FVA - Identified Research & Development Questions

Through FVA's activities numerous research and development questions have been identified that are relevant for the aviation sector. Some of these may serve as topics for short FVA analyses (e.g. within a thesis lab) and/or future Think Tank sessions, while others could be explored independently or outside or the timeline of the FVA project.

This document gives an initial list of questions which are currently being reviewed internally. More topics, as well as prioritization of the listed topics, are expected to be identified and discussed during future Think Tank sessions, validation workshops, and other FVA activities.

In summary, the following research and development questions have been identified. More detailed information can be found in the Appendix – detailed information on the identified topics.

Category	Research questions
Implementation of Alternative Aviation Fuel (SAF)	Is Aviation's Carbon Revenue Enough to accelerate the sustainability transition, such as the transition to SAF?
	Which emerging synthetic blending component (SBC) production technologies have the potential to increase the production of SAF?
	How can we overcome (current) barriers for SAF blending above 50%?
	What is the impact of the state aid framework in funding local SAF production?
Implementation of Hydrogen / Hydrogen-powered aircraft	How should a LH2 refueling system be designed, both to and on the airport, which is safe, and capable of high flow rates?
	How to design an aviation certified tank & distribution system for liquid hydrogen storage aboard aircraft?
	How might cryogenic components be mechanically assembled in an aircraft environment?
	How might two-phase flow instabilities in hydrogen-powered aircraft systems be mitigated?
	What are the main drivers affecting the depressurization phase performance of tanks aboard hydrogen powered aircraft?
	How can split propulsion and multi-fuel combustion concepts facilitate the transition towards hydrogen powered and more sustainable aviation.
Electric-powered aviation	Techno-economic assessment of future networks employing electric aircraft.
	How to effectively recycle batteries?
	What role could batteries play towards more sustainable aviation?
Smart Energy Airport	Should airports have to become energy hubs? If so, what is needed for that?
	How should energy production, storage and supply systems be designed to deliver the required energy (quantity and form) at the right location and time?
	What are promising and creative ways to store and transfer energy?
Future traveler needs	What does the Cabin of the Future look like, considering a passenger centric view?
	Which passenger trends are shaping the future of air travel?

Version Dec 2025. This document is a work in progress and presents an initial list of identified topics. It will be updated throughout the course of the FVA project. FVA is part of the National Growth Fund Project "Luchtvaart in Transitie" and is funded by the European Union – Next Generation EU

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Energy reduction & circularity	How to reduce the environmental impact, particularly the non-CO2 emissions, of a flight?
	How can rotor & fan designs be optimized to increase propulsive efficiency, while overcoming key challenges such as bird strikes, noise reduction, and maintenance requirements?
	How might disruptive aircraft configurations, such as Blended Wing Bodies (BWB) be designed in the future, and what operational-, infrastructure-, and regulatory changes are required to support integration in the aviation system?
	How can existing advanced integrated sensor technologies be effectively and durably embedded within advanced aerospace materials, such as composites or else, to create a self-monitoring structural network that enables real-time, predictive maintenance by 2050?
	How might the development and implementation of a Materials Digital Passport (MDP), specifically a digital substances and formulation passport, effectively enhance safety and promote circularity in the aerospace industry simultaneously?
	How might changes in the early development phases lower the energy consumption of production?
	How might AI aid inline monitoring in additive manufacturing processes?
	Intelligent manufacturing process chains: how to create a green global industrial system?
	How can the use of quantum computing for simulation of bio-species leverage the use of bio-materials
Regulatory boundaries / policy	How do Legal and regulatory barriers to electric, hydrogen, or hybrid aviation, influence the sustainable transition of aviation?
	How do 'Eco branding' and regulatory inventions such as the EU Flight Emissions Label in aviation competition act as a market differentiator?
	How does the Green Deal actually influence competitiveness in aviation, given the objective to decarbonize?
General FVA topics	How might "Next Gen Roadmapping" look like; what dynamic decision-making tools towards the decarbonisation of aviation might be developed?
	How can public/shared tech validation facilities accelerate the development of new products service systems for sustainable aviation, both from a technological, societal, and financial perspective?
	What is needed to support and accelerate certification of emerging concepts and innovations contributing to sustainable aviation by 2050?

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Appendix – detailed information on the identified topics

Implementation of Alternative Aviation Fuel (SAF)

R&D question	**Is Aviation's Carbon Revenue Enough to accelerate the sustainability transition, such as the transition to SAF?**
Description	To commit to achieving climate neutrality by 2050, the EU implemented regulations such as the EU Emissions Trading System (EU ETS), a "cap and trade" principle, generating significant revenue through the auctioning of emission allowances. The EU and individual Member States, such as the Netherlands, are exploring various mechanisms to reinvest the revenue from the EU ETS back into the sector to accelerate the sustainability transition, such as transitioning to SAF. **Sub research question(s):** - How are current EU Emissions Trading System (EU ETS) auction revenues (historical and projected) reinvested in the sector, such as in SAF production or developing new technologies, such as electric aircrafts or hydrogen aircrafts? - What are investments needed to meet climate goals? Develop a reinvestment model that illustrates how this financial yield can create a self-sustaining cycle of innovation and adoption. - What are key financial and policy bottlenecks in the reinvestment loop? - Why is private debt financing for new SAF plants hesitant? Are there any policy inconsistencies or regulatory hurdles between EU-level mandates and national implementation?
Linked to FVA topic / Work package (WP)	General topic WP2: Implementation of Novel Energy Carriers
Where/when identified	Topic identified by NLR. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	Policy makers, energy suppliers, OEMs, investors, airlines
Potential next steps	It's a potential topic for a short FVA study/analysis

R&D question	**Which emerging synthetic blending component (SBC) production technologies have the potential to increase the production of SAF?**
Description	**Sub research question(s):** - Which SBC production technologies are emerging and seeking approval with ASTM? (ASTM = American Society for Testing and Materials) - What is the basic concept of these technologies? - What makes these technologies different from those that are certified? - What is the potential for each technology to contribute to decarbonisation of aviation?
Linked to FVA topic / Work package (WP)	- General topic - WP2: Implementation of Novel Energy Cariers
Where/when identified	Topic identified by NLR. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	Energy suppliers, airlines, regulators, knowledge institutes
Potential next steps	It's a potential topic for a short FVA study/analysis

R&D question	**How can we overcome (current) barriers for SAF blending above 50%?**
Description	At the moment aviation fuel specifications, developed by ASTM, allow for a maximum of 50% blending of synthetic blending components (SBCs) in conventional aviation fuel (CAF) to produce SAF. Current SAF mandates in the European Union, namely ReFuelEU Aviation, go beyond 50% blending, with a mandate of 70% SAF in 2050. Additionally, recent studies have confirmed that using a high SAF blend on one flight leads to a higher climate impact reduction, than using a low SAF blend on multiple flights, while keeping the total SAF amount constant **Sub research question(s):** - What are the (current) barriers for SAF blending above 50% and do they apply to all SBCs? - How could these barriers be removed? - What can individual stakeholders do to help overcome the barriers?
Linked to FVA topic / Work package (WP)	General topic WP2: Implementation of Novel Energy Carriers
Where/when identified	Topic identified by NLR. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	Energy suppliers, airlines, regulators
Potential next steps	It's a potential topic for a short FVA study/analysis

R&D question	**What is the impact of the state aid framework in funding local SAF production?**
Description	It is interesting to conduct a critical assessment of the State aid framework in funding local SAF production in the regions, noting that airlines will need to 'uptake' SAF not only at major hubs but also at smaller regional airports. Ensuring equivalent access to SAF at these airports is vital, as differences can affect competition, and EU State aid rules already set distinct conditions for airports of different sizes.
Linked to FVA topic / Work package (WP)	FVA general topic WP2: Implementation of novel energy carriers
Where/when identified	Identified by Leiden Law School. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	Energy suppliers, airports, regulators
Potential next steps	It's a potential topic for a short FVA study/analysis

Implementation of Hydrogen / Hydrogen-powered aircraft

R&D question	**How should a LH2 refueling system be designed, both to and on the airport, which is safe, and capable of high flow rates?**
Description	Many airports have set goals to be climate neutral in 2050. Airports therefore need to investigate which (big) infrastructure changes are required to accommodate novel energy carriers, hydrogen being one of them. It's therefore key to address how LH2 get transported to the airport stands. There are different ways this can be done, for instance via trucks or pipelines, each having its pros and cons. Keeping the LH2 at a temperature of -253 degrees Celcius is key and considered to be a big challenge. Furthermore, boil-off needs to be addressed adequately. **Sub research questions:** - What are effective ways to transport LH2 from the production site towards the aircraft stands? - How to effectively and safely transport LH2 through (underground) pipelines over large distances? - In case electric solutions are not available, would GH2 be a solution for fueling the ground equipment at airports? Is it necessary to have LH2 hydrant systems at all gates? - How to address boil-off? - How to continue the current operation at airports during large infrastructure changes? - Is it feasible to establish a liquefaction plant at the airport, considering the large investments and required size for this plan? - Is it feasible to scale up the required infrastructure over time? - What infrastructure is required and needs to be developed? - How and by whom might this be financed? - Is it possible to establish underground LH2 transport? - Could fieldlabs (in operational environments) play a role in the development and approval of such a LH2 refueling system? - Which projects and initiatives, inside and outside of the aviation sector, look into this topic?
Linked to FVA topic / Work package (WP)	WP2: Implementation of novel energy carriers
Where/when identified	During a FVA Think Tank session
Relevant for which stakeholders (examples)?	Energy suppliers, airports, ground handlers, research institutes

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Potential next steps	Next steps to be determined. Topic has potential to be discussed in future Think Tank sessions with experts.

R&D question	**How to design an aviation certified tank & distribution system for liquid hydrogen storage aboard aircraft?**
Description	For the transition towards hydrogen-powered aviation, it is key to develop efficient and safe solutions for storage of liquid hydrogen in aircraft. What is an adequate tank design that ensures safe, efficient, and reliable storage of 300 m3 of LH2 in an aviation certified tank, while meeting the performance, safety, and regulatory requirements for future hydrogen-powered aircraft? The following factors need to be considered: - Tank geometry and material selection to minimize weight and ensure structural integrity - Insulation and thermal management systems to maintain LH2 at cryogenic temperatures - Safety features and emergency response systems to prevent and mitigate potential hazards - Integration with existing aircraft systems and infrastructure
Linked to FVA topic / Work package (WP)	WP1: Reducing energy demand for the aircraft and its flight WP2: Implementation of novel energy carriers
Where/when identified	Identified by NLR. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	OEMs, energy suppliers, knowledge institutes, airports
Potential next steps	- It's a potential topic for a short FVA study/analysis

R&D question	**How might cryogenic components be mechanically assembled in an aircraft environment?**
Description	Cryogenic propulsion systems, a key enabler for flight based on Liquid hydrogen, require robust mechanical assemblies to join ultra-cold components (e.g., superconducting magnets or cryocoolers) to a room-temperature support structure. In ground-based applications, this is typically achieved by using composite structures for their low thermal conductivity, which minimizes heat ingress and thermal losses. However, an aircraft environment introduces unique challenges, including high vibrations and frequent thermal cycling (from -40°C to 200°C), that can lead to material fatigue and joint failure over the aircraft's lifecycle. These differential temperatures induce differential dilatation, a phenomenon that must be understood and accounted for in the mechanical joint to ensure its longevity. The success of

	this technology is critical for the broader societal goal of decarbonizing the aviation sector and reducing its environmental impact. A deep dive is needed to evaluate and propose assembly solutions that can withstand these specific aerospace constraints and enable a sustainable future for air travel **Sub research questions:** - What are the primary design and material considerations for mechanical joints connecting cryogenic (20 to 100K) and room-temperature structures in an aerospace environment? - How do vibration, differential contraction and thermal cycling affect the structural integrity and thermal performance of composite-based assemblies? - Can a methodology be developed to test and validate the fatigue life of these mechanical joints at cryogenic temperatures, considering the effects of differential contraction?
Linked to FVA topic / Work package (WP)	WP 1: Reducing energy demand for the aircraft and its flight WP2: Implementation of novel energy carriers
Where/when identified	Topic identified by Airbus. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	OEMs, research institutes
Potential next steps	It's a potential topic for a short FVA study/analysis
R&D question	**How might two-phase flow instabilities in hydrogen-powered aircraft systems be mitigated?**
Description	Two-phase flow instabilities in hydrogen piping networks have been reported in literature to affect the operability of a phase change system. These phenomena must be considered during the design of hydrogen storage and distribution system for uses in aircraft. **Sub research question:** - What are the parameters affecting the hydrogen phase change pressure instabilities?
Linked to FVA topic / Work package (WP)	WP 1: Reducing energy demand for the aircraft and flight WP2: Implementation of novel energy carriers
Where/when identified	Topic identified by Airbus. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	OEMs, research institutes, energy suppliers
Potential next steps	- It's a potential topic for a short FVA study/analysis - Furthermore, it's addressed in the Coolpipe project, which is part of LiT: LiT Open Calls | Luchtvaart in Transitie

R&D question	**What are the main drivers affecting the depressurization phase performance of tanks aboard hydrogen powered aircraft?**
Description	Development of hydrogen tank bulk-boiling models are required for optimizing depressurization of hydrogen tanks. During the refueling phase, it is predicted that a depressurization of the aircraft tanks is necessary. As this operation is contributing to the overall refueling time and it is required to obtain a certain level of temperature homogeneity across the tank after it, it is necessary to evaluate the main drivers affecting the depressurization phase performance. Research into this topic could contribute to the development of tank bulk-boiling models to support the refueling evaluation studies.
Linked to FVA topic / Work package (WP)	WP 1: Reducing energy demand for the aircraft and flight WP2: Implementation of novel energy carriers
Where/when identified	Identified by Airbus. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	OEMs, research institutes, energy suppliers
Potential next steps	It's a potential topic for a short FVA study/analysis

R&D question	**How can split propulsion and multi-fuel combustion concepts facilitate the transition towards hydrogen powered and sustainable aviation.**
Description	**Sub research questions:** - Which splitted propulsion and multi-fuel combustion concepts might be developed? - How might they support the transition towards sustainable aviation - Which facilities, partnerships and standards are required to develop these concepts?
Linked to FVA topic / Work package (WP)	WP1: Reducing energy demand for the aircraft and flight WP2: Implementing novel energy carriers
Where/when identified	During a FVA Think Tank session
Relevant for which stakeholders (examples)?	OEMs, energy suppliers, research institutes
Potential next steps	Next steps to be determined. Topic has potential to be discussed in future Think Tank sessions with experts.

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Electric-powered aviation

R&D question	**Techno-economic assessment of future networks employing electric aircraft (topic under review)**
Description	**Sub research questions:** - What are potentially new airline network strategies operated by electric aircraft? - What is the effect on KPIs such as CO2 emissions, travel time, and demand captured?
Linked to FVA topic / Work package (WP)	WP 1: Reducing energy demand for the aircraft and its flight WP2: Implementation of novel energy carriers
Where/when identified	Identified by a start-up focused on electric powered aviation, and TU Delft. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	OEMs, start-ups, energy suppliers, airports, research institutes
Potential next steps	It's a potential topic for a short FVA study/analysis

R&D question	**How to effectively recycle batteries?**
Description	**Sub research questions** - Which sectors and/or application areas could benefit from recycled aviation batteries? - What developments are necessary to enable adoption of those recycled batteries in other sectors?
Linked to FVA topic / Work package (WP)	WP2: Implementation of novel energy carriers
Where/when identified	During a FVA Think Tank session
Relevant for which stakeholders (examples)?	Battery organisations, including MRO, energy suppliers
Potential next steps	Next steps to be determined. Topic has potential to be discussed in future Think Tank sessions with experts.

R&D question	**What role could batteries play towards sustainable aviation?**

Description	**Sub research questions**
	- What are the physical limits of batteries?
	- Which energy densities and charge and discharge range might be achieved over the time period until 2050?
	- For nuclear batteries:
	  ○ How to deal with nuclear waste?
	  ○ Would society accept nuclear batteries?

Linked to FVA topic / Work package (WP)	WP2: implementation of novel energy carriers

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Where/when identified	During a FVA Think Tank session
Relevant for which stakeholders (examples)?	Battery organisations, OEMs, energy suppliers
Potential next steps	Next steps to be determined. Topic has potential to be discussed in future Think Tank sessions with experts.

Smart Energy Airport

R&D question	**Should airports have to become energy hubs? If so, what is needed for that?**
Description	Supporting research questions: - How should an effective Energy Management System be designed to provide different energy flows and type of fuels? - What business models are viable, taking into account scaling over time. - What infrastructure developments & regulatory frameworks are necessary for airports to become energy hubs?
Linked to FVA topic / Work package (WP)	WP2: implementation of novel energy carriers
Where/when identified	During a FVA Think Tank session
Relevant for which stakeholders (examples)?	Energy suppliers, airports, ground handlers, research institutes, local communities
Potential next steps	Next steps to be determined. Topic has potential to be discussed in future Think Tank sessions with experts.

R&D question	**How should energy production, storage and supply systems be designed to deliver the required energy (quantity and form) at the right location and time?**
Description	Accommodating aircraft flying on various energy carriers, while maintaining a competitive turnaround time is a challenge. Another challenge for energy suppliers and airports lies in the increasing demand over the years towards 2050, especially considering the high development costs of infrastructure and electricity grids already operate at or are near capacity.
Linked to FVA topic / Work package (WP)	WP2: implementing novel energy carriers
Where/when identified	During a FVA Think Tank session
Relevant for which stakeholders (examples)?	Energy suppliers, airports, knowledge institutes
Potential next steps	Next steps to be determined. Topic has potential to be discussed in future Think Tank sessions with experts.

R&D question	**What are promising and creative ways to store and transfer energy?**
Description	**Research questions:** - Which energy storage and transfer methods, both on-ground and in-flight, might play a role in the future of aviation? - Which of those are most promising? - What is needed to develop these methods?

Linked to FVA topic / Work package (WP)	WP 1: Reducing energy demand for the aircraft and flight WP2: Implementing novel energy carriers
Where/when identified	During a FVA Think Tank session
Relevant for which stakeholders (examples)?	
Potential next steps	Next steps to be determined. Topic has potential to be discussed in future Think Tank sessions with experts.

Future traveler needs

R&D question	**What does the Cabin of the Future look like, considering a passenger centric view?**
Description	Traditional aircraft design has been constrained by the needs of fossil-fuel propulsion, leading to the familiar tubeand-wing configuration. Future designs, however, are not limited in this way, allowing for a creative exploration of what "ultimate comfort" truly means for a passenger. It's an opportunity to research, analyse, and propose an innovative cabin design for a future sustainable aircraft, bases on passengers' needs. **Sub research question(s):** - How does the ultimate comfortable aircraft look like? What are next-generation sustainable aircraft concepts, such as the Airbus ZeroE hydrogen aircraft or the Flying-V blended-wing design. - How their unique shapes and propulsion systems could influence cabin layout, window placement, and interior space. - What are passengers' needs when taking a flight? - What is a suitable design that weighs passengers' comfort and needs against an optimal sustainable set up?
Linked to FVA topic / Work package (WP)	- WP 3: Future passenger in 20250 - WP1: Reducing energy demand for the aircraft and its flight
Where/when identified	Topic identified by NLR. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	- Aircraft OEMs, airlines, passengers
Potential next steps	It's a potential topic for a short FVA study/analysis

R&D question	**Which passenger trends are shaping the future of air travel?**
Description	A FVA analysis (a short study) is conducted with the goal to validate input gathered during Think Tank sessions for "the Future Passenger" work package of FVA, and provide input for future sessions. Several passenger demand forecasting models are analysed to identify trends and drivers influencing global air passenger growth.
Linked to FVA topic / Work package (WP)	WP 3: Future passenger in 2050
Where/when identified	Topic identified by NLR and the FVA consortium
Relevant for which stakeholders (examples)?	FVA consortium
Potential next steps	It's a FVA analysis

Energy reduction & circularity

R&D question	**How to reduce the environmental impact, particularly the non-CO2 emissions, of a flight?**

Description	**Sub research questions:**
	- How to avoid flying through ISSR zones?
	- Which models, decision tools and/or algorithms should be developed to aid relevant stakeholders in reducing the emissions and noise? (e.g. climate impact models, weather models, optimization of flight, performance based navigation, multi-objective algorithms, etc)
	- What is the reduction potential when using these models and tools?
	- What is the reduction potential of flight operation strategies, such as:
	  ○ Selective use of SAF on contrail risk flights?
	  ○ Flying on lower FL?
	  ○ Flying around ISSR zones?
	  ○ What other strategies might be relevant?
	  ○ Flying slower
	  ○ Hopping long-distances

Linked to FVA topic / Work package (WP)	WP 1: Reducing energy demand for the aircraft and flight
Where/when identified	During a FVA Think Tank session
Relevant for which stakeholders (examples)?	Airlines, ANSP's, research institutes, regulators, satellite & communication providers, avionics suppliers, meteo organisations
Potential next steps	Next steps to be determined. Topic has potential to be discussed in future Think Tank sessions with experts.

R&D question	**How can rotor & fan designs be optimized to increase propulsive efficiency, while overcoming key challenges such as bird strikes, noise reduction, and maintenance requirements?**
Description	
Linked to FVA topic / Work package (WP)	WP1: reducing energy demand for aircraft and flight WP2: integration of novel energy carriers
Where/when identified	During a FVA Think Tank session
Relevant for which stakeholders (examples)?	OEMS, regulators, airlines, research institutes.
Potential next steps	Next steps to be determined. Topic has potential to be discussed in future Think Tank sessions with experts.

R&D question	**How might disruptive aircraft configurations, such as Blended Wing Bodies (BWB) be designed in the future, and what operational-, infrastructure-, and regulatory changes are required to support integration in the aviation system?**
Description	**Sub research questions** - What efficiency gains can be achieved? - Which airport adjustments (incl. luggage loading, refueling) are required to be able to handle BWBs? - How should the cabin lay-out be designed? - Hoe to integrate the propulsion system?
Linked to FVA topic / Work package (WP)	WP1: Reducing energy demand of the aircraft and flight WP2: Implementation of novel energy carriers WP3: Passenger in 2050
Where/when identified	During a FVA Think Tank session
Relevant for which stakeholders (examples)?	OEMs, research institutes, airports, start-ups, certification bodies
Potential next steps	Next steps to be determined. Topic has potential to be discussed in future Think Tank sessions with experts.

R&D question	**How can existing advanced integrated sensor technologies be effectively and durably embedded within advanced aerospace materials, such as composites or else, to create a self-monitoring structural network that enables real-time, predictive maintenance by 2050?**
Description	How can the integration of advanced biosensor networks into next-generation aircraft architecture create a living, responsive intelligent platform? This could help enhance safety, operational efficiency, and passenger well-being, addressing societal needs for sustainable, resilient, and human-centric flight by 2050 The aviation industry constantly strives to improve safety, reduce environmental impact, and enhance the passenger experience. Today's aircraft rely on scheduled maintenance and passive monitoring, which can be costly and reactive. By 2050, the demand for air travel will have surged, requiring a fundamental shift in how aircraft are designed, built, and maintained. Biosensing technologies can offer a paradigm-shifting solution. From a societal perspective, a living aircraft that can self-diagnose and adapt in real-time addresses critical concerns. - Safety and Security: A biosensor network can detect micro-damage in materials before it becomes a risk,

	preventing catastrophic failures and making air travel even safer. - Sustainability: By enabling predictive, condition-based maintenance, we can extend the lifespan of components, reduce waste, and optimize flight paths based on real-time structural data, leading to greater fuel efficiency. - Human-Centric Design: The ability to monitor the physiological state of passengers and crew creates a more comfortable and responsive environment
Linked to FVA topic / Work package (WP)	WP1: reducing energy demand for the aircraft and its flight WP3: Future passenger in 2050
Where/when identified	Identified by Airbus, and by participants during a FVA Think Tank session. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	Aircraft OEM's, MRO, airlines
Potential next steps	It's a potential topic for a short FVA study/analysis. Topic has potential to be discussed in future Think Tank sessions with experts.

R&D question	**How might the development and implementation of a Materials Digital Passport (MDP), specifically a digital substances and formulation passport, effectively enhance safety and promote circularity in the aerospace industry simultaneously?**
Description	The current state-of the art of tracking substances in different aerospace applications along the life-cycle, lacks a comprehensive systems for monitoring and analysis purposes - from initial production to final use in aircraft structures and also extending it to end-of-life, meaning recycling and circular use. This deficiency can lead to a safety risk, as it hinders the identification and management of hazardous substances during manufacturing, maintenance, and disposal. Furthermore, the absence of this verifiable data prevents the effective reuse and recycling of valuable materials, leading to an unsustainable, linear economic model. A solution is therefore needed to establish a digital chain of custody for materials, enabling better safety management while simultaneously unlocking the potential for a circular economy in aerospace. Multiple elements should be explored: - the technical requirements, data architecture, and governance framework for such a passport, addressing how it can provide a secure, transparent, and immutable record of material composition and

	structural relevance, including the presence of critical and hazardous substances. - the passport's potential to facilitate the identification of materials for reuse and recycling, quantify their environmental impact, and streamline regulatory compliance, ultimately creating a more sustainable and safer aerospace value chain. Furthermore, it is key to investigate how we can design for repairability and circularity, and which incentives would be effective to stimulate this design principle.
Linked to FVA topic / Work package (WP)	General topic WP1: reducing energy demand for the aircraft and its flight
Where/when identified	Identified by Airbus, and participants during a FVA Think Tank session. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	OEMs, recycling organisations, research institutes
Potential next steps	It's a potential topic for a short FVA study/analysis. Topic has potential to be discussed in future Think Tank sessions with experts.

R&D question	**How might changes in the early development phases lower the energy consumption of production?**
Description	An important part of the life-cycle of materials is the conversion from a raw state material to the desired design of the end-product. In this section of the life-cycle, typically a lot of energy is consumed, depending on e.g. the number of processing steps or other process parameters like temperature profiles. The definition of the process chain and assembly route is defined by the design of the final product - typically already at very early stages of the product development. The optimization to be done is therefore complex, since different technical challenges have to be considered simultaneously. **Sub research questions:** - How can low-energy-production requirements be linked to the design and material selection process already in early development phases? - What are today's technology blockers? - What is the difficulty in mapping energy consumption already in the design phase? - How can this be overcome?
Linked to FVA topic / Work package (WP)	WP1: reducing energy demand for the aircraft and its flight
Where/when identified	Identified by Airbus. Input for a FVA thesis lab

Relevant for which stakeholders (examples)?	OEMs, research institutes
Potential next steps	It's a potential topic for a short FVA study/analysis

R&D question	**How might AI aid inline monitoring in additive manufacturing processes?**
Description	Additive manufacturing is key to a sustainable future aerospace as it enables manufacturers to create parts perfectly designed for purpose, reducing unnecessary weight and thus energy consumption in use and manufacturing. So far, each part that will "fly" must be inspected manually in a time-consuming qualified process after printing. Inline monitoring of the additive manufacturing process utilizing AI is a promising approach to remove post-printing inspection, reducing the overall time and cost, as well as energy consumption, material consumption and waste. This is done by monitoring printing parameters during the process, enabling the prediction of the expected outcome and allowing for corrective actions early in the manufacturing process. **Sub research questions:** - What are the approaches and associated obstacles towards the use of inline monitoring in additive manufacturing? - How do different manufacturers/developers/researchers intend to overcome the challenge of qualifying inline monitoring as replacement for post-printing inspection?
Linked to FVA topic / Work package (WP)	WP1: reducing energy demand for the aircraft and its flight
Where/when identified	Identified by Airbus. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	OEMs, research institutes
Potential next steps	It's a potential topic for a short FVA study/analysis

R&D question	**Intelligent manufacturing process chains: how to create a green global industrial system?**
Description	**Sub research questions:** - what kind of concepts and meta data are missing to determine if a manufacturing location has less environmental impact than another? - What metrics are necessary to determine if one means of transportation is more environmental friendly than another?

	- What are efficient solver approaches to find promising industrial system network solutions that can be assumed to dominate large portions of the design space relative to relevant FoMs, including sustainability but also recurrent cost, lead time, and rate-adaptation capability, and that provides solutions that differ significantly from each other?
Linked to FVA topic / Work package (WP)	WP1: reducing energy demand for the aircraft and its flight
Where/when identified	Identified by Airbus. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	OEMs, research institutes
Potential next steps	It's a potential topic for a short FVA study/analysis

R&D question	**How can the use of quantum computing for simulation of bio-species leverage the use of bio-materials**
Description	Bio-species (e.g. enzymes, bacteria, fungi, algae) gain more and more importance for processing and manufacturing. A low environmental impact as well as a high selectivity for specific biochemical processes contribute to the increasing interest for bio-species-based products and technologies that enable recycling and circularity of resources. While the technology for (large scale) production of bio-species is usually available, the identification of the right species is challenging. Many time-consuming test procedures are necessary to analyse the properties of the macromolecular structure and assess their catalytic capabilities, leading to long development cycles. Therefore, computational methods are an essential backbone of biological science, allowing the simulation and prediction of properties and capabilities of bio-species. However, computational methods face increasing challenges when it comes to complexity and scale of simulated problems. Quantum computing can contribute to overcome some limitations of classical methods by providing more computational power and new approaches to solve even the most complex problems.
Linked to FVA topic / Work package (WP)	WP1: reducing energy demand for the aircraft and flight
Where/when identified	Identified by Airbus. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	OEM's, Recycle companies, policy makers, research institutes
Potential next steps	It's a potential topic for a short FVA study/analysis

Regulatory boundaries / policy

R&D question	**How do Legal and regulatory barriers to electric, hydrogen, or hybrid aviation, influence the sustainable transition of aviation?**
Description	An investigation into the legal and regulatory barriers to electric, hydrogen, or hybrid aviation, with a focus on cross[1]border operations. Certification depends not only on manufacturers but also on safety authorities and diverging standards and regulatory requirements across jurisdictions could create ramp-up issues and operational hurdles for seamless deployment
Linked to FVA topic / Work package (WP)	WP 1: Reducing energy demand for the aircraft and flight WP2: Implementation of novel energy carriers
Where/when identified	Identified by Leiden Law department. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	Engine OEM's, Airframe OEM's, policy makers
Potential next steps	It's a potential topic for a short FVA study/analysis

R&D question	**How do 'Eco branding' and regulatory inventions such as the EU Flight Emissions Label in aviation competition act as a market differentiator?**
Description	Exploring the concept of "eco-branding" and regulatory innovations such as the EU Flight Emissions Label as potential market differentiators in airline competition. The key issue is how far airlines can use such labels to stand out to consumers without crossing into misleading or legally risky claims
Linked to FVA topic / Work package (WP)	WP 1: Reducing energy demand for the aircraft and its flight WP2: Implementation of novel energy carriers
Where/when identified	Identified by Leiden Law department. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	Airports, Airlines, policy makers
Potential next steps	It's a potential topic for a short FVA study/analysis

R&D question	**How does the Green Deal actually influence competitiveness in aviation, given the objective to decarbonize?**
Description	European Green Deal vs competitiveness in aviation: Considering the extent to which the European Green Deal is being overtaken by the drive for competitiveness, with aviation as a test case. This concept has been highlighted in

	the Draghi Report. Yet, competitiveness concerns are increasingly being used to scale back climate ambition, raising key questions for cross-border industries striving to decarbonize
Linked to FVA topic / Work package (WP)	General topic
Where/when identified	Leiden Law department. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	Policy makers, Airports, Airlines, Aircraft OEM's
Potential next steps	It's a potential topic for a short FVA study/analysis

General FVA topics

R&D question	**What might "Next Gen Roadmapping" look like; what dynamic decision-making tools towards the decarbonisation of aviation might be developed?**
Description	Aviation is facing the decarbonisation challenge. New roadmapping tools are needed to inform policy and decision making. The sector finds itself at a crossroads where many complex decisions are taken on all levels: policy, technology, product/service development, resource allocation, etc. To tackle such complex decision-making processes, organisations often use (technology) roadmaps to guide them. These roadmaps include different levels with interlinkages showing dependencies based on time and progress. **Sub research questions:** - How can (technology) roadmapping evolve to fit the challenge of informing the decision making towards the decarbonisation of the aviation sector? - What characteristics of aviation technologies and R&D developments should be considered for decision making? - How can these characteristics be implemented in dynamic (technology) roadmaps? - How can the interdependencies between future policy decisions, business decisions, and technological progress in time be displayed informatively in a roadmap format?
Linked to FVA topic / Work package (WP)	WP4: Consolidation of the FVA roadmap
Where/when identified	Identified by Airbus. Input for a FVA thesis lab
Relevant for which stakeholders (examples)?	All decision makers in the aerospace industry
Potential next steps	It's a potential topic for a short FVA study/analysis

R&D question	**How can public/shared tech validation facilities accelerate the development of new products service systems for sustainable aviation, both from a technological, societal, and financial perspective?**
Description	**Sub research questions:** - Which type of facilities, infrastructure, equipment, flying testbeds etc, would be needed? - How to finance this facility? Which business models can be foreseen over time? - How to manage confidential information between users?
Linked to FVA topic / Work package (WP)	General topic
Where/when identified	During a FVA Think Tank session
Relevant for which stakeholders (examples)?	OEMs, start-ups, research institutes, etc
Potential next steps	Next steps to be determined. Topic has potential to be discussed in future Think Tank sessions with experts.

R&D question	**What is needed to support and accelerate certification of emerging concepts and innovations contributing to sustainable aviation by 2050?**
Description	**Sub research questions:** - What might be the role of AI techniques and virtual to accelerate certification? - How to stimulate a closer relation between authorities and industry? - Which certification rules apply? - What funding schemes are relevant to look into?
Linked to FVA topic / Work package (WP)	General topic
Where/when identified	During a FVA Think Tank session
Relevant for which stakeholders (examples)?	OEMs, technology organisations, regulators, knowledge institutes, start-up etc.
Potential next steps	Next steps to be determined. Topic has potential to be discussed in future Think Tank sessions with experts.