** institutions that could contribute to implementation: European Union (EU), Member States (MS), Aerospace Industry (AI), Research Centres (RC), Universities and Academia (UA), Certification Authorities (CA), Accident Assessment Organizations (AA), Air Navigation Service Providers (AN), Airlines (AR), Airports (AP), Professional Associations (PA);
- e. **Relevance:** potential impact of the initiative;
- f. **Priority:** justification of the priority rating on a scale from 3 asterisks (top) to zero asterisks;
- g. **Justification:** reference to the section of the PARE Report containing more detailed information.

1.2 PART I – Assessment of the 23 ACARE Goals

The recommendations are made in the same order as the ACARE goals that appear in the PARE report. There may be one or more recommendations per ACARE Goal and the justification is referred to the sections and key topics of PART I of the PARE Report.

Chapter 2. Meeting Societal and Market Needs

1a. ACARE GOAL 1: *An air traffic management system is in place that provides a range of services to handle at least 25 million flights a year of all types of vehicle, including unmanned and autonomous systems that are integrated into and interoperable with the overall air transport system with 24 hour efficient operation of airports. European air space is used flexibly to facilitate reduced environmental impact from aircraft operations.*

1b. Recommendation 1*:** A broad and deep research effort must be maintained concerning all aspects of Air Traffic Management (ATM) that can contribute to increase airspace capacity with equal or greater safety.

1c. Rationale: The growth of air transport puts increasing demands on air traffic capacity with undiminished safety. The foreseen operation of UAVs in manned airspace will increase the demand for capacity. As capacity limits are approached there are more delays that cause inconvenience to passengers and increase emissions and fuel costs. Together airport noise and air traffic capacity could become the two main bottlenecks for the growth of aviation.

1d. Stakeholders: EU, MS, AN, AP, AR, AI, RC, UA.

1e. Relevance: The air traffic capacity must increase with undiminished or improved safety to accommodate traffic growth and UAV's without incurring major delays.

1f. Priority: Air traffic capacity could potentially become an obstacle to the growth of aviation and past experience shows that approaching capacity limits can cause major disruption in terms of flight delays and operating costs and emissions.

1g. Justification: PARE report Section 2.1 and Topics T2.1 and T2.2.

2a. ACARE GOAL 2: *A coherent ground infrastructure is developed including: airports, vertiports and heliports with the relevant servicing and connecting facilities, also to other modes.*

2b. Recommendation 2*: Urban and land planning methodologies need to be developed to optimise on a regional basis the location of airports, vertiports and heliports to simultaneously provide convenient links to other transportation nodes and minimise environmental impacts and disturbance of populations.

2c. Rationale: The integration of airports into regional planning must include the interfaces with other modes of transport and also the compatibility with other land users.

2d. Stakeholders: EU, MS, AP, AR, AN.

2e. Relevance: The airport network should cover population needs at regional, national and European and intercontinental level.

2f. Priority: There is the need to harmonize inter-modal transport at regional level and fast air transport on a European scale.

2g. Justification: PARE report Section 2.2 and Topic T2.3.



3a. ACARE GOAL 3: *European citizens are able to make informed mobility choices and have affordable access to one another, taking into account: economy, speed, and level of service (which can be tailored to the individual customer). Continuous, secure and robust high bandwidth communications are provided for added value customer applications.*

3b. Recommendation 3*: Promote a one-shop centralised travel information site where the EU citizen can readily find the alternative options for connecting any two locations, including costs and timetables, with links to reliable booking.

3c. Rationale: There are many sources of travel information and services with different objectives and priorities making a choice confusing and often non-comparable.

3d. Stakeholders: EU, MS, AR, AP, CA, AR, PA.

3e. Relevance: An independent, reliable and comprehensive source of comparable and reliable travel information would serve the interests of the citizen and fair competition to offer the highest quality and most efficient air travel, promoting the growth of air transportation.

3f. Priority: The information is available, although in a scattered and inconsistent form, with plenty of scope for improvement.

3g. Justification: PARE report Section 2.3 and Topic T2.4.

4a. ACARE GOAL 4: *90% of travellers within Europe are able to complete their journey, door-to-door within 4 hours. Passengers and freight are able to transfer seamlessly between transport modes to reach the final destination smoothly, predictably and on time.*

4b. Recommendation 4*: Revise the goal to take into account (a) the distance and duration of flight and (b) cover the time period from arrival at the departure airport to exit from the destination airport.

4c. Rationale: The aviation sector (b) cannot be responsible for what happens outside the aircraft and airports and cannot influence travel time between home/work and the airport. The flight distances within the EU can go up to 3 000 Km, and some aircraft are slower (propeller driven) than others (jet powered) so travel times can differ.

4d. Stakeholders: AR, AP, MS, EU.

4e. Relevance: The realistic information that can be provided to a traveller consists of: (i) Flight time that airlines can provide; (ii) Time for departure and arrival procedures that the airport can manage. Travel beyond the airport is out of control of the aviation sector.

4f. Priority: The information is available or predictable but not as reliable or accurate as the business traveller needs and can disrupt leisure travel connections and plans.

4g. Justification: PARE report Section 2.4 and Topics T2.5, T2.6 and T2.7.

5a. ACARE GOAL 5: *Flights arrive within 1 minute of the planned arrival time, regardless of weather conditions. The transport system is resilient against disruptive events and is capable of automatically and dynamically reconfiguring the journey within the network to meet the needs of the traveller if disruption occurs. Special mission flights can be completed in the majority of weather, atmospheric conditions and operational environments.*



5b. Recommendation 5.1: More comprehensive weather data is made available to ATM and airlines to assist achieving punctuality targets (see recommendations 13 and 15.1).

Recommendation 5.2: A rapid near real time simulation capability is developed for ATM to (a) accommodate special emerging flights and (b) adjust to major disruptive events.

5c. Rationale: Punctuality of air transport in adverse weather conditions depends on availability of meteorological data sufficiently in advance for efficient re-routing. Disruptive events and special flights that require reconfiguration of multiple flight paths can be made efficiently if supported by fast and reliable simulation tools.

5d. Stakeholders: EU, MS, AN, AC, AR, AI, RS, NA.

5e. Relevance: Being able to maintain a steady flow of air traffic is particularly relevant, and more difficult, during major disruptive weather events, like ash clouds or freezing conditions.

5f. Priority: This is an area of gradual progress where steady effort should be maintained, but nothing revolutionary is expected.

5g. Justification: PARE report Section 2.5 and Topic T2.8.

Chapter 3. Maintaining and Extending Industrial Leadership

6a. ACARE GOAL 6: *“The whole European aviation industry is strongly competitive, delivers the best products and services worldwide and has a share of more than 40% of the world market.”*

6b. Recommendation 6*:** Maintain a broad-based application-oriented research and development activity covering all sectors relevant to the global competitiveness of the European aircraft industry.

6c. Rationale: The importance of the aeronautical industry to the prosperity of Europe is well documented. Since aeronautics is a synthesis of advanced technologies it requires a mastery of all of them to remain competitive.

6d. Stakeholders: EU, MS, AI, RC, UA, AN, AA, AP, PA.

6e. Relevance: taking as example the market for airliners with more than 100 seats, maintaining the Airbus share of 50% of the world market will require technological leadership in a broad range of technologies.

6f. Priority: This is the core of the aircraft market worldwide. The problems of the Airbus A380 with the passenger infotainment system and those of the Boeing 787 with the lithium-ion batteries show that even seemingly secondary aspects can cause major disruption.

6g. Justification: PARE report Section 2.5 and Topic T2.8.

7a. ACARE GOAL 7: *Europe will retain leading edge design, manufacturing and system integration capabilities and jobs supported by high profile, strategic, flagship projects and programmes which cover the whole innovation process from basic research to full-scale demonstrators.*

7b. Recommendation 7:** Support an observatory of global trends in aviation to ensure that major breakthroughs occur first in Europe or are matched without a delay in reaching the market.

7c. Rationale: The industry does by itself a good job of ensuring its own competitiveness, although shorter term needs may prevail over longer terms prospects. The EC and MS programs aim at long-term competitiveness on the basis of professional recommendations but could still benefit from a stable independent observatory of citizen needs, market trends and technological advances that could meet them.



7d. Stakeholders: EU, MS, AI, AR, RC, UA

7e. Relevance: Although the European aerospace industry is currently quite competitive there are a number of emerging technologies that could be used by current and new competitors to change the balance; these need to be monitored and supported to ensure Europe remains a leader in the aeronautical sector.

7f. Priority: Current mechanisms to remain competitive though still relevant in the future may not be sufficient.

7g. Justification: PARE report Section 3.3 and Topics T3.4 and T3.5.

8a. ACARE GOAL 8: Streamlined systems engineering, design, manufacturing, certification and upgrade processes have addressed complexity and significantly decreased development costs (including a 50% reduction in the cost of certification). A leading new generation of standards is created.

8b. Recommendation 8: Analyse the architecture of industrial aviation programmes, to identify the best practices in matching design, development, certification, production, operations and maintenance in the most cost-effective and time-efficient manner. The introduction of new technologies and stricter safety requirements should be accompanied by more efficient testing and validation to minimise time and cost.

8c. Rationale: Emerging technologies like 4.0, Artificial Intelligence and Big Data offer the prospect of more efficient integration of the aircraft life-cycle from design through production to operations but require large investments in complex systems that should preferably be phased in a try-and prove approach.

8d. Stakeholders: EU, MS, AI, RC, UA, AR, CA.

8e. Relevance: The 4.0 factory is the next big trend in industry, and aeronautics is no exception, adding operations and maintenance to designs and production.

8f. Priority: Developments in this area are widespread in industry, and aeronautics requires specific adaptations.

8g. Justification: PARE report Section 3.3 and Topics T3.4 and T3.5.

Chapter 4. Protecting the Environment and the Energy Supply

9a. ACARE GOAL 9: "In 2050 the technologies and procedures available allow a 75% reduction in CO₂ emissions per passenger kilometre and a 90% reduction in NO_x emissions. The perceived noise emission of flying aircraft is reduced by 65%. These are relative to the capabilities of typical new aircraft in 2000".

9b. Recommendation 9.1*:** Support a broad research effort to reduce aircraft noise (a) at the source (b) through operating procedures and (c) taking into account psychoacoustic effects.

Recommendation 9.2*: Besides struggling with short term solutions to an increasingly pressing noise problem a modest effort should be made towards a long-term definitive solution: aircraft inaudible outside airport boundaries.

Recommendation 9.3:** Formulate a set of trade-offs between (a) different types of emissions (CO₂, NO_x, particles and water vapor) in (b) local airports and global cruise flights.

Recommendation 9.4: Besides struggling with short-term emissions problems put a modest effort towards a long-term definitive solution: the hydrogen powered aircraft.

9c. Rationale: The growth of air transport at a rate of 3 to 7% per year, leads to flights increased to the double by 2030, and triple by 2050; in order to avoid increased noise exposure near airports and emissions in cruise the corresponding reductions must be made per flight. Noise is dominated by the engine at high thrust at take-off and by aerodynamics



at approach with the engine at idle: thus, the full range of noise sources needs to be tackled, the operating procedures optimized, and psychoacoustic effects accounted for in order to succeed in this major challenge. The requirements for low emissions of CO₂, NO_x, particles and water vapor near airports and in cruise are sometimes contradictory and a reasonable compromise needs to be defined to guide engine design. The 'definitive' solutions to aircraft noise and emissions, such as aircraft inaudible outside airports and hydrogen propulsion that emits only water vapor, are far away but deserve a modest effort to establish how they might be viable.

9d. Stakeholders: EU, MS, AI, RC, UA, AN, AR, AP.

9e. Relevance: Tolerance to airport noise is reducing and court or other actions to limit airport operations are likely to increase if overall noise exposure cannot be contained. Aviation should have a non-increasing and preferably decreasing role in global emissions.

9f. Priority: It is very challenging to contain total noise exposure at airports and failure to do so could limit airport operations and become a bottleneck for the growth of aviation. Emissions are a major local and global environmental concern and aviation should be an example of positive action. Beyond the pressing short-term issues of noise and emissions a modest effort should be made to assess and mature in out-of-the-box long-term solutions.

9g. Justification: PARE report Section 4.1 and Topics T4.1 and T4.2.

10a. ACARE GOAL 10: *Aircraft movements are emission free when taxiing.*

10b. Recommendation 10: Develop a methodology to comprehensively assess the implications of electric aircraft taxiing and electrical energy supply in terms of requirements, costs, land and environmental impact for a variety of airport configurations.

10c. Rationale: Aircraft taxiing under the power of its own engines and to a lesser extent auxiliary power unit (APU) running contribute to airport emissions that could be avoided by electric towing and power supplies.

10d. Stakeholders: EU, MS, AP, AR, CA.

10e. Relevance: Although electric towing and power supplies are feasible, the investment in vehicles and support infrastructure must be assessed as well as how costs are covered.

10f. Priority: This is mainly an implementation issue that will be supported by progress in electric power, especially batteries.

10g. Justification: PARE report Section 4.2 and Topic T4.3.

11a. ACARE GOAL 11: *Air vehicles are designed and manufactured to be recyclable.*

11b. Recommendation 11: Make a comprehensive assessment of materials used in aircraft production and assess recyclable alternatives and related issues of availability, ease of use, certification, maintenance and cost.

11c. Rationale: The trend towards recycling is industry wide, and in the case of aeronautics as others can be integrated as one of the objectives of goal 8.

11d. Stakeholders: EU, MS, AI, RC, AU, AR, CA.



11e. Relevance: Aviation must share the goal of preventing depletion of limited resources and making better and repeated use of materials already available.

11f. Priority: This is a wide effort among most industries, which aviation must share taking into account its specific needs.

11g. Justification: PARE report Section 4.3 and Topic T4.4.

12a. ACARE GOAL 12: *Europe is established as a centre of excellence on sustainable alternative fuels, including those for aviation, based on a strong European energy policy.*

12b. Recommendation 12: Perform a comparative study of potential alternative fuels, their availability in the required large quantities and the feasibility and cost of large-scale production, distribution and use.

12c. Rationale: There is a strong need to reduce the dependence on fossil fuels and although there are several potential alternatives it is not easy to match the energy density, usability and cost of kerosene in large quantities.

12d. Stakeholders: EU, MS, Energy industry; AI, RC, UA, AR, CA.

12e. Relevance: Avoiding fast depletion of finite oil resources, finding alternative less polluting fuels and possibly also safer handling with undiminished energy density per unit weight and volume: demanding and necessary.

12f. Priority: This is an issue affecting all modes of transport, among which aviation is a major but not the largest user and should try to improve its position and contribution to the whole.

12g. Justification: PARE report Section 4.4 and Topic T4.5.

13a. ACARE GOAL 13: *Europe is at the forefront of atmospheric research and takes the lead in the formulation of a prioritised environmental action plan and establishment of global environmental standards.*

13b. Recommendation 13: Use the regular airliner flights to collect in-situ atmospheric data and process this large amount of information to have near real time knowledge of conditions along flight routes. This data could be supplemented by drones specially designed to fly in more remote regions of the atmosphere.

13c. Rationale: It is possible to obtain much more comprehensive weather data both in time and location by using sensors aboard aircraft in regular flights. The collection, organization and processing of this data with quite homogeneous structure should be feasible by big data methods.

13d. Stakeholders: EU, MS, AN, AR, CA, AI, RC, UA.

13e. Relevance: Detailed weather data with higher spatial and temporal resolution is the key to achieve several objectives of timeliness and safety of aviation, like ACARE goals 5 and 15.

13f. Priority: This major improvement in geographical and temporal coverage of weather data can be of use to other sectors as well as aviation.

13g. Justification: PARE report Section 4.5 and Topic T4.6.

Chapter 5. Ensuring Safety and Security

14a. ACARE GOAL 14: *Overall, the European air transport system has less than one accident per ten million commercial aircraft flights.*

14b. Recommendation 14*: Consider accident causes by order of statistical occurrence and for each class identify and implement appropriate safeguards.

14c. Rationale: The progress in aviation safety has been remarkable and steady on a timescale of decades by progressively identifying, investigating and virtually eliminating the major causes of accidents.

14d. Stakeholders: EU, MS, AA, AN, CA, AI, RC, UA, AR.

14e. Relevance: The safest mode of transport can only benefit from being made even safer, and this requires investigating accident classes, finding corrective actions and proving that they can be implemented.

14f. Priority: This is a long-term sustained effort not a peak-and-done activity.

14g. Justification: PARE report Section 5.1.

15a. ACARE GOAL 15: *Weather and other hazards from the environment are precisely evaluated and risks are properly mitigated.*

15b. Recommendation 15*: Promote low-cost basic research on flight in adverse weather conditions (wind, rain, ash clouds, lightning, icing, storms and weather fronts) and select promising advances for demonstration.

15c. Rationale: Besides collecting higher-quality and more comprehensive weather data with higher spatial and temporal resolution (ACARE goals 5 and 13) its effects on aircraft dynamics must be modelled to identify effective prevention/corrective actions that must be simulated/validated.

15d. Stakeholders: EU, MS, UA, RC, AI, AA, AN, CA, AR.

15e. Relevance: High quality weather data and accurate knowledge of its effects on aircraft promote general timeliness of air transport (ACARE goal 5) and can prevent major accidents (ACARE goal 14).

15f. Priority: This must be a long-term sustained effort of learning from incidents how to prevent them from becoming accidents.

15g. Justification: PARE report Section 5.2 and Topic T5.1.

16a. ACARE GOAL 16: *The European air transport system operates seamlessly through interoperable and networked systems allowing manned and unmanned air vehicles to safely operate in the same airspace.*

16b. Recommendation 16.1*: Assess the evolution of air traffic capacity in Europe compared with the growth of air transport to identify the spare capacity available to other users like UAVs.

Recommendation 16.2:** Establish the qualifications required of operators of UAVs and other aircraft compared with airline pilots and air traffic controllers to ensure that aviation remains the safest means of transportation.

Recommendation 16.3:** Define the design, production, certification and maintenance procedures for UAVs and other aircraft to preserve or improve on the safety levels of current airliners that operate in the same airspace.



Recommendation 16.4: Explore the increased use of partially underused airspace to enable the expansion of operations by new types of aircraft.

16c. Rationale: The air traffic capacity needs to increase to keep up with the growth of air transport and the operation of UAV's in manned airspace will require additional capacity within the total achievable. The record of aviation as the safest mode of transportation is based on the highest engineering standards and professional qualifications as regards aircraft and cannot be compromised for UAV's operating in the same airspace. The use of partially unused airspace could provide testing area and additional capacity for UAV's to prove at least equal to manned aircraft in terms of safety, which is far from case at present.

16d. Stakeholders: EU, MS, AI, CA, RC, UA, AR, AA.

16e. Relevance: UAV's offer an immense potential to expand air operations that will be realized sooner if design and operational issues are addressed to prove they are at least as safe as manned aircraft.

16f. Priority: Is high for safety issues related to engineering standards of UAV's and qualifications of operators. Is medium for issues of sufficient airspace capacity to add UAV's as another class of users. The maturation of UAV technologies and operations to the safety standards of aircraft is the baseline fundamental effort on which other objectives depend.

16g. Justification: PARE report Section 5.3 and Topic T5.2.

17a. ACARE GOAL 17: *Efficient boarding and security measures allow seamless security for global travel, with minimum passenger and cargo impact. Passengers and cargo pass through security controls without intrusion.*

17b. Recommendation 17: Develop non-intrusive passenger screening methods and foolproof luggage checking that allow fast flow through registration, border and boarding procedures.

17c. Rationale: Unfailing detection of dangerous individuals and objects can be combined with fast and efficient passenger and luggage screening only by developing better technology at the level of detector sensitivity and data processing.

17d. Stakeholders: EU, MS, AP, AR, CA, PA.

17e. Relevance: Although passengers should understand that their safety is paramount, it is preferable not to test their tolerance and patience with intrusive and lengthy airport checking procedures.

17f. Priority: As many other issues in aviation, again a matter of sustained unrelenting effort to adopt the most recent effective technologies.

17g. Justification: PARE report Section 5.4 and Topic T5.3.

18a. ACARE GOAL 18: *Air vehicles are resilient by design to current and predicted onboard and on the ground security threat evolution, internally and externally to the aircraft.*

18b. Recommendation 18.1*: Design aircraft and establish procedures to (a) prevent unauthorised entry into the cockpit, (b) allow remote take-over up to safe landing in the case of an identified flight anomaly while (c) designing the system to be immune to the most sophisticated hacking.

Recommendation 18.2*: Set up an independent observatory of external risks to aircraft overflights to advise airlines or failing that warn passengers.



Recommendation 18.3: Design a worldwide airliner flight monitoring system and accident data recorders to ensure that accident/incident data is available regardless of time and location of occurrence.

18c. Rationale: Threats to aircraft can come not only from hijackers but also from aircrew disabilities and in some cases remote control may be the only solution that must be immune to hacking or interference. The ICAO mandated national reporting of risks to aviation safety in areas of conflict has proved inadequate in Ukraine and elsewhere, and an independent observatory is needed to advise airlines and warn passengers. The occurrence of accidents that cannot be explained or take years to be investigated should be avoided in the future by worldwide monitoring of aircraft flights and mandatory fitting of air data recorders that can survive nearly all conditions, e.g. separate from the aircraft, float in the ocean and emit location.

18d. Stakeholders: EU, MS, CA, AN, AR, AI, RES, AU.

18e. Relevance: Aircraft overflights of unsafe regions must be avoided. Interference with safe flight procedures must be prevented. If an accident occurs its causes must be known to prevent recurrence.

18f. Priority: It is imperative to prevent interference with safe flight or overflight of conflict regions. Accident investigation should be feasible even in the most extreme cases.

18g. Justification: PARE report Section 5.5 and Topic T5.4

19a. ACARE GOAL 19: *The air transport system has a fully secured global high bandwidth data network, hardened and resilient by design to cyberattacks.*

19b. Recommendation 19.1: Assess the evolution of bandwidth requirements required to cope with increasing telecommunication needs associated with improved navigation, on-board systems monitoring, passenger connection and other services.

Recommendation 19.2:** Establish evolving standards for protection against cyberattacks, with different levels, the highest for flight systems and the lowest but non-trivial for ticketing, bearing in mind the risk of intrusion from lower levels.

19c. Rationale: The increase in bandwidth is a pre-requisite for more efficient and safer air transport in such aspects as navigation and air traffic management, systems and safety monitoring and general communications. More data on more flight critical functions requires cyber protection to a higher level. The vulnerability to disruption by cyber-attacks goes to the lowest level of airline ticketing. Countering cyber-attacks at all levels also requires blocking access up to the criticality chain.

19d. Stakeholders: EU, MS, AN, AR, AP, AI, RC, UA.

19e. Relevance: Aviation has been one of the preferred targets of malicious actions that could extend from hijacking to hacking. The cyber-attacks should be prevented in the future better than hijacking has been in the past.

19f. Priority: It is important to ensure cyber resistance at all levels, and in particular flight critical systems on board and on the ground. The challenges of larger bandwidth are shared by aviation with other sectors that may be competing for the electromagnetic spectrum.

19g. Justification: PARE report Section 5.6 and Topics T5.4, T5.5 and T5.6.

Chapter 6. Prioritizing Research, Testing Facilities and Education

20a. ACARE GOAL 20: *European research and innovation strategies are jointly defined by all stakeholders, public and private, and implemented in a coordinated way with individual responsibility.*

20b. Recommendation 20:** Safeguard the long-term competitiveness of European aviation by supporting a broad program with a wide variety of low-cost applied basic research up to TRL3, to bridge the gap between the fundamental research of ERC and near-market driven focus of JUs, ensuring that Europe does not miss out the promising new ideas that could be exploited first by others to their advantage.

20c. Rationale: The EU aeronautics programme has had a remarkable growth in the allocation of resources from 36M€ in FP2 to 3.6B€ in FP7. This has been accompanied by a shift in projects from basic research (less than 1M€), to industrial cooperation (4-10M€), to large-scale demonstration (20-120M€) to the Joint Undertakings (more than 1B€). This shift to large scale near market research and development has led to a neglect of basic fundamental research essential to the long-term competitiveness of the aeronautical sector.

20d. Stakeholders: EU, MS, UA, RC, AI.

20e. Relevance: There is a large gap between the high-quality scientific research sponsored by the ERC and the market oriented near term developments of the JUs that needs to be filled by fundamental applied research with an aeronautical focus, to ensure that Europe retains a source of new ideas that are the basis of innovation and long-term competitiveness.

20f. Priority: The prosperous current state of the aeronautical sector could be undermined by a lack of long-term vision and new ideas that can be supported at a small fraction (1-3%) of what is invested in JUs.

20g. Justification: PARE report Section 6.1.

21a. ACARE GOAL 21: *Creation of a network of multidisciplinary technology clusters based on collaboration between industry, universities and research institutes.*

21b. Recommendation 21*:** The creation of multidisciplinary technology clusters requires a balanced and proportionate support of 4 levels of projects: (a) basic (3-5%); (b) collaborative industrial (15-17%); (c) large-scale demonstrators (20-30%); joint undertakings (50-60%).

21c. Rationale: A balanced aeronautical research programme should have 4 levels: (i) 50-100 basic research UA up to 1M€ each exploring up to TRL3 all sorts of novel promising ideas; (ii) 20-40 industrial research projects (4-10€) joining AI, RC, UA develop further the more prospects; (iii) 5-10 large scale demonstrators (20-100 M€) to reach practical scale on the best results at lower level; (iv) 1-2 joint undertakings (Clean Sky and SESAR) lead by industrial shorter term applications (1-2) B€. The EU FP Programs have shifted from one end to the other and should be rebalanced.

21d. Stakeholders: EU, MS, AI, AN, RC, UA, AR, AP, CA.

21e. Relevance: The technology clusters could provide the filtering of results up the basic-industrial-demonstration-development chain. The basic projects as sources as new ideas should be based on peer review by UA as the ERC. The three higher levels would be based on selection by industry to ensure the focus of larger investments.

21f. Priority: Only a balanced allocation of resources at all 4 levels can promote the new ideas and links to practical application that can sustain competitiveness from the present to the future.

21g. Justification: Section 6.2 and Topic T6.1

Remark: The recommendation 21 is a means of implementation of recommendation 20.

22a. ACARE GOAL 22: *Identification, maintenance and ongoing development of strategic European aerospace test, simulation and development facilities. The ground and airborne validation and certification processes are integrated where appropriate.*

22b. Recommendation 22: Compare (a) a list of simulation, testing and certification needs with (b) an inventory of existing facilities to identify the needs currently satisfied and those requiring upgraded or new facilities.

22c. Rationale: The large simulation and test facilities are an essential institutional support to the aeronautical industry. They represent large investments of the Member States that have been coordinated in some occasions (DNW, ETW). An overall approach should compare what is needed with what is available, to prepare a program of upgraded and new facilities.

22d. Stakeholders: EU, MS, RC, AI, AU, AN.

22e. Relevance: Duplicate facilities may be justified by high demand at European level or nationally funded objectives. Some facilities may have multiple uses besides aeronautics. The cost, maintenance and benefits (or indispensability) of facilities are essential issues.

22g. Justification: PARE report Section 6.3

23a. ACARE GOAL 23: *Students are attracted to careers in aviation. Courses offered by European Universities closely match the needs of the aviation industry, its research establishments and administrations and evolve continuously as those needs develop.*

23b. Recommendation 23*: Foster a comprehensive program of attraction of talent to aeronautics to all education levels, complemented by job satisfaction measures at professional level, with special measures to promote gender equality and increase the participation of women.

23c. Rationale: The attraction of young talent to aeronautics should focus equally on both genders, start with the fascination of flying in youngsters, and continue with access to high-quality diversified university courses, followed by challenging and interesting careers in industry.

23d. Stakeholders: EU, MS, UA, AI, RC

23e. Relevance: Aeronautics requires mostly but not only hard skills in STEM (Science, Technology, Engineering and Mathematics), that are becoming less abundant and eagerly sought by other sectors: thus aviation industry must engage promising young talent of both genders as early as possible, and sustain interest through industry visits and contact with professionals.

23f. Priority: A good talent pool exists in students and educators that must be supported to continue to provide industry with the best engineers, as countries with large population outnumber Europe in aerospace graduates.

23g. Justification: PARE report Section 6.4 and Topic T6.2

1.3 PART II – Complementary PARE Objectives

The PART II of the PARE report addresses a number of major topics related to the ACARE Goals and leads to additional PARE Objectives. The ACARE Goals and PARE Objectives are related among themselves or between each other, form complementary sets, and thus are numbered sequentially together with the associated recommendations.

Chapter 7. Aircraft Markets

24a. PARE OBJECTIVE 24: *Promote a level playing field in the large aircraft market*

24b. Recommendation 24: develop a strong legal, commercial and technical basis to (a) in any case, if necessary, deal with litigation at the WTO, and (b) preferably, if possible, renew the large aircraft agreement between the EU and the USA.

24c. Rationale: The airlines that want a competitive choice of aircraft are least interested in the Airbus-Boeing duopoly becoming a monopoly. This has not deterred the long running dispute at the WTO that may become a permanent nuisance.

24d. Stakeholders: EU, MS, AI, AR.

24e. Relevance: The distorted charges made at the WTO should not be allowed to question the fact that European success in the airline market is based on the merits of engineering quality and efficient operations.

24f. Priority: Bears in mind mean that engineering excellence is the market winner, and legal challenges should not become an obstacle.

24g. Justification: sections 7.1 and 7.2 and topics T7.1, T7.2, T7.3 and T7.5.

25a. PARE OBJECTIVE 25: *Strengthen the position of the EU in the regional aircraft market.*

25b. Recommendation 25*: Support the development of European regional aircraft in a world market with an increasing number of competitors and additionally consider synergistic tie-ups between large and regional aircraft suppliers.

25c. Rationale: the majority stake of Airbus in the Bombardier C-series renamed A220 has extended the market reach to all jet airliners above 100 seats, with Boeing-Embraer as the only major competitor. In the regional market below 100 seats, the leading position of ATR faces multiple challengers from Canada, Japan, Russia and China.

25d. Stakeholders: EU, MS, AI, RC, UA, AR.

25e. Relevance: The under 100-seat regional aircraft market is relevant both as a feeder to major hubs and as a direct link between smaller communities, both in Europe and worldwide, amounting to a large and growing market, that attracts increased competition.

25f. Priority: The leading position of ATR needs to be maintained as the number and variety of challengers increases.

25g. Justification: Sections 7.3 and 7.4 and topics 7.4 and 7.5.

26a. PARE OBJECTIVE 26: *Strengthen the position of the EU in the business jet market.*

26b. Recommendation 26*: Support the development of European business jets and their expanded use as sensor/surveillance/control platforms.

26c. Rationale: Dassault, together with Gulfstream and Bombardier, is a world leader in large business jets, and European share of the rest of the market could increase.

26d. Stakeholders: EU, MS, AI, RC, UA.



26e. Relevance: The miniaturization of electronics allows business jets to be adapted to other missions like sensor platforms, patrol and surveillance, that are high-value extensions of the baseline business jet market.

26f. Priority: This is a successful area of European aviation that needs to be sustained and could be expanded

26g. Justification: Section 7.5 and topics 7.4 and 7.5.

27a. OBJECTIVE 27: *Maintain the EU leadership in the world helicopter market.*

27b. Recommendation 27*:** Ensure that Europe keeps at least abreast of developments in high-power high-speed helicopters/convertibles with enhanced hot-and-high lift capabilities.

27c. Rationale: The USA has started a major program FVL (Future Vertical Lift) to design helicopters/convertibles with (i) twice the range, (ii) 50% higher speed, (iii) over twice the hover payload in demanding hot and high conditions, using engines with double power but similar fuel consumption, size and weight. Although it is military program it could have civil spinoffs: (i) double-range for off-shore oil exploration; (ii) higher speed for medical emergencies and executive transport; (iii) greater payload for rescue and transport missions. All this could challenge the position of Europe with over 50% of the world helicopter market.

27d. Stakeholders: EU, MS, AI, RC and UA.

27e. Relevance: The FVL program in the USA is justified by the need to counter threats from near peer adversaries in Europe and elsewhere: hence it is relevant to the defence of Europe. The implications in the civil market could be to reverse the tables passing dominance from Airbus Helicopters and Agusta-Westland to Bell and Sikorsky. The FVL contenders are the Valor tilt-rotor from Bell and Defiant dual rotor plus pusher-propeller helicopter from Sikorsky; Europe has analogues in the Augusta-Bell AB609 and Airbus X3 that holds the world helicopter speed record, and competitive turboshaft engines from Turbomeca and Rolls-Royce.

27f. Priority: There is a need for a program with a minimum investment to ensure that Europe does not fall behind. It is not necessary to match the massive US funding of FVL. The result of FVL could be as expensive as the Bell V-22 Osprey with small effect on the market; or it could like the RAH-66 Comanche lead to no significant production after years and billions of investment. The aim here is to safeguard against potential surprise breakthroughs that could change the European leading market position without making large speculative investments.

27g. Justification: PARE report Section 7.6 and topics 7.5 and 7.6.

28a. PARE OBJECTIVE 28: *Provide an European alternative to the drones used in Europe with potential to also enter the world market.*

28b. Recommendation 28*:** Leverage the technological capabilities demonstrated in several prototype drones into a coherent European Programme covering all levels, to satisfy internal needs and complete in the world market.

28c. Rationale: The market for MALE (Medium Altitude Long Endurance) drones is a sad example of lack of coordination in Europe: (i) of several prototype programs (Taranis in the UK, Mako in Germany, Hammerhead in Italy, Neuron Multinational led by France) none has yet reached operational status; (ii) in the meantime several European nations have bought American drones; (iii) in the international market China has emerged as the major competitor of the US through lower prices and less export restrictions.

28d. Stakeholders: EU, MS, AI, RC, UA.



28e. Relevance: Europe has the technology to develop all classes of UAVs that are increasingly relevant to a wide range of defence and civil missions, so the issue is one of coordination in the allocation of resources.

28f. Priority: There must be an end to the European dependence on foreign UAVs, and a move to enter the international market, since there is the technology to achieve both targets.

28g. Justification: PARE report Section 7.6.

Chapter 8. Emerging Aviation Technologies

29a. OBJECTIVE 29: *Keep the EU at the forefront of progress in the electrification of aircraft.*

29b. Recommendation 29*:** Make a thorough assessment followed by support measures on (a) emerging electric systems and propulsion technologies, (b) their potential to satisfy mission requirements and (c) the likely evolution of both.

29c. Rationale: Although the automobile sector may lead the electrification of transport vehicles, the specific needs of aeronautics and fast technological evolution will have increasing importance from drones to airplanes.

29d. Stakeholders: EU, MS, AI, RC, UA, AR.

29e. Relevance: Small electric drones, emerging electric air taxi, more electric airliners with bleedless engines and advances in electric propulsion and systems all point towards increasing electrification.

29f. Priority: Progress in electrification is rapid and although major market impact could be years away those caught unprepared may take a long time to catch-up.

29g. Justification: PARE report Section 8.1.

30a. PARE OBJECTIVE 30: *Promote and exploit advances in additive manufacturing.*

30b. Recommendation 30*: Consider the implications on prototyping, series production and spares supply of additive manufacturing regarding (a) usable materials, (b) quality standards and (c) life-cycle costs.

30c. Rationale: Although additive manufacturing is an industry wide activity, aeronautics may be the leader in some areas and should keep up with progress in other areas.

30d. Stakeholders: EU, MS, AI, RC, UA, AR, CA.

30e. Relevance: Additive manufacturing allows the production of complex pieces with less parts and could replace spare part inventories with local production, as limitations in series production, choice of materials and quality finish are overcome.

30f. Priority: Aeronautics needs to benefit from general progress and lead only where necessary.

30g. Justification: PARE report Section 8.2.

31a. PARE OBJECTIVE 31: *Incorporate the experience from other sectors to achieve more efficient and economical production in aeronautics.*

31b. Recommendation 31*: Consider the best combination of 4.0 technologies, including automation and information, as applicable to various production rates and scales of equipment in aeronautics.



31c. Rationale: Aeronautics can benefit from 4.0 technologies, especially by integrating the full life-cycle design-production-operation-maintenance.

31d. Stakeholders: EU, MS, AI, AR, CA, RC, UA.

31e. Relevance: The 4.0 factory requires significant investment and reliance on big data and artificial intelligence and could lead to reduction on development time and cost of production and operation.

31f. Priority: Aeronautics is a user more than a leader except in specific areas with the large-scale integration over a long-life time as the main issue.

31g. Justification: PARE report Section 8.3 and topic 8.1.

32a. PARE OBJECTIVE 32: *Provide the telecommunications capacity needed for connected aircraft, navigation, monitoring and other services.*

32b. Recommendation 32*: Assess the growth of capacity needs for navigation, systems monitoring and passenger services, and how the required bandwidth can provide free from unintended or malicious interference.

32c. Rationale: Increases in air traffic capacity and safer and more efficient aircraft operations will require increased data sharing and larger telecommunications bandwidth protected from unintended or malicious interference.

32d. Stakeholders: EU, MS, AN, AR, AI, RC, UA, AP.

32e. Relevance: The growth of air traffic and progress in safety plus passenger services may require more than proportional increases in data sharing and telecommunications.

32f. Priority: This is an issue for society in general, with particular incidence in aviation.

32g. Justification: PARE report Section 8.4 and topic 8.2.

33a. PARE OBJECTIVE 33: *Monitor threats in cybersecurity and devise timely protection for all levels of aviation systems.*

33b. Recommendation 33:** Consider the levels of cyber protection needed for the various aeronautical activities, and how to monitor and counter threats.

33c. Rationale: The informatics incidents at specific air traffic control facilities and with airline reservation systems suggest possible vulnerabilities that could be also exploited in malicious attacks.

33d. Stakeholders: EU, MS, AN, AR, AP, AI, CA.

33e. Relevance: Security in aviation would be enhanced by a comprehensive cyber protection system with several levels, highest for flight critical tasks and lowest for commercial ticketing.

33f. Priority: The consequences if cyber-attacks have been seen elsewhere, aviation in the past has been a preferred target of malicious actions and thus preventive measures are desirable.

33g. Justification: PARE report Section 8.5 and topics 8.3 and 8.4.



34a. PARE OBJECTIVE 34: *Assess the implications in aeronautics of advances in big data, including the use of what is already available.*

34b. Recommendation 34*: Consider the expected benefits versus the required investment in using big data techniques in aeronautical activities for which relevant data already exists or has to be newly sourced.

34c. Rationale: Large amounts of systems data are already recorded by aircraft in flight and its use for maintenance, safety or other purposes could be enhanced.

34d. Stakeholders: AR, AN, AP, EU, MS, AI, RC, UA.

34e. Relevance: More benefit could be taken out of currently collected data and there is the prospect of gathering more data with a well targeted strategy.

34f. Priority: This is part of a global trend shared by aviation.

34g. Justification: PARE report Section 8.6 and topics 8.5, 8.6 and 8.7.

35a. PARE OBJECTIVE 35: *Assess the potential benefits and risks of the use of artificial intelligence in aeronautics.*

35b. Recommendation 35*: Identify the situations in aeronautics in which the learning processes of Artificial Intelligence can be efficient and safe and distinguish those where there is limited training material or potential dependence on imagination.

35c. Rationale: Artificial Intelligence has the advantage of systematic learning from large amounts of data ('Artificial Imitation') but lacks any form of imagination when facing untrained situations.

35d. Stakeholders: EU, MS, AI, RC, UA, AR, AN, AP.

35e. Relevance: The use of artificial intelligence can lead to much more efficient and reliable implementation of known tasks, but care is needed concerning unforeseen or untrained situations, when it cannot replace human imagination, resourcefulness or true and real intelligence.

35f. Priority: Part of a general trend that aviation may share without losing an eye on risks.

35g. Justification: PARE report Section 8.7 and topics 8.8 and 8.9.

36a. PARE OBJECTIVE 36: *Assess the implications on aircraft design, certification, operation and maintenance of new developmental and breakthrough materials and structures.*

36b. Recommendation 36:** Consider the progress in advanced materials like composites, ceramics and special alloys and also the prospects of less mature developments like nanotube structures and other nanotechnologies.

36c. Rationale: Progress in material, structures and production methods has a main steady gradual element (composites, ceramics, alloys) and there is also a potential for revolutionary breakthroughs (nanotube structures, microelectromechanical devices).

36d. Stakeholders: AI, RC, UA, EU, MS, AR, CA.

36e. Relevance: Research on materials, structures and production is a major topic, and a complement is some forward look on the maturation of long-term prospects.



36f. Priority: Maintaining current high level of activity perhaps with a little more emphasis on promising developments still lacking maturity.

36g. Justification: PARE report Sections 8.8 and 8.9, and topics 8.10, 8.11, 8.12 and 8.13.

Chapter 9. Cooperation beyond Europe's borders

37a. PARE OBJECTIVE 37: *Promote the seamless compatibility of Air Traffic Management (ATM) systems worldwide, across continents and oceans.*

37b. Recommendation 37:** Support cooperation between SESAR in Europe and NextGen in the US to ensure compatibility across the North Atlantic and provide the basis for progress in the world ATM market as the growth of air travel increases capacity needs elsewhere.

37c. Rationale: Air Traffic Management is the major potential bottleneck to the growth of aviation on a global scale, with particular incidence in developed regions with dense traffic like Europe and Eastern US, but gradually spreading to other regions.

37d. Stakeholders: EU, MS, AN, AR, AP, AI, RC, UA.

37e. Relevance: Air Traffic Management should be seamless across continents and oceans, and the needed increases in capacity combined with safety and security are a major market for equipment suppliers in areas of European leadership

37f. Priority: It is essential to avoid the congestion and delays of the past and cope with traffic growth and new users like UAVs

37g. Justification: PARE report Section 9.1 and topic 9.1 and 9.2.

38a. PARE OBJECTIVE 38: *Promote harmonized certification standards worldwide as already exist in other sectors to ensure the growth of aviation as the safest mode of transport.*

38b. Recommendation 38*:** Strengthen the cooperation of EASA/FAA on common certification standards and their adoption worldwide to avoid duplication or degradation in specific regions.

38c. Rationale: The coordinated and mutually accepted certification by either the FAA and EASA is a major breakthrough in avoiding costly duplication and preventing misuse of certification as a trade barrier. The Russian example of local certification is being followed by China, whose aircraft have faced long delays and major difficulties in obtaining EASA or FAA certification. Resorting to 'local certification' leads to lower safety standards that can affect not only locals but also Europeans travelling in those countries. The export of such EASA/FAA uncertificated aircraft could damage the unique overall safety record of aviation.

38d. Stakeholders: The EU and MS, possibly with US coordination, since there is a common interest in supporting EASA/FAA standards.

38e. Relevance: The EU and MS could insist on cooperation with China and Russia being conditional on progress towards worldwide certification standards. Although aircraft not certificated by EASA or FAA cannot operate in Europe, US or other developed regions their use as cheap unsafe transport elsewhere cannot be encouraged and puts European visitors at risk.

38f. Priority: It is prudent to prevent the emergence of a parallel market of local or third world aviation with degraded safety standards that are already lower elsewhere than in Europe/US. Will require diplomatic and negotiation skills.

38g. Justification: PARE report section 9.2 and topics 9.6 and 9.7.

39a. PARE OBJECTIVE 39: *Minimize the effects of aviation on the environment on a global scale.*

39b. Recommendation 39:** The reduction of environmental effects of aviation in a global scale should be a key point in the EU cooperation with other countries.

39c. Rationale: The EU has played a leading and exemplary role as champion of environmental protection in all areas including aviation and this is a worthy effort to pursue.

39d. Stakeholders: EU, MS, AN, CA, AI, RC, UA, AP.

39e. Relevance: Although aviation is not the biggest polluter in general or among means of transport the objective should be to reduce its percentage by doing better than average progress.

39f. Priority: There is already a significant effort, although airport noise and en-route emissions are increasing concerns.

39g. Justification: PARE report Section 9.3 and topic 9.5.

40a. PARE OBJECTIVE 40: *Promote aviation safety worldwide including for European and other passengers flying with non-European airlines.*

40b. Recommendation 40: Support activities raising the aviation safety standards to more uniform high levels across the globe, in particular helping the improvement of airlines banned from flying into Europe that may still carry European passengers elsewhere.

40c. Rationale: The differences in aviation safety standards among airlines from different countries justify banning some from flying into Europe, and the provision of some technical assistance could help lifting the bans and improving safety in less developed regions.

40d. Stakeholders: EU, MS, CA, AN.

40e. Relevance: Besides ensuring safety (and security) of air travel in Europe it is desirable to promote similar standards in less developed regions of the world, both for the locals and for the European business or leisure travel.

40f. Priority: This is an extension of current preventive bans to cooperative improvement for non-European airlines and aviation authorities.

40g. Justification: PARE report Section 9.4 and topics 9.6 and 9.7.

41a. PARE OBJECTIVE 41: *Promote aviation security worldwide, including at airports and destinations frequently used for European business and holiday travel.*

41b. Recommendation 41: Support high security levels at airports outside Europe by cooperating with authorities eager to keep European business/tourism travel, and otherwise warn travellers of risk.

41c. Rationale: European travellers may be at greater risk when travelling in less developed regions where extremist groups target aviation and foreigners and thus support to cooperative local authorities is important to boost security.



41d. Stakeholders: EU, MS, CA, AP, AI.

41e. Relevance: Local authorities in third world countries may have an interest in attracting business and tourism and welcome assistance in making foreigners and their own citizens safer.

41f. Priority: This is a continuous, gradual and moderate effort.

41g. Justification: PARE report Section 9.5 and topic 9.8.

42a. PARE OBJECTIVE 42: *Promote as far as possible an open and fair market for aircraft at least in the civil sector.*

42b. Recommendation 42: The advances in efficiency and compliance with the highest environmental, safety and security standards can contribute to a competition based on quality rather than other interests.

42c. Rationale: Making available safe and efficient aircraft may help undermine protectionist and biased local choices.

42d. Stakeholders: EU, MS, AI, RC, UA.

42e. Relevance: Promoting a level playing field is not easy and desirability and quality may function in a more effective and subtle way than harsh political pressures.

42f. Priority: It is a matter of good business practice.

42g. Justification 43: PARE report Section 9.6 and 9.7 and topics 9.9 and 9.10.

Chapter 10. Attracting Young Talent to Aeronautics

43a. PARE OBJECTIVE 43: *Stimulate the interest of children with entertaining stories about flying.*

43b. Recommendation 43: Make available on-line and accessible to primary schools and parents, children stories and cartoons involving flying that are both entertaining and educational.

43c. Rationale: Flying and space can be fascinating subjects for children and can be used to make interesting stories.

43d. Stakeholders: EU, MS, AI, families, primary schools.

43e. Relevance: In the history of aviation many of the pioneers and major contributors started their interest at an early age.

43f. Priority: Normal activity to be sustained.

43g. Justification: PARE report Section 10.1 and 9.7 and topics 10.2 and 10.3.

44a. PARE OBJECTIVE 44: *Motivate secondary school students to choose university degrees in aerospace engineering.*

44b. Recommendation 44.1: Make available from the early teens, on-line and to secondary schools, a set of easy to implement flight experiments and challenges such as drones now so commonplace and cheap.

Recommendation 44.2*: Give secondary school students at later stages the opportunity to come to presentations and laboratories at a university, together with a parent/mentor or trusted friend.



44c. Rationale: There are readily available inexpensive ‘toy’ drones that give real flying experience and can teach also responsible use. Complemented by visits to university laboratories and presentations this would continue to attract good candidates of both genders.

44d. Stakeholders: EU, MS, UA, secondary schools, families, friends.

44e. Relevance: Given the variety of university degrees that university candidates can choose from and the demands of ‘hard skills’ in STEM (Science, Technology, Engineering and Mathematics) aeronautics can attract the best as a combination of advanced technologies with bright future prospects.

44f. Priority: In addition to suitable dissemination, the visits to universities with aeronautical education can make all the difference in attracting the best candidates.

44g. Justification: PARE report Section 10.2 and topic 10.3.

45a. PARE OBJECTIVE 45: *Attract the brightest graduates in aeronautical engineering to industry before they are lured away by attractive, well-paid offers elsewhere, e.g. by consultant and financial services.*

45b. Recommendation 45:** Provide industrial stays for students of aeronautical engineering with mentoring that values their skills and keeps track of the most promising for employment after graduation.

45c. Rationale: in order to attract bright graduates in aeronautical engineering with many alternative enticing job offers, industry and other employers should engage them at an early stage through professional stays and follow-up with attractive job offers without delay after graduation.

45d. Stakeholders: EU, MS, AI, RC, UA, AN, AR, AP.

45e. Relevance: The strong analytical and problem-solving skills of the graduates from the best aerospace engineering degrees are in much demand from other sectors in and out of engineering, so the aeronautical industry cannot afford to be slow in attraction measures.

45f. Priority: Attracting the best engineers is the key to progress in aviation, and an absolute must if Europe wants to remain a leader as other developed (US, Japan, Canada) or more populous (China, India) or lower cost (Russia, Brazil) regions strengthen their competitive challenge.

45g. Justification: PARE report Section 10.3 and topics 10.4 and 10.5.

46a. PARE OBJECTIVE 46: *Make careers in aeronautical industry interesting relative to other alternatives by focusing on fascinating technology with adequate reward.*

46b. Recommendation 46: Bring an aeronautical engineering student together with a mentor/relative/trusted friend to a one-day visit to industry to be remembered for life as a career choice.

46c. Rationale: An in-depth one-day visit to industry with briefings and access to facilities can be a day to be remembered for life and make a career decision. The company of a mentor/relative/trusted friend can play a major role in advising a mature choice.

46d. Stakeholders: EU, MS, AI, RC, UA, AN, AR, AP, PA, other employers.

46e. Relevance: Perhaps the most important question when choosing a career is “What will I do or be my work?” and convincing answers with supporting evidence is the best reply.



46f. Priority: This kind of initiative already exists and the idea of a memorable one-day visit could be expanded.

46g. Justification: PARE report Section 10.4 and topics 10.6 and 10.7.

47a. PARE OBJECTIVE 47: *Motivate and reward the workforce to promote dedication, ingenuity, efficiency and loyalty.*

47b Recommendation 47: Give employees opportunities for innovation, let them share important and interesting work, and recognise their contribution to the success of the company.

47c. Rationale: Giving opportunities for the workforce to be creative and proactive rewards the commitments of employees, creates links with a receptive management and promotes the prosperity of the enterprise.

47d. Stakeholders: EU, MS, AI, RC, UA, AN, AR, AP, CA.

47e, Relevance: The best way to keep a skilled and up-to-date workforce is to follow-up on their initiatives for progress with suitable mature support.

47f. Priority: Should be normal company practice and is well worth reminding and keeping in mind.

47g. Justification: PARE report Section 10.5 and topics 10.8 and 10.9.

48a. PARE OBJECTIVE 48: *Retain a capable and faithful workforce by providing stable employment, interesting work, reliable benefits and a friendly environment.*

48b. Recommendation 48: A worthwhile alternative to job mobility is to have competent staff, able to adapt to change and to contribute to progress, sufficiently well integrated not to wish other careers and serve as example to relatives and friends.

48c. Rationale: As an alternative to the modern high-mobility, short-term employment, and not excluding intermediate cases, there is nothing wrong with the old model of a company-family which support a dedicated workforce with long experience and attracts the next generation.

48d. Stakeholders: EU, MS, AI, UA, AR, AN, AP, CA, other employers.

48e. Relevance: The maintenance of a faithful long-experienced workforce can also attract new ideas and support further recruitment by proving a stable and progressive environment for progress.

48f. Priority: Should be normal company practice worth keeping.

48g. Justification: PARE report Section 10.6 and topics 10.10 and 10.11.

Chapter 11. Increasing the Participation of Women in Aerospace

49a. PARE OBJECTIVE 49: *Counter family and societal bias discouraging girls from interest in vehicles, be it cars or planes.*

49b. Recommendation 49: Make available on the internet and to primary school's children stories and cartoons where girls drive cars and fly aeroplanes as much as boys do and let them play with vehicle models or ask for them as presents.

49c. Rationale: The bias since childhood that "girls play with dolls and boys play with cars/planes" needs to be countered by gender neutral stories about boys and girls flying or collaborating in making origami' planes.



49d. Stakeholders: EU, MS, primary education, families, friends.

49e. Relevance: Flying has always been an inspiration for mankind from childhood through adulthood to old age, regardless of gender.

49f. Priority: This should be a normal steady activity.

49g. Justification: PARE report Section 11.1 and topics 11.1 and 11.3.

50a. PARE OBJECTIVE 50: Give girls and boys in primary schools the same opportunities to choose their games and entertainment.

50b. Recommendation 50: The primary and secondary school programmes and activities could include flight experiments equally accessible to boys and girls.

50c. Rationale: Gender bias may be countered in a natural, non-dramatic, non-political fashion by simple neutral education since primary school by providing educators with suitable material that is attractive to children of both genders.

50d. Stakeholders: EU, MS, primary schools, families.

50e. Relevance: The best way to avoid problems is not to create them by adopting a neutral attitude, and this also applies to gender in the education of children.

50f. Priority: Should be normal primary school practice and deserves further encouragement.

50g. Justification: PARE report Section 11.2 and topic 11.5.

51a. PARE OBJECTIVE 51: Encourage more girls to take aeronautical engineering degrees.

51b. Recommendation 51:** Reinforce and accelerate this slowly growing trend by visits to universities and industry, role models of success stories and the same fascinating technologies.

51c. Rationale: The measures to attract young talent to aeronautical careers are similar and some extra effort needs to be put in compensating gender bias.

51d. Stakeholders: EU, MS, UA, AI, RC, PA, other educators and employers.

51e. Relevance: Women perform at least as well as men in aeronautical engineering degrees and enlarge the talent pool both in quantity and diversity.

51f. Priority: There is a vast potential of talent that is only modestly tapped.

51g. Justification: PARE report Section 11.2 and topic 11.5.

52a. PARE OBJECTIVE 52: Provide women with attractive careers in aeronautics in industry and academia.

52b. Recommendation 52: Make all aspects of job recruitment, from the announcements, to the interview, to the benefits, gender equal, and try to compensate for eventual gender differences.



52c. Rationale: The outdated lingering view that aviation is a job for men except for attendants should be countered by recruiting campaigns that are carefully gender neutral and cleverly undermine any gender bias.

52d. Stakeholders: EU, MS, AI, RC, UA, PA, AN, AR, AP.

52e. Relevance: Women bring similar competence and different skills and having both genders is a human resources asset.

52f. Priority: Should be normal practice and offers scope for improvement

52g. Justification: PARE report Section 11.3 and topic 11.8.

53a. PARE OBJECTIVE 53: Discourage and prevent continuation of abuse based on gender.

53b. Recommendation 53*: Take gender abuse as seriously as gross incompetence or major financial misconduct as concerns the consequences and leave no doubts on anyone's mind about this policy.

53c. Rationale: The activity of a company and its hierarchical structure should not tolerate gender abuse as much as it should not tolerate gross incompetence or financial fraud.

53d. Stakeholders: EU and MS legislations, AI, RC, UA, PA, AR, AN, AP, all other employers.

53e. Relevance: The tendency to ignore gender abuse or look the other way if it comes from up the chain are among the examples of non-acceptable attitudes.

53f. Priority: This is a human rights issue that is a fundamental principle.

53g. Justification: PARE report Section 11.3.

54a. PARE OBJECTIVE 54: Ensure that the protection of family, maternity and parenthood is effectively implemented with its legal basis as a minimum.

54b. Recommendation 54: Take family, maternity and parenthood in consideration in the assignment of tasks and giving a suitable working environment.

54c. Rationale: In addition to faithfully implementing the legislation on the protection of family more can be done by goodwill towards dedicated employees.

54d. Stakeholders: EU, MS, employers in general.

54e. Relevance: Respect for family values and culture should be part of company ethics.

54f. Priority: Normal practice to be encouraged.

54g. Justification: PARE report Section 11.3.

55a. PARE OBJECTIVE 55: Give equal recognition of achievements regardless of gender, taking into account the circumstances.

55b. Recommendation 55: Avoid direct and reverse discrimination or bias by judging and rewarding achievements in an even, transparent and fair way, that is not seen as gender bias.



55c. Rationale: Perhaps the best way to achieve gender balance is to avoid direct or reverse discrimination and to recognise and compensate for legitimate differences.

55d. Stakeholders: EU, MS, employers in general.

55e. Relevance: Women need no favours, only fair and equal treatment so that their merits are recognised and cannot be dismissed as reverse discrimination.

55f. Priority: Should be normal practice and it is still not always the case.

55g. Justification: PARE report Section 11.3.

56a. PARE OBJECTIVE 56: *See the differences between the genders as an opportunity for a symbiosis of distinct talents that furthers smooth progress.*

56b. Recommendation 56: Assign positions and tasks using the best talents and skills available in both genders to promote creativity and efficiency.

56c. Rationale: The equality of men and women does not exclude different talents that bring most benefit in a symbiotic collaboration.

56d. Stakeholders: EU, MS, all employers.

56e. Relevance: Choosing the right person on team for the task should be based not only on experience but also the balance of skills in which gender can be one of many factors.

56f. Priority: Should be normal practice.

56g. Justification: PARE report Section 11.3.

57a. PARE OBJECTIVE 57: *Increase the participation of women in aeronautics in the most effective way.*

57b. Recommendation 57: The greater numbers of women in aeronautics should be regarded as not just as a numerical enlargement of the workforce but also as a broadening of the talent available.

57c. Rationale: The rationale for the increased participation of women in aeronautics is not just a potential increase in numbers but also an opportunity for broader individual and team skills.

57d. Stakeholders: EU, MS, AI, RC, UA, other employers.

57e. Relevance: A broad view of the added talent brought by more women in aeronautics is needed to obtain the greatest benefit.

57f. Priority: A general policy issue.

57g. Justification: PARE report Section 11.3 and topic 11.2.

58a. PARE OBJECTIVE 58: *Recognise the historic achievements of women, including in aeronautics, in biased or unfavourable circumstances.*



58b. Recommendation 58*: Consider the lives of outstanding women, including aviators and astronauts, not only from a biographical point of view but also recognising the challenges they had to overcome to realise their achievements.

58c. Rationale: The achievements of great women in aeronautics and the gender unequal challenges they had to overcome are an indicator of the obstacles that should be removed

58d. Stakeholders: EU, MS, employers

58e. Relevance: The role models serve as example for women who should be assured to have more of a gender equal treatment.

58f. Priority: It is an activity to counter unfounded and untrue preconceptions that could reduce the value of women contributions to aeronautics.

58g. Justification: PARE report Section 11.3 and topics 11.11 to 11.14.

1.4 Conclusion

The ACARE Goals and PARE Objectives are complementary:

- The ACARE Goals state broad aims, and deliberately do not detail how to achieve them, since there are many possible contributions that can be used;
- The PARE Objectives detail some specific measures that could contribute to ACARE Goals without excluding other alternatives or complementary measures.

Thus, the ACARE Goals provide the broad overall justification of an aeronautics activity, and the PARE Objectives contribute to a more detailed work plan that will include additional ideas.

The 23 ACARE goals with 32 recommendations and 35 PARE objectives with 36 recommendations add to 58 initiatives with 68 recommendations.

While it would be easy to give many high priorities, this would not be helpful and would defeat the very purpose of prioritization.

To enforce some discipline for each of the sets of ACARE goals and PARE objectives as indicated in the following table, the highest priority of 3 asterisks was limited to 4, plus 6 two asterisks, 10 one asterisk and the rest no asterisks to total 68 recommendations.

Initiatives for Horizon Europe 23 + 35 = 58	ACARE Goals 23	PARE Objectives 35
Highest Priority *** 4+4=8	1, 6, 9.1, 21	27, 28, 29, 38
Very High Priority ** 6+6=12	7, 9.3, 16.2, 16.3, 19.2, 20	33, 36, 37, 39, 45, 51
High Priority * 10+10=20	2, 3, 4, 9.2, 14, 15, 16.1, 18.1, 18.2, 23	25, 26, 30, 31, 32, 34, 35, 44.2, 53, 58

Medium Priority 12+16=28	5.1, 5.2, 8, 9.4, 10, 11, 12, 13, 16.4, 17, 18.3, 19.1, 22	24, 40, 41, 42, 43, 44.1, 46, 47 48, 49, 50, 52, 54, 55, 56, 57
Total Recommendations 68	32	36

Table 1.1 Assignment of priorities to the 23 ACARE Goals and 35 PARE objectives