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Evaluation of the scheme exempted from notification No SA.59366 on aid for research and development for decarbonisation, competitiveness and safety of air transport for the period 2020-2023

Intermediate report

Document prepared by Deloitte Finance and GAC for the Directorate-General for Civil Aviation (DGAC)

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European Commission

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Preamble

Limits and scope of our intervention

We declare in the context of this report that we are acting independently and objectively.

The opinions in this report are the result of our study and experience and are based exclusively on the conclusions drawn from our analysis. In good faith, we consider that the conclusions set out in this report are correct, taking into account the information available to us.

This report must be read in its entirety. We are not responsible for any part of this report that is selectively cited or used in isolation or for any summary or reformulation of the report prepared by others.

The data and information contained in this note

The results of our work are also based on the elements identified during our research and on the cross-checking work we carry out. This obligation of means is part of our research method. However, we do not guarantee the veracity and completeness of the information contained in the available databases and other sources of information. In addition, some of the information comes from Internet publications. We do not accept any liability for the inaccuracies and opinions contained in these publications.

Our intervention was limited by the time available, the scope of the work entrusted to us and the information made available to us. We cannot be held liable for items not covered or omitted from our report due to limited access to information sources and limited work entrusted to us.

In the course of research carried out in the public domain, information was collected over a limited period of time, namely between 29 April 2022 and 13 October 2022. Thus, we have not identified the information published before those dates and which would have been removed from public sources, as well as the information published after those dates. We are under no obligation to monitor or update the information collected and we are under no obligation to warn you of any changes.

Deloitte Finance assumes no responsibility for events occurring after the date of issue of the report. Our research was carried out in public sources in French, the DGAC's local language of activity and English. The majority of the information identified and provided in this note was collected from sources published in French. For the sources published in English, we translated the relevant parts of this report and we do not accept any liability for translation errors.

The information and data obtained during our mission have been treated confidentially. During the collection, analysis and review no source data was changed or deleted. The information collected during our mission was used only for the purpose for which it was collected.

Introduction

Aid scheme No SA.59366 on aid for research and development for the decarbonisation, competitiveness and safety of air transport for the period 2020-2023 is a support scheme targeted at the aviation industry. Its rationale is based on different motivations, the main ones of which are:

- **The COVID-19 crisis,** which has weakened air transport as a whole, including the aviation industry, which has suffered a sudden drop in production rates. This decrease is due to the weakening of airlines by the cancellation of a large number of flights due to sanitary constraints and the impact on the upstream sector of the aviation industry through the cancellation/postponement of aircraft deliveries.
- The **importance of the environmental transition**, with air transport accounting for between 2 and 3 % of global CO_2 emissions according to ICAO (International Civil Aviation Organisation), with a high environmental impact which led to a ban on flights in France where a rail alternative of less than 2: 30 hours exists or an obligation to offset carbon emissions (Climate Law and Resilience, Article 145).

Scheme No SA.59366 forms part of a state aid context and was introduced in October 2020 as part of the

France Relance plan announced in July 2020 by the French State.

A scheme with clearly defined objectives

Under this scheme, the overall objective of the French State is to support the aviation industry by co-financing projects carried out by operators in the sector. The objective of the scheme is therefore to "support research, development and innovation projects in the air transport sector aimed at removing technological bottlenecks related to the decarbonisation, competitiveness and safety of air transport". The indicative budget1 for the application of the scheme which entered into force on 20 October 2020 is EUR 1 billion per year until 31 December 2023. This co-financing relates to research and technology (R &T) and research and development (R &D) activities. The projects thus financed are intended to prepare for the technological disruption of decarbonised aviation in all segments of the sector, while maintaining its competitiveness. More generally, the objectives of the aid granted are:

- **Promote R &D-related activities in the** sector in line with the objectives of the support plan; while promoting R &Demployment and the purchase of new equipment;
- **Stimulate market access,** including the development of new products;
- **Stimulate collaborative dynamics** with both industrial partners and academic, and to encourage the filing of patents and publications (for academic actors), so as to encourage an increase in knowledge

The projects financed may concern all undertakings in the aviation sector with no conditions of size (including SMEs and mid-caps), with the exception of undertakings belonging to the sectors excluded by Article 1 of[Commission] Regulation (EU) No 651/2014 of 17 June22014, and undertakings which do not meet certain3criteria.

An *ex-post* evaluation plan for the scheme validated by the European Commission

Since the estimated annual budget for this scheme exceeds the threshold of EUR 150 million laid down in the European Commission's General Block Exemption Regulation (GBER), the scheme is the subject of an *ex-post* evaluation plan notified to the European Commission and approved by the Commission in its decision of 16 April 2021. That evaluation plan provides, in addition to an ad hoc assessment based solely on the scope of the aid beneficiaries, an econometric assessment based on a counterfactual method, more precisely the method of double differences with matching. The main objectives of this evaluation are to assess:

- The effectiveness and direct impact of the aid on the beneficiaries (A);
- The effectiveness and indirect impact of the aid (B);
- Proportionality and appropriateness of the aid scheme (C).

The evaluation plan proposes an evaluation of the scheme in three parts:

1. A description of the aid scheme and the sector,
2. An *ad hoc* comprehensive analysis component, and
3. An econometric analysis component.

1This annual budget is indicative – See text of the aid scheme exempted from notification No SA.59366 on aid for research and development for the decarbonisation, competitiveness and safety of air transport for the period 2020-2023.

2This Article declares certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty.

3Text of the aid scheme exempted from notification No SA.59366 on aid for research and development for the decarbonisation, competitiveness and safety of air transport for the period 2020-2023 – paragraph 3.1.

On this basis, it intends to answer, as far as possible, the following questions:

A. Direct impact of support on beneficiaries

1. Did the aid lead to the development of strategic projects for the beneficiaries?
2. Has the aid made it possible to remove technological lock-ins encountered by businesses?
3. Has the aid enabled the development of knowledge and skills among its beneficiaries?
4. Did the aid lead to projects that could not have been launched without the aid or in a much longer period?
5. Has the aid allowed beneficiaries in the context of the COVID-19 pandemic to protect their R &D-strategy? Outside this context, has the aid allowed the beneficiaries to increase their R &D-related expenditure?
6. Has the aid had any effect on employment within the beneficiary companies (recruitment, retention of posts)?
7. Did the aid lead to the development of new products/technologies at the end of the project?
8. Did the aid enable the beneficiaries to enter the aviation market?
9. Has the aid had a potential negative impact on trade or competition in the air transport sector or in other sectors?

B. Indirect impact of support

10. Has the aid had any impact (in particular in terms of dissemination of knowledge) on the activities of other undertakings in the same sector or in other sectors?
11. Has the aid allowed SMEs/mid-caps to be integrated into large projects?
12. Did the aid increase the collaboration and risk-taking of beneficiaries?
13. Has the aid contributed to achieving the objectives of decarbonisation, competitiveness and safety of air transport set out in the aid scheme?

C. Proportionality and relevance of the project

14. Was the aid proportionate to the issues addressed?
15. Would it be possible to achieve the same result with less aid or in a different form?

In order to answer these questions, the evaluation plan lists a number of indicators. The table below summarises the proposed indicators and the question to which each of these indicators provides an answer.

Table 1. List of indicators provided for in the evaluation plan

Indicator	Evaluation question
Number of patents filed under the project	1, 2, 3, 4, 7, 10
Number of scientific publications produced under the project	1, 2, 3, 4, 7, 10
Level of maturity reached at the end of the project (TRL)	2, 3, 4, 7
Potential for applying project results (concepts, architectures, technological bricks, etc.) to future aircraft programmes (this indicator is to be assessed qualitatively)	1, 2, 3, 4, 7, 8, 10
Number of direct jobs (in FTE) mobilised under the project	6
Number of jobs (direct and indirect) created or maintained through the aid	6
Total R &D expenditure per project and per beneficiary	5

Number of subcontractors involved in the project and associated indirect jobs (in FTE) mobilised in the project	6, 8, 11
Number and share in value of SMEs and laboratories directly or indirectly involved in the project	8, 11
Number of collaboration contracts awarded	12
Contribution of the project to the environmental objectives set at European level for 2050	13
Share of private R &Dfinancing	9, 14, 15
Amounts of aid paid out by instrument form	14, 15

Source: Scheme evaluation plan

An assessment subject to significant methodological challenges

The aviation industry is characterised by a pyramid organisation. Airframe manufacturers are the major contractors around which engine manufacturers, equipment manufacturers and sub-contractors of various ranks (rank 1, rank 2, rank 3) engraved4. This pyramid organisation and the scale of the investment needed in R &Dwithin this sector make it necessary for the various players to work together in R &Dprojects and for the DGAC to intervene in order to support and connect this multiplicity of actors under the scheme.

In this context, the evaluation methodology chosen is subject to two main challenges:

1. While the double differences method is one of the counterfactual methods generally advocated by the European Commission in its methodological guide for the evaluation of state aid, **this organisation of the sector raises a first methodological challenge, namely the lack of a comparison group for companies at the top of the pyramid.** Indeed, the limited presence of large donors at the top of the pyramid makes it difficult to compare with actors of similar size/role. Thus, the European Commission has validated the implementation of an econometric assessment based solely on the SME/mid-cap perimeter. However, this approach also raises a number of complementary questions that are important to answer: access to data, time availability of data, multiplicity of concomitant aids, etc.

2. The evaluation plan calls for the introduction of an *ad hoc* evaluation methodology for all companies. **The introduction of this *ad hoc* methodology also presents a challenge linked to the collection of data held by actors (beneficiaries and granting authority), thus constituting the second methodological challenge.**

The construction of an evaluation methodology is therefore necessary in order to answer the relevant identification questions. As part of the methodology, it will also be necessary to reflect on identifying the relevant indicators adapted to the case at hand.

Aid for R &Dconsists of an amount granted to an entity which may be an academic undertaking, establishment or laboratory (hereinafter 'the beneficiaries') in order to carry out research and development which may lead to a final product over a longer or shorter period of time. Applicants for such aid shall submit one or more projects on which they may work in partnership with other entities.

In practice, the effects of R &D- and innovation aid are first directly measured at the level of its beneficiaries.

4However, at national level, Tier 1 players have their own product policy aimed at serving the global market. This therefore gives them a certain degree of independence from local airframe manufacturers.

The direct effects measured correspond to the leverage effects of the scheme on:

- The resources used to innovate (**additionality of the input**);
- Results in terms of innovation or economic performance (**additionality of output**);
- Cooperative behaviour (**behavioural additionality**).

In the present case, the scheme consists of upstream support for R&D. This is mainly aid for R&T in the form of grants. Thus, in terms of additionality of the input, the expected effects relate to the promotion of R&D and the stimulation of R&D.D.

Since the aid relates only to R&T in the context of long aircraft manufacturing cycles in the aviation sector, it does not lead to a finished product in the short/medium term. Thus, the indicators of financial performance, level of activity or level of production do not seem relevant in the present case. Therefore, in terms of additionality of output, the expected effects relate only to the increase in foreground.

Finally, as regards behavioural additionality, the expected effect of the scheme is to foster coordination between private and public actors.

A methodological report to define the methodology for evaluating the scheme

This report thus serves as a memorandum for the definition of the methodology for the evaluation of the aid scheme SA.59366 on aid for research and development for the decarbonisation, competitiveness and safety of air transport for the period 2020-2023, both on:

- The *ad hoc* methodology;
- Econometric methodology;
- The data used.

The document is organised in three chapters:

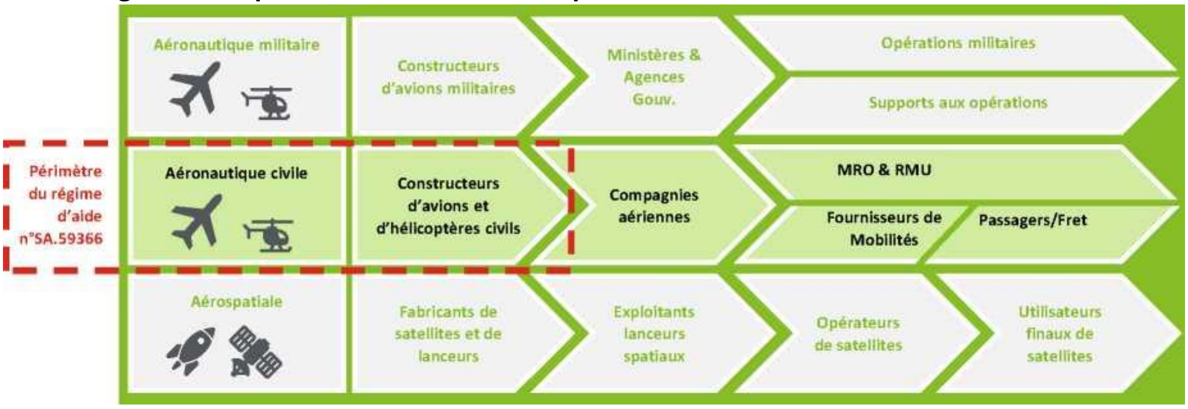
- **Chapter 1 presents** the background to the establishment of the scheme to be assessed and describes factual elements on the beneficiaries;
- **Chapter 2 presents** a proposal for a methodology for *ad hoc* analysis;
- **Chapter 3 presents** a proposal for a methodology for counterfactual econometric analysis.

Chapter 1. Context in which the scheme was set up

Aid scheme No SA.59366 was put in place by the French Ministry for Ecological Transition and Territorial Cohesion. Its objective is "to support research, development and innovation projects in the air transport sector aimed at removing technological bottlenecks related to the decarbonisation, competitiveness and safety of air transport"5. It covers the period 2020-2023 and concerns all players in the French civil aeronautics industry carrying out research and development projects.

In 2020, companies operating in the aviation sector in France generated EUR 95 billion in turnover6. They form a subset of the aeronautics and space industry, comprising 4 480 companies involved in the construction of aircraft and7 astronition for civil, military and space applications.

Figure 1. Simplified Aeronautical and Space Value Chain



Source: Deloitte analyses

The aid scheme focuses mainly on research and technology, which covers the upstream stages of R &D. It enables the development of technological bricks that can be incorporated into products or production processes, and where the Technology Readiness Level (TRL) does not exceed level six (6). Some of these bricks may be combined to give prototypes or models of (sub) systems tested under conditions representative of a real environment.

Technology is a major driver of competitiveness for actors in the civil aviation industry. It responds to the challenges facing the sector, in particular as regards passenger safety or the reduction of the environmental impact. The performance of the French civil aeronautics industry can be explained in particular by its technological positioning, based on constant and continuous research, and enabled by the synchronisation of the efforts of the players in the sector.

The following subsections present the civil aviation sector and its technological challenges (1.1), public intervention in the planning and support of the technology roadmap for the sector (1.2), aid scheme No

5www.europe-en-france.gouv.fr/sites/default/files/sa.59366_relatif_aux_aides_a_la_recherche_et_au_developpement_pour_la_decarbonation_la_competitivite_et_la_securite_du_transport_aerien.pdf

INSEE6 figures – Study "The aeronautics and space sector in France in 2020" – December 2021.

7Definition of INSEE – Study "The aeronautics and space sector in France in 2020" – December 2021. Starting from 1 % of turnover devoted to aerospace, the company is considered to belong to the industry.

SA.59366 (1.3) and its beneficiaries (1.4).

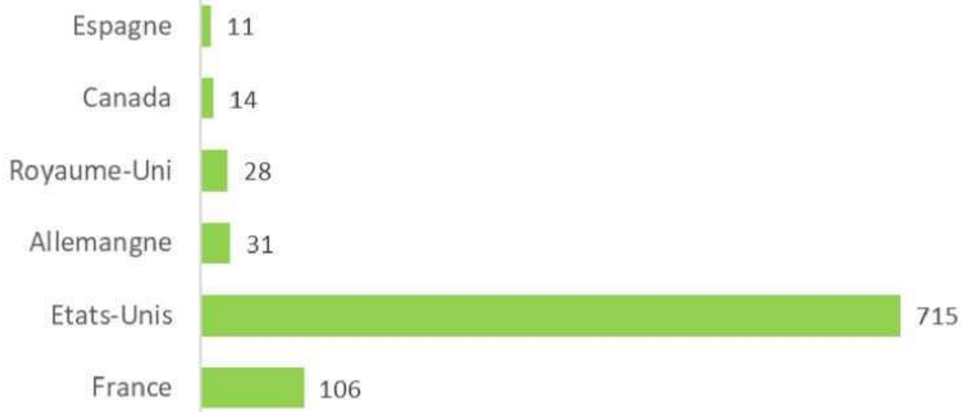
1.1. Presentation of the civil aviation industry and its technological challenges

1.1.1 Market and trends: Presentation of the civil aviation market and its key figures

France and the United States are the only countries with an aviation industry to build and assemble all aircraft segments in their territories. Other countries, such as Germany, the United Kingdom, Canada or Spain, specialise in the manufacture of certain aircraft parts or segments.

The civil aviation market has historically been structured around five producing countries or groups of countries (USA, Russia, Brazil, Canada and the European Union) which have developed global aviation industries. They are involved in the high value-added stages from design to manufacturing and then in the integration of aircraft parts.

Figure 2. Size of the aviation and space industry in the historical countries[8] (Turnover 2020, billion EUR)



Source: INSEE – Study "The aeronautics and space industry in France in 2020" US Aerospace Industries Association (AIA) – "2021 Facts and Figures", German Aerospace Industries Association – "Industry figures", UK Aerospace Technology Institute (ATI) – "Annual Review 2020/21" Aerospace Industries Association of Canada (AIAC) – "Industry statistics" – Spanish Ministry of Industry, Trade and Tourism – "Aerospace industry" (1) Total turnover of aeronautics and space industries

[8] Brazil is an important historical country (with Embraer as a major player) for which aggregated data could not be found for 2 020. As a guide, the sector's turnover was more than USD 7 billion in 2014, with an Embraer turnover of USD 6.3 billion. In 2020 a nd 2021, Embraer's turnover was $3.8 billion and $4.2 billion – Embraer's 2021 annual report, respectively. https://esg.embraer.com/global/en/assets/OS_16747_Embraer_RelatorioAnual2021_EN.pdf

At the same time, the historical sectors see the emergence of other international players, in particular 'natives 4.0' (e.g.: China, Tunisia, Morocco, etc.), which increasingly position themselves on steps with high added value, contributing to the production process of aircraft segments.

For example, the Chinese State participated in the development of COMAC in 2008. It takes advantage of the dynamism of the Chinese domestic market and massive public support to compete in the future with the main global aircraft manufacturers (Boeing and Airbus) in the commercial aircraft segment. Boeing estimates that *"between 2018 and 2038, China's demand could exceed the combined demand from Europe and North*

America, amounting to 40 % of the aircraft delivered"[8]. However, the Chinese industry still relies mainly on foreign technologies (engines, landing trains, etc.).

Over the last six years, economic developments in the global civil aviation market can be broken down into three distinct stages:

Between 2017 and 2019, before the COVID-19 crisis, the growth rate of air traffic was estimated at around 5 % per year[9]. The industry experienced a strong growth in demand for short and medium-haul commercial aircraft, which accounted for example for the bulk of Airbus orders (81 % of aircraft orders over the period were from the A320 family[10]). This growth was lower on long-haul commercial aircraft.

However, the other segments of civil aeronautics were experiencing a reduction in activity, since the 2008 financial crisis for business aviation, and in a context of rising oil prices from 2013 onwards for the helicopter market.

The period of health measures related to the COVID-19 crisis (2020-2021) experienced a sharp reduction in air traffic, which contracted by 60 % in 2020[11]. This led to cancellations of orders, carry-overs of aircraft deliveries and a partial suspension of aircraft maintenance activities. As a result, the French aviation industry recorded a decline in activity of 28 percentage points[12] between March and December 2020 and a decrease in the employment level of around 8,3 percentage points compared to the level of June 2019.[13]

Since the easing of travel restrictions (2021-2022), air traffic has recovered, sometimes hampered by the persistence of local health constraints. In June 2022, air traffic grew by 76.2 % compared to June 2021, but remained 29.2 % lower than in June 2019[14]. This takeover has revived airline orders for short and medium haul aircraft manufacturers. At the same time, the context of rising kerosene prices and environmental pressures have accelerated the need for aircraft fleet renewal (see Section 1.1.3).

The French civil aviation industry is highly exposed to the movements of the global aviation market, in particular the evolution of air traffic, given its degree of international openness. 83 % of the consolidated turnover of the members of the Groupement des Industries Française Aéronautiques et Spatiales (GIFAS, presented in section 1.1.2) was made on export in 2021[15]. The evolution of international air traffic is one of the factors affecting the level of commercial activity of the operators in the sector, as illustrated in the graph below.

Figure 3. Combined turnover of GIFAS members, representing the main players in the French industry, compared with the annual number of air passengers worldwide

8Court of Auditors – Report "Public support for the aviation sector" – February 2022.
Information9 report registered at the Presidency of the National Assembly on 12 January 2022 - https://www.assemblee-nationale.fr/dyn/15/rapports/cion-eco/l15b4892_rapport-information
10 Presentation of Airbus annual financial results - https://www.airbus.com/en/investors/financial-results-annual- carry-overs
11ICAO – Press release of 15 January 2021 – *2020 passenger totals drop 60 impact as COVID-19 Assault on international mobility continuous*
12INSEE – Note "The aeronautics sector: one year of COVID-19 crisis".
13Court of Auditors – Report "Public support for the aviation sector" – February 2022.
14 Analysis of the International Air Transport Association (IATA) – https://www.iata.org/en/iata-Repository/publications/economic-reports/air-passenger-monthly-analyis/
15GIFAS figures.

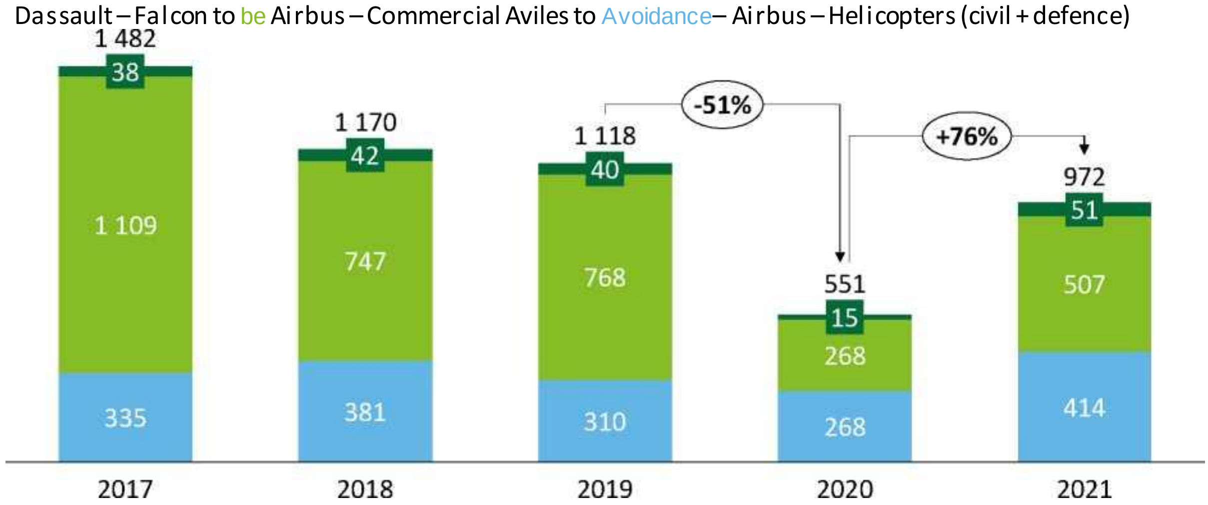
Cumulative French aviation turnover (MrdsEUR) # of passengers carried (Mrds)

Source: Deloitte analyses Data from GIFAS Annual Reports 2018-2019-2020, GIFAS Website and ICAO Global Air Transport Estimate

Moreover, the economic situation linked to the COVID-19 health situation has had a significant impact on the volume of orders from the main French aircraft manufacturers Airbus and Dassault Aviation. Their orders were reduced by 51 % between 2019 and 2020, before increasing by 76 % between 2020 and 2021 as air traffic picked up, although Airbus did not return to the pre-crisis level.

Figure 4. Change in the number of aircraft orders (net of cancellations) registered by Airbus and Dassault between 2017 and 2021

Dassault – Falcon to be Airbus – Commercial Aviles to Avoidance – Airbus – Helicopters (civil + defence)



Source: Deloitte analyses Data from Airbus Investigators Relations Airbus & Dassault Aviation

Moreover, the economic dynamism of the French aviation industry has a significant impact on the trade balance. On average, 12 % of the country's total exports of goods came from the aviation industry over the last ten years. In 2019, it contributed to the French trade surplus of EUR 34 billion and accounted for 1.1 % of national GDP16. During the COVID-19 crisis, however, aviation and space exports decreased by 45.5 % between 2019 and 202117. The structuring of its actors is therefore of strategic interest to the country.

16Data reconstructed from INSEE and Esane databases and a value added/turnover ratio of 19 %.
France's Foreign Trade 17 Report 2021 – https://www.vie-publique.fr/sites/default/files/rapport/pdf/278462.pdf

1.1.2 structuring of operators in the sector

The French civil aviation industry is active in all market segments and the value chain: manufacturers of different types of aircraft (long aircraft, courier and regional aircraft involved in commercial aviation, business aviation, helicopters), motorists and equipment manufacturers capable of offering all components of an aircraft.

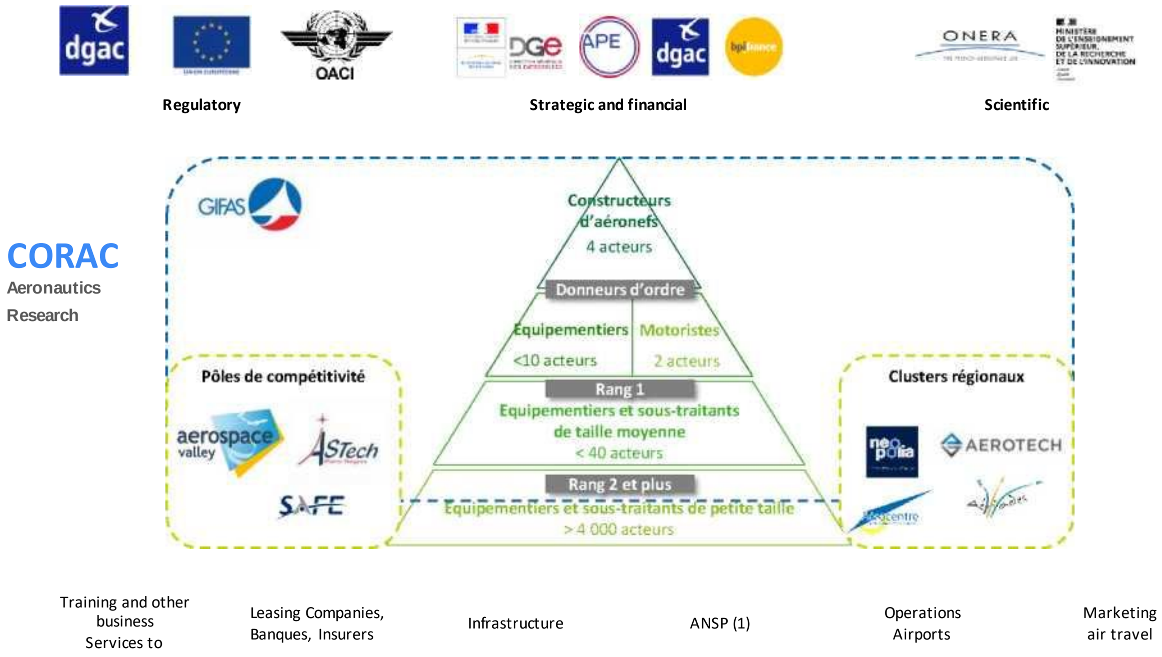
In 2020, the sector employed 194 000 people, 4 % less than in 2019.18 Although they are present throughout France, most of their activities are concentrated in three administrative regions, which account for more than 70 % of jobs in the sector: Occitanie, Ile-de-France and New Aquitaine19. Its economic weight has resulted in the formation of interregional groupings. The Greater South-West (Occitanie and New Aquitaine) set up the Aerospace Valley competitiveness centre in 2005 to align the actions of the region's aviation and space companies, which account for 16 % of the region's industrial employment20.

18GIFAS – Press release – May 2022.
19Court of Auditors – Report "Public support for the aviation sector" – February 2022.
20INSEE – The Great South-West Aerospace Sector: a momentum halted by the health crisis – December 2021.

The sector is structured by a limited number of contractors (aircraft manufacturers and large equipment manufacturers), working with subcontractors and suppliers from lower ranks.

Private companies in the sector interact continuously with French and international public actors on multiple dimensions (regulatory, strategic, financial and scientific). As such, they are represented by the **Groupement des Industries Française Aéronautiques et Spatiales (GIFAS)**. Established in 1908, this professional federation coordinates and defends the interests of its members at national and international level. In 2020, it comprised more than 400 members21.

Figure 5. Simplified diagram of the main players in the civil aviation sector in France



Source: Court of Auditors22, Xerfi23, Analyses Deloitte
(1) air navigation service provider

Private actors in the sector can be divided into the following categories:

Aircraft manufacturers

Chain bridge heads with airlines or charter companies, the main contractors in the sector are aircraft manufacturers (airframe manufacturers and helicopter manufacturers). They act as industrial prime architect, assuming the technical and commercial responsibility for aircraft programmes. In France, four major players, active in both civil and military markets, have a significant share of their industrial activity in France: Airbus, Dassault Aviation, ATR and Daher24.

The territorial anchoring of aircraft manufacturers is mainly permitted by the means used in the country to ensure the financing of R&T and the provision of favourable scientific and technological infrastructure (testing facilities, computers)25.

21 GIFAS Yearbook 2020 – https://www.gifas.fr/news/annuaire-du-gifas-parution-de-la-version-imprimee-2020.
22Court of Auditors – Report "Public support for the aviation sector" – February 2022.
23Xerfi – Report "The aeronautics and space industry in France" – April 2022.
24 7th manufacturer in general and business aviation, Daher also acts as an OEM, from the design of elementary parts to fully equipped sections (https://www.daher.com).
25Pipame – Study "Value Chain in Aeronautics Industry" – September 2009.

The following boxes describe the Airbus group and Dassault Aviation:

Airbus Group

Airbus is the European leader in the aeronautics and space industries. The group is present in more than **60 countries worldwide**, with a concentration of staff in Europe, in particular in France (around 48 000 employees in France in 2020, or almost 40 % of the group's workforce), Germany, Spain and the United Kingdom.

The group is at the same time a leader in the markets for civil aviation, helicopters and defence and space. Airbus also owns 50 % of ATR, which is active in the regional aircraft market262728. Finally, *through* its 100 % owned subsidiary Airbus Atlantic (e.g. STELIA Aerospace), Airbus acts as a supplier specialising in aerostructures.

Table 2. Key figures – Airbus Group (global perimeter)

	2017	2018	2019	2020	2021
Turnover (EUR billion)	**66,8**	**63,7**	**70,5**	**49,9**	**52,1**
of which civil aviation (EUR billion)	51,0	48,0	54,8	34,3	36,1
of which helicopters (EUR billion)	6,5	5,9	6,0	6,3	6,5
EBIT (EUR billion)	**4,3**	**5,8**	**6,9**	**1,7**	**4,9**
R &DTotal (EUR billion)	**2,6**	**2,9**	**3,0**	**2,9**	**2,8**
of which civil aviation (EUR billion)	2,0	2,2	2,4	2,4	2,3
of which helicopters (EUR billion)	0,3	0,3	0,3	0,3	0,3
Total number of staff (000 employees)		**133,7**	**134,9**	**131,3**	**126,5**
of which France				~ 48,0	

Source: Airbus Investment Relations[28], XERFI[29] (Airbus staff in France)

Airbus's **Commercial Aircraft** Division competes with the US aircraft manufacturer Boeing.
Five large families of aircraft make up Airbus' range of commercial aircraft:

- The short and medium-haul aircraft market is covered by the A320 and A220 families, with the A220 family resulting from the acquisition of the CSeries programme in Bombardier in 2018;
- Airbus is also on the market for medium long-haul aircraft thanks to A330 and A350 aircraft families. The group announced the abandonment of the A380 programme in 2019 (the last 17 copies ordered were delivered in 2021).

The headquarters of the division are located in Blagnac (Haute-Garonne, France). It brings together assembly lines of all commercial aircraft (excluding A220), finance, marketing and research and testing units of the division.

Airbus Helicopters (formerly Eurocopter) is the world leader in the manufacture of civil helicopters. It is also one of the leading manufacturers of military helicopters. Airbus Helicopters produces and markets both light helicopters ('Ecureuil' family), medium helicopters ('Dauphin' family) and heavy helicopters ('Super Puma' family). The French subsidiary accounts for almost half of the division's activities, with its headquarters in Marignane (Bouches-du-Rhône, France), where almost 8 400 people are employed.29 30

26The other half is owned by Italian industry Leonardo.
27 Presentation of Airbus' annual financial results - https://www.airbus.com/en/investors/financial-results-annual-carry-overs # annualcarry-overs
28Xerfi – Report "The aeronautics and space industry in France" – April 2022.
29Xerfi – Report "The aeronautics and space industry in France" – April 2022.
30 Presentation of Dassault's annual financial results - https://www.dassault-aviation.com/en/group/finance/

Dassault Aviation

Dassault Aviation, the second-largest French aircraft manufacturer, is one of the main players in the construction of business jets, military aircraft and space systems. The group produces both high-end business aircraft *through* its Falcon range and multi-role combat aircraft with the Rafale range.

More than three-quarters (78 %) of the group's employees are located in France, where production and assembly lines for Rafale and Falcon are located. Dassault Aviation, on the other hand, accounts for almost 90 % of its turnover outside France.

Table 3. Key figures – Dassault Aviation (global perimeter)

1	2017	2018	2019	2020	2021
Turnover (EUR billion)	4,9	5,1	7,3	5,5	7,2
of which FALCON (EUR billion)	3,0	2,6	2,2	2,2	2,0
EBIT (EUR billion)	0,3	0,7	0,8	0,3	0,5
Self-financed R &D(EUR billion)	0,3	0,4	0,5	0,5	0,6
Total number of staff (000 employees)	11,4	11,5	12,8	12,4	12,4

Source: Dassault Aviation Investment Relations[31]

Large OEMs and OEMs

Some ten large manufacturers and motorists have a significant weight in the supply of aircraft manufacturers and may have to market their products directly to airlines. They offer complete subsets of aircraft, develop their clean technologies and drive the subcontracting chain of the industry.

The French aviationindustry can rely on several internationally leading companies in their markets, starting with national players Safran and Thales. Safran Aircraft Engines, because of its footprint on both the French and the world market (via the joint venture CFM with GE, the exclusive engine operator of B737MAX and a motorist of 70 % of the A320neo) can also be considered as one of the main suppliers of orders to the sector. These companies have diversified customer portfolios, including among foreign aircraft manufacturers, such as:

Boeing or Embraer, in addition to the major French donors. For example, the US Boeing spent more than $6,3 billion (around EUR 5,6 billion) of orders from French suppliers in 201731.

Table 4. Main OEMs and motorists present on French territory

Actor	Total CA 2021 (MEUR)	R &D2021 expenditure (MEUR)	Aérosterr	Avioni.	Equip. Interest.	Engine	Train atter.	Description:
Safran	15 133	1 430	X	X	X	X	X	3th global Aeronautical Equipment Manufacturer. The group is present in both the propulsion segment (which accounts for ~ 50 % of its AC) of equipment and sub-assemblies (~ 40 % of its AC) and interior equipment (~ 10 % of its AC).
Thales	17 857	1 027		X	X			Leader in electronic equipment and systems in the aeronautics, space, naval and rail sectors. Aeronautics (including air navigation) and space account for ~ 25 % of Thales' turnover (Thales AVS, ATM).
ISIS Aerospace (1)	663	36	X		X	X		Lisi Aerospace, a member of the Lisi Group, specialises in the manufacture of fixings and assembly components for aero-structure and motors.
Daher	1 100	N.C	X			X		French family group, manufacturer of aerostructure subassemblies and business aircraft manufacturer.
Latecoère	380	23	X	X				Group mainly positioned in aerostructures (doors, fuselage) and interconnection systems (wiring, avionics, cable test benches).
Liebherr Aerospace & Transport (Germany)	1 024	N.C		X	X		X	Division of the Liebherr Group, specialising in machine tools, Liebherr produces approximately EUR 400 million through its subsidiary Liebherr Aerospace Toulouse, which is positioned on the air systems segment. The division also produces and maintains landing gear parts, flight control systems or transmission boxes.
Raytheon Technologies (United States)	54 404	2 600	X	X	X	X	X	Raytheon Technologies is the largest supplier of aircraft equipment in the world, including through Pratt & Whitney (engines) and Collins Aerospace (electronic, electrical and mechanical systems). Although mainly located in the United States, the group generates ~ EUR 1 billion of turnover in France, mainly via the following subsidiaries: - Goodrich actuation System: EUR 378 MILLION (2019) - Rockwell Collins France: EUR 296 MILLION (2020) - Ratier-Figeac: EUR 253 MILLION (2020)

Source: XERFI Studies32 – Reporting DIANE – Stakeholders' website
(1): Data 2020 – the amount of R &Dexpenditure corresponds to the whole Lisi Group

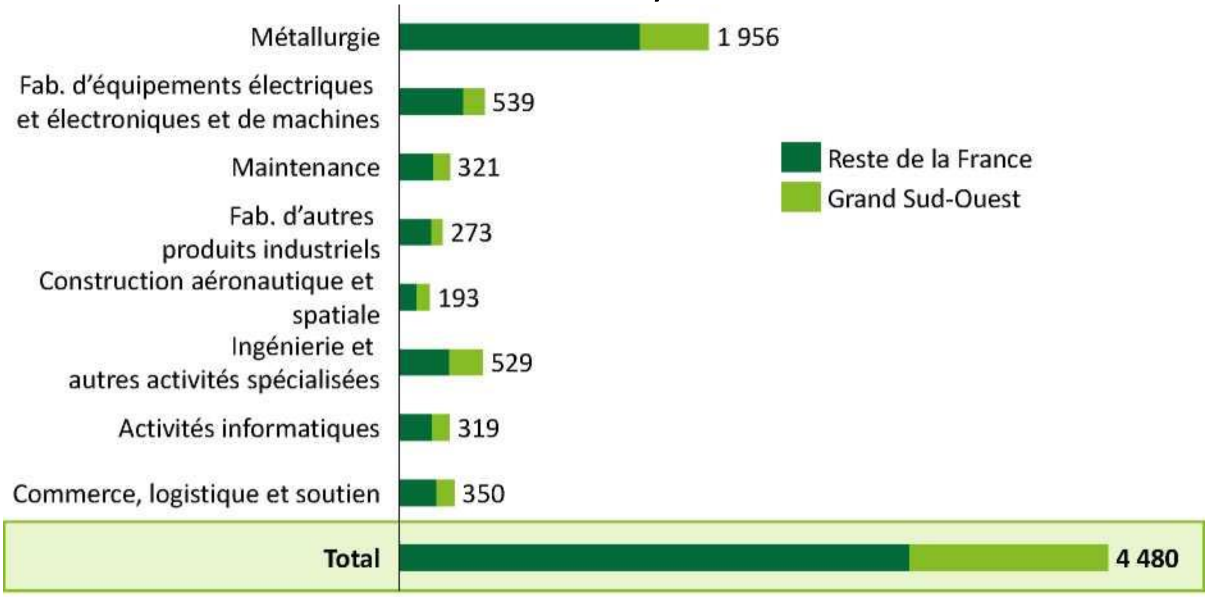
Thales, Safran, as well as a few large OEMs such as Daher and Latecoère, act like "pivot firms33", which rely on a set of medium and small subcontractors.

31https://www.boeing.fr/boeing-en-france/l-industrie-francaise.page?
32Xerfi – Report "The aeronautics and space industry in France" – April 2022.
33Frédéric Mazaud – Frédéric Mazaud – *Frédéric Mazaud – Frédéric Mazaud – Frédéric Mazaud – Frédéric Mazaud – Frédéric Mazaud – Frédéric Mazaud – Frédéric Mazaud – Frédéric Mazaud – Frédéric Mazaud – Frédéric Mazaud – Frédéric Mazaud – Frédéric Mazaud – Frédéric Mazaud – Frédéric Mazaud* – Frédéric Mazaud – F@@

Medium and small suppliers and subcontractors

This group of subcontractors, ranging from 1, 2, 3 or more, is highly atomised. 80 % of the enterprises making up the sector are Intermediary Size Enterprises (mid-caps) and Small and Medium Enterprises (SMEs). These actors are specialised in specific aeronautical technologies or sub-products, specific to their sectors of activity.

Figure 6. Number of companies in the aeronautics and space sector as at 31/12/2020 according to sector of activity



Source : Insee - Enquête Filière aéronautique et spatiale 2020.

Subcontracting companies cover the whole of French territory, although a significant proportion is located close to the contractors.

Some of the industry's subcontractors supply niche products to equipment manufacturers and motorists, and is highly dependent on aircraft outlets. In 2020, aviation and space activities accounted for 73 % of the total turnover of industrial companies in the sector. However, for only 21 % of them, the aeronautical and space business accounted for more than 80 % of total turnover.

Example of Coriolis Composites[34]

Located in Morbihan, Coriolis Composites designs and manufactures robots and industrial production software for composite parts. The company is active in both France and Germany, but also in Asia and North America. It generates an overall annual turnover of approximately EUR 25 million and employs almost 120 employees. In 2022, its total turnover was achieved with customers in the aviation sector, whether they were major players in the French sector (Dassault Aviation, Safran, Airbus Atlantic – formerly Stelia Aerospace, etc.) or international (Boeing, Composites Technology Research Malaysia, etc.).

During the COVID-19 crisis, the company experienced a sharp reduction of its activity of around 40 %. In response, it has developed a strategic plan which puts it as a key player in alleviating the forthcoming aircraft programmes planned for 2027-2028. The company also seeks to capitalise on its know-how to explore diversification opportunities in other sectors (automotive, naval, etc.).

Other identified players in aviation subcontracting are diversifying their outlets in several industries. Therefore, aeronautics represents only part of their activity, thus limiting their dependence on other players

34 Example from an interview with a representative of the company – June 2022.

in the sector.

Example of Radiall Society35

Radiall is a French ETI owned by family capital. It designs, develops and manufactures electrical components for civil and military aircraft equipment, but also for wireless telecommunications and industrial applications.

Of the EUR 305 million in turnover generated in 2020, around 36 % came from sales to the civil aeronautics industry, mostly to contractors or Tier 1 suppliers36. Industry has played a leading role in the group's activity since the 2000s.

However, the COVID-19 crisis has prompted the group to diversify in order to rebalance its business portfolio: Radiall suffered a loss of turnover of around 40 % in 2020 and 65 % in 2021 from its civil aeronautical customers.

In order to differentiate itself against strong competition in electrical components, society is positioned in "niche" markets, where innovation is a key success factor.
To this end, it invests annually more than 8 % of its turnover in R &D.

On aeronautics, the group works directly on the development of new solutions with all donors, be they aircraft manufacturers (Airbus, Dassault, Boeing, Bombardier) or avionics manufacturers (Thales in France, Collins Aerospace, Honeywell, etc.).

Given the capital intensity of the sector, the atomic nature of the players in the sector is likely to hinder the development of new programmes or the increase in rates. Attempts to consolidate the sector (particularly in the context of the 'Power 8' economy plan, launched in 2008 by Airbus) have had limited impact, particularly as a result of the shareholder structure of the players, many of which remain family members37. However, complementary initiatives were launched in 2020 to enable companies to reach a critical size; for example, the aeronautical investment fund managed by a subsidiary of Tikehau Capital ("Ace ero Partner" set up in July 2020) aims to strengthen the equity of strategic SMEs in the sector and to support the consolidation of the sector.

The specific features of the structure of the French industry, in particular the low concentration of medium-sized and small equipment and subcontractors, highlight the need for a coordinated response to the need for technological solutions necessary for the competitiveness of the sector.

1.1.3 key technologies: Presentation of the issues at stake in the sector and the main technological levers envisaged to respond to them

The safety requirement

The civil aviation industry is facing heavy regulatory pressure, in particular on safety. The standards of national and supranational bodies are added together to ensure the highest level of safety, for a sector in which any error can cost human lives. Compliance with standards is framed by the award of qualifications. The certification procedure shall cover the entire development process of a new aircraft and any subsequent developments. The components of the *product (e.g.* structure, engines, control systems, electrical systems and flight performance) are analysed in relation to the certification basis. The certification requirements apply to all actors in the sector and represent 17 % of the overall cost of developing an aircraft38. An aeroplane must be certified in each country of registration. Several organisations are involved in the introduction of

35Example from an interview with a representative of the company – June 2022.
Heroes36 Project – Technical file – March 2022.
37Court of Auditors – Report "Public support for the aviation sector" – February 2022.
38Pipame – Study "Value Chain in Aeronautics Industry" – September 2009.

qualifications and compliance with standards:

- At international level, ICAO (International Civil Aviation Organisation) issues the standards and recommendations applicable in the countries that are signatories to the Chicago Convention (193 Member States). It is by complying with ICAO standards that an aircraft can obtain the minimum recognised certification to operate worldwide.

- At European level, Regulation (EU) 2018/1139 – the 'basic Regulation' – lays down common rules in the field of civil aviation and establishes a European Union Aviation Safety Agency (EASA). The Regulation aims to "establish a high uniform level of civil aviation safety while ensuring environmental protection39".

- In France, the Civil Aviation Safety Directorate (DSAC) monitors the manufacture and maintenance of aircraft, in accordance with European regulations. It issues approvals of maintenance organisations, certificates of airworthiness of aircraft and engineer licences.

The sector is also exposed to risks linked to the openness and interconnection of actors and products, particularly in terms of cybersecurity. The entire value chain of the sector must respond to this immutable security challenge, which is fundamental and underlying all research projects.

A principle of competitiveness

In addition to the security issue, stakeholders in the sector are mobilising to support their competitiveness. Given the importance of exports in the industry, the French civil aviation industry is evolving in an international market. In the face of increased competition, maintaining the position of French companies requires the development of innovative products or services.

The competitiveness of the sector is also based on optimising the operational performance of all the players making up the sector, in order to keep up with the rates set by the contractors and maintain cost competitiveness.

The principle of competitiveness of aviation players is a prerequisite for maintaining France's position on the international market. It is increasingly dependent on the growing challenge of decarbonisation.

A fundamental trend towards decarbonisation

The challenge of decarbonising the civil aviation sector is part of the underlying trend of the environmental transition, also meeting a societal requirement. If air transport continued to grow at the same pace as before the COVID-19 crisis, without changing technologies, energy sources or operational practices, industry would contribute to a significant increase in global CO_2 emissions by 2050. For example, aviation, which had emissions of around 900 $MtCO_{2/year}$ in 2018, could emit more than 2000 $MtCO_{2/year}$ in 2050 if technologies were maintained in 201840. The current environmental impact of aviation calls for a transformation of the sector.

The transition to a low-carbon future requires that the sector gradually decalises, questioning its business model. It implies an impact on all actors in the sector. Unless zero-emission aircraft are developed, the entry into force of regulations setting the price of carbon emissions should reduce demand for short flights and encourage the use of sustainable alternative modes of transport (*e.g.* rail transport). This could lead to a drop in income of around $40 billion and a loss of 110 000 jobs worldwide.41

The decarbonisation challenge is a major challenge for the sector, which will have to rely on technological

39https://eur-lex.europa.eu/legal-content/FR/TXT/?uri=LEGISSUM:4359400

40ATAG – *Balancing growth in connectivity with a comprehensive global air transport response to the climate emergency: a vision of net-zero aviation by Mid-Century* – September 2021.

41Deloitte – Decarbonising aerospace study – October 2021.

disruptions in order to maintain its global position.

Several levers are envisaged to address the challenges of security, competitiveness and decarbonisation: ultra-energy frugality, carbon neutrality, more productive operations without disruption and support for the digital revolution42. In order to activate these levers, the players in the French aviation sector are following a process of innovation structured in two main stages commonly covered by research and development:

1. **Research Technological Research, which** aims to identify or create and make technologies applicable to aeronautical products;
2. The **development** stage, when these technologies are integrated into products.

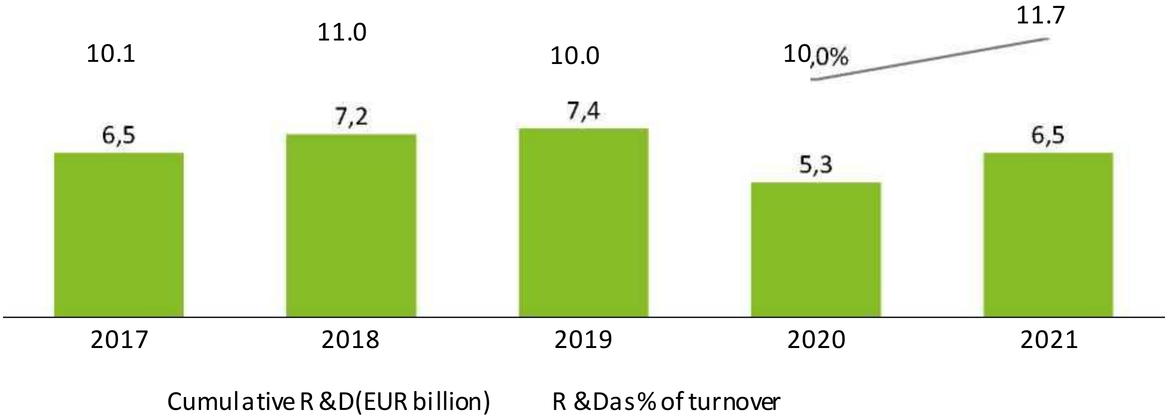
In2019, aircraft and space manufacturing accounted in France for 10 % of the internal expenditure on business research and development (DIRDE), second behind the automotive industry43. The main players in the sector spend almost EUR 7 billion each year on research and development44.

42https://aerorecherchecorac.com/feuille-de-route-corac/.

43Ministry of Higher Education, Research and Innovation – Study “State of Higher Education, Research and Innovation in France No 15”.

44Perimeter: members of GIFAS.

Figure 7. Expenditure on research and development in the aviation sector in France



Source: GIFAS Annual Reports 2018-2019-2020 and GIFAS Website

Research and development efforts are a key means of responding to the challenges of the civil aviation industry. Given the multiplicity of private actors that make up it and the length of the cycles in which new technologies are introduced (*e.g. engines* – 15/20 years, composites – 20 years)45, the French industry benefits from the mobilisation of public actors to ensure that initiatives are consistent at national level.

1.2. Public intervention in the sector

1.2.1 Recovery plan for the sector during the COVID-19 crisis (2020-2022)

The aeronautical industry is considered by the French State to be indispensable for the French economic and social landscape. It represents a strategic domestic sector providing added value, jobs and innovation, and represents a significant trade surplus for the economy. In these various respects, it receives particular attention from the public authorities.

In the military field, aircraft play a major role in force equipment and in the aerial deterrent component. The sector comprises a range of strategic suppliers for the Directorate-General for the Armaments (DGA), which is responsible for preparing national defence systems. As such, the French aviation industry is an issue of national sovereignty.

As a result of the COVID-19 crisis, the sharp reduction in orders due to the drop in air traffic prompted the French State to launch a support plan of EUR 15 billion. The plan had 3 objectives:

- Responding to the emergency by supporting firms in difficulty and protecting their employees;
- Investing in SMEs and mid-caps to support the transformation of the sector;
- Invest in designing and producing tomorrow's devices in France46.

To this end, the French State has relied on a variety of aid mechanisms for undertakings: loan guarantee, anticipation of public purchases, acquisition of shareholdings, grant or repayable advance.

45Pipame – Study "Value Chain in Aeronautics Industry" – September 2009.
46Presentation of the aviation support plan by the Ministry of Economy, Finance and Recovery on 9 June 2020.

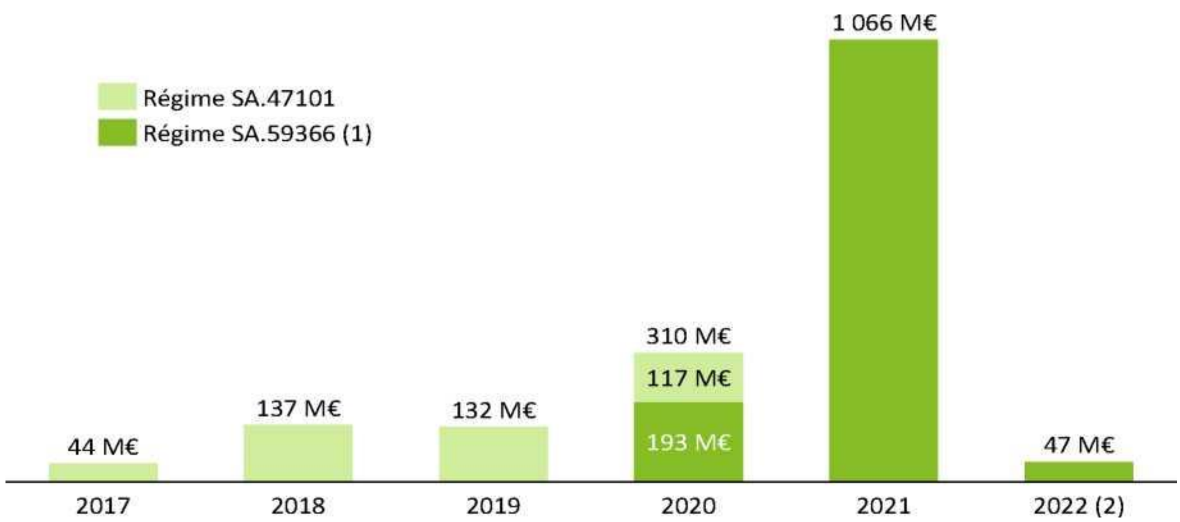
Table 5. Measures to support and support the structural transformation of the sector set up in 2020 by the French State

	Public aid	Pilot	Total amount of aid (MEUR)	Period covered by the aid
Devices emergency and support	State aranti loan (PGE) – Aeronautics subsidiary	DGT, B PI France	1 500	2020
	Adjustment of export guarantees	DGT, BPI France	3 600	2020-2021
	Anticipating military controls	DGA	832	2020-2022
	State Garanti Loan (PGE) – Air France	DGI BPI France	4 000	2020
	Shareholder account advance Air France	< EPA	3 000	
Devices for processing in the sector	Subsidies for the modernisation of operators in the sector	DGE, B PI France	300	2020-2022
	Fund for the consolidation anddiversification of the sector *	Tikehau Capital	200	2020-2030
	2020-2022 support for R &T/R &Dand innovation in the sector	**DGAC**	**1 500**	**2020-2022**
Total			**14 932**	

Source: Court of Auditors[48] – Information report Sénat February[2022] – Draft budget law 2020/2021/2022

Aid scheme No SA.59366 (in bold in the previous table) was put in place in this context of increased State support for the sector. It forms part of a coherent package of financial aid, proposing a specific research component as a continuation of the aid scheme SA.47101 put in place between 2017 and 2020:

Figure 8. Commitments to support R &Din the sector by the French State since 2017



Source: DGAC data, Deloitte Analyses
(1) Current liabilities, including firm and conditional instalments
(2) Committed as per 31 May 2022

48 Court of Auditors – Report “Public support for the aviation sector” – February 2022.
49 https://www.senat.fr/rap/r21-538/r21-5381.pdf

This regular support is consistent with the specificities of the aviation industry: long innovation cycles (around 15 years), which require high R & D investment (several billion euros), continuously and continuously.

The level of funding and the uncertainties specific to research projects (i.e. returns on investment, etc.) encourage the pooling of costs and risks and, more generally, the synchronisation of the efforts of the operators in the sector.

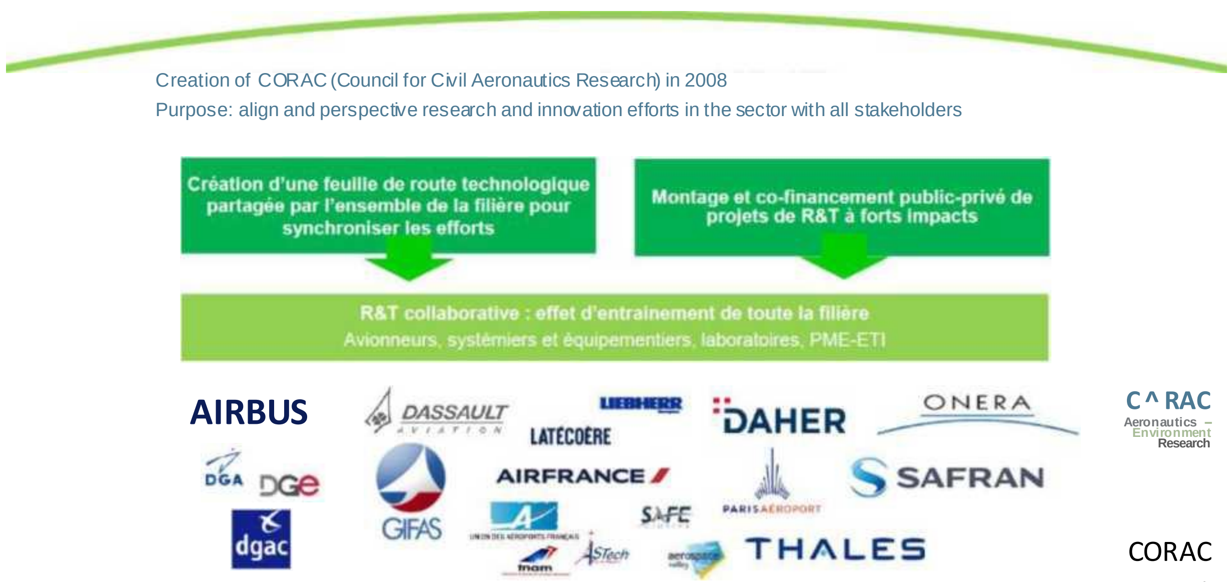
Aid schemes are necessary tools to steer and support these efforts on R &Dand reflect a national civil aviation policy.

1.2.2 French public policy to support research in the sector

The French State's industrial policy in the civil aviation sector is carried out by the Directorate-General for Civil Aviation (DGAC). The DGAC is responsible for ensuring the security and safety of French air transport and maintaining a balance between the development of the air transport sector and environmental protection. It is the national regulatory authority, provides air navigation services and trains civil aviation actors through the National Civil Aviation School (ENAC). This public structure is specific to the aeronautics sector in France and allows the State to participate in the strategic steering of the sector.

As a partner of the main players in the aviation industry, the DGAC allocates financial aid to research in civil aeronautics. To this end, it draws on the COnla pour la Recherche Aeratique Civile (CORAC) to draw up the technological roadmap for the sector.

Figure 9. Presentation of CORAC



Source: Presentation by DGAC-CORAC, R &D- 2020-2021

CORAC was set up in 2008 following the signing of a commitment agreement between industry manufacturers and the French Ministry of Ecology, Energy, Sustainable Development and Spatial Planning, in the framework of the Grenelle Environment. This commitment focused on stepping up technological progress and research efforts in aviation to reduce the environmental impact of the sector.

Under the leadership of DGAC and GIFAS, CORAC was founded to synchronise the efforts of French air transport actors. It aligns R &Defforts in the sector by establishing the objectives assigned to the various players involved in French aeronautical research, by constructing and updating a technological roadmap.

The main task of CORAC is to build and update a roadmap to define disruptive technology axes for future aeronautical programmes. The roadmap is developed by CORAC members (representatives of aircraft manufacturers, motorists, large OEMs, as well as companies in row 1 and SMEs ETI). It is broken down into three axes50:

- **The energy revolution** with ultra-frugality of energy and carbon neutrality;
- The **revolution in operations** with flight support and flight safety, operations with a reduced environmental footprint and more productive operations without disruption;
- The **competitive revolution with the** establishment of new standards, the disruption of products and uses, and the digital revolution and the efficiency of the integrated sector.

On each of these axes, CORAC has defined the technological levers and building blocks to address them.

Table 6. Major technological levers supported by the CORAC roadmap

CORAC technology axis		Technological levers of CORAC
Energy revolution	U	• More efficient wing (elongation, active control), lighter aerodstructures and aerodynamic gains • Introduction of new formulae, electric hybridisation of electric turbines and propulsion engines • Other work than that carried out the engine intended to: reduce the energy consumption • Carbon neutrality objective: replacement of kerosene for current machinery with cleaner energy, electrification, hydrogen
Revolution of operations	U	• Automation of in-flight functions, lightening of crew load and size, securing of flights • Predictive and assisted maintenance • Optimisation of flight paths, reduction of ATM (Air Traffic Management) constraints and collaborative optimisation, flight in training
Competitiveness revolution	U	• Digital continuity across the value chain, better integration of the supply chain, agility of production systems • Means of conformity, certification, transposition of industrial standards, qualifications

Source: https://aerorecherchecorac.com

50https://aerorecherchecorac.com/feuille-de-route-corac/

The multiannual roadmap aims to optimise public and private efforts. It is based on the expression of the clients' needs, which are returned to suppliers and subcontractors of various ranks. Building a shared roadmap is one of the three pillars of the research plan developed by CORAC. The other two pillars are (i) "the annual implementation of a set of projects selected by decision of the State, on the basis of the priorities of the technology roadmap, co-financed on a parity basis by the State and industry" and (ii) "the broad association of GIFAS's entire industry, suppliers and SMEs, competitiveness clusters, regional clusters, technological research institutes, academic laboratories, and ONERA" 51.

Since 2020, CORAC-SMEs has also been a relay to further integrating SMEs into projects supported by DGAC, through two approaches: at the top ('Top- Down') and at the bottom ('Bottom-up').

Under the 'Top-Down' approach, CORAC-SMEs distributes calls for expertise on projects proposed by major contractors in the SME network, in order to involve them more in joint projects52.

The Bottom-up approach is based on the empowerment of SMEs as promoters of R &D.CORAC-SMEs acts as an interlocutor for SMEs wishing to participate in the sector's R &Dand identifies those likely to contribute to relevant technological bricks or to provide their own building blocks. It then accompanies these SMEs in setting up their projects or integrates them into existing consortia, providing insights into the guidelines of the industry roadmap and helping them to structure the appropriate partnership option.

Inaddition to the national initiatives promoted by CORAC, the administrative regions contribute, on a smaller scale, to the funding of research in the sector. For example, the Occitanie and New Aquitaine regions introduced light aviation development aid at the beginning of 2020, supported by the Aerospace Valley Competitiveness Hub.

Aerospace Valley

Aerospace Valley is one of the three areas of competitiveness of the aviation industry that drive French territory. It is geographically rooted in the regions of Occitanie and New Aquitaine. In these regions, the sector accounts for about 16 % of industrial employment.

It is composed of 812 members:

- Private sector: Large companies, mid-caps and SMEs;
- Academics: Laboratories and schools;
- Institutional: Regions and metropolitan areas.

The tasks of the cluster are twofold:

- Developing the activity of the aeronautics and space industries *through* the leverage of innovation, which is a major driver of its success;
- Accompany members on export, diversification and the search for funding.

To this end, the cluster carries out various actions:

- Project research, but also stimulation of ecosystem actors to offer solutions (calls for skills);
- Seeking cofinancing for projects.

The cluster provides support to smaller players (SMEs, VSEs) in the sector by enabling them to reach

51Court of Auditors – Report "Public support for the aviation sector" – February 2022.
52Interview with CORAC-SME representative – June 2022.

out to clients and funders5354555657. Aerospace Valley is ranked in the top trio of global competitiveness poles for the performance of its cooperative R &T. projects. The sector's R & D steering bodies rely on these competitiveness poles to multiply their actions and reach new players.

The synchronisation of stakeholders in the sector with regard to the development of research projects was thus organised under the supervision of the DGAC, by setting up CORAC and then CORAC-PME. This public intervention should be informed in the light of that of other major civil aviation countries.

1.2.3 public intervention in R &D: comparative view with other main countries of the civil aviation market

The involvement of public actors in the technological development of the aviation sector is not a phenomenon specific to France, although public intervention may be organised differently between countries. The European Union participates in the financing of projects *through* its *Clean Aviation* programme, while the German and British aviation industries have also put in place research aid schemes.

Table 7. Public support for R &D in different countries

Countries	Helping hand	Average annual amount 2020-2022 (MEUR)
France	CO RAC	500
Germany	LU FO	175
United Kingdom	ATI Programme Fund	172
European Union	Clean Sky 2 and CLEAN Aviation (1)	215

Source: Court of Auditors[54], Aerospace Technology Institute (ATI-UK)[55], The German R & T Public Funding Framework and the Aeronautics R &T- Program (LuFo)[56] – Site Clean Aviation[57]

(1) Clean Aviation provides EUR 1,7 billion in aid for the period 2021-2027. This programme was preceded by Clean Sky II, with an annual allocation of EUR 220 million between 2014 and 2020.

Aid granted by the European Union

The European Union, *through* the European Commission, runs the *Clean Aviation* initiative set up under the Horizon Europe project, a common research and innovation framework programme for all Member States. It follows on from the *Clean Sky* (2008-2014) and *Clean Sky II* (2014-2024) initiatives.

It aims to accelerate the development of disruptive technologies to introduce low-emission aircraft already in 2030 and to ensure carbon neutrality of commercial aircraft already in 2050, following the ACARE (*Advisory Council for Aeronautics Research in Europe) roadmap. It* focuses on technological bricks related to short and medium-haul and regional aircraft and the use of hydrogen as an energy source for aircraft.

It has a budget of EUR 1,7 billion between 2021-2027 and must create conditions for collaboration between public and private actors at European level by bringing together complementary expertise. In addition, the initiative aims to define standards and prepare certification rules for EASA (*European*

53https://www.aerospace-valley.com/ and interview with a representative of Aerospace Valley – June 2022
54Court of Auditors – Report "Public support for the aviation sector" – February 2022.
55https://www.ati.org.uk/wp-content/uploads/2022/04/ATI-Annual-Review-2020-21.pdf
56https://ftfsweden.se/wp-content/uploads/2019/10/FT2019-Plenary_LuFo-Jan-Bode.pdf
57https://clean-aviation.eu/sites/default/files/2022-03/CAJU-GB-2022-03-16-Amended-WP-Budget-2022-23_en.pdf

Union Aviation Safety Agency) for disruptive technologies.

Aid schemes in Germany (LUFO)

The German Federal State runs a national aviation strategy, one of the objectives of which is to ensure the competitiveness of the national industry58 in terms of technological innovation.

To this end, the Federal Ministry of Economy and Energy (BMWi) has introduced the Luftfahrt-Forschungsprogramm (LUFO) aid schemes since 1995. These schemes are run by the German Centre for Aeronautics and Aeronautics (DLR), which is responsible for both German space and aeronautical research, but also energy and transport research.

The schemes are put in place over a period of 4 to 5 years and aim to foster innovation *through* collaboration between private actors in the sector and academics.

Set up in 2019, the LUFO VI-1 aid scheme supports R &T projects between 2020 and 2023. The projects selected must not exceed the TRL 6. LUFO VI-1 feeds into projects on optimising production and operational maintenance processes (Industry 4.0, interconnected production systems) and on products (improved aerodynamics, propulsion, etc.).

UK Aid Mechanisms (ITA)

The Aerospace Technology Institute (ATI) is an independent organisation responsible for defining the technological orientations of the British aeronautics and space sectors59. It is financed equally by the United Kingdom *through* the *Department for Business, Energy and Industrial Strategy* (BEIS) and by industry in the sector.

In order to operationalise the strategic guidelines laid down by the ITA, the BEIS has, since 2013, set up a programme to finance R &Dfor the national civil aviation industry involving private and public sectors, the *ATI programme funds*. This programme is managed by the agency attached to BEIS " *Innovate UK*". ATI plays an expert role in ensuring the alignment of the supported project portfolio with the national strategy. The UK government has committed itself to fund the programme alongside industry industry until 2031.

The amount of aid granted by aid scheme No SA.59366 compared with aid granted by foreign countries demonstrates the importance attached by the French industry to the search for technological solutions for future aviation. It is now necessary to set out the specific features of this scheme.

1.3. Presentation of aid scheme SA.59366 (2020-2023)

1.3.1 Socio-economic context and rationale of the scheme

Aid scheme No SA.59366 is a support scheme targeted at the aviation industry. Its rationale is based on various reasons which have been decisive in the choice of amounts invested, the timing of the scheme and the arrangements for intervention.

COVID-19 crisis: The health crisis, which led to the cancellation of a large number of flights due to health constraints, has weakened the downstream aviation industry. This shock had an impact on the

The58 German aviation and space industry accounts for around 29 % of the French sector (see Figure 2).
The59 British aviation and space industry accounts for about 26 % of the French industry (see Figure 2).

upstream sector of the aviation industry, by cancelling/postponing aircraft deliveries. Although the size of the shock was reduced by the importance of pre-crisis orders and by the measures to support the sector under the recovery plan, the sector's turnover fell by 29 % in 2020[60] and aircraft deliveries fell to 2012/2013 for commercial aviation (566 aircraft delivered by Airbus in 2020 compared with 863 in 2019) and orders collapsed (268 net orders for Airbus in 2020 compared to 768 in 2019)[61].

Importance of the environmental transition: Air transport accounts for between 2 and 3 % of global CO_2 emissions. It is a sector criticised in Europe for its environmental impact, which has resulted in a ban on flights in France where there is a rail alternative of less than 2: 30 hours[62] or an obligation to offset carbon emissions. Reducing the environmental footprint of air transport is essential in Europe. This transition is naturally implemented by manufacturers due to the high fuel costs in air transport (around 40 % of all costs). However, the rate of change in CO_2 emissions so far (around 15 % per decade) is insufficient to meet the European objective of carbon neutrality by 2050 and a halving of emissions by 2030. These objectives require a major technological leap forward in aviation: improved design of appliances, change of materials to gain lightness, electrification, change in the energy sources used and associated motorisation (development of biofuels and hydrogen), etc.

It should be noted that in terms of environmental impact, support for the decarbonisation of the aviation sector can be particularly effective. It will directly address the decarbonisation of air transport at global level and not just at French or European level. This will require, in particular, the decarbonisation of average and long-haul flights of more than 500 km, which account for 95 % of the sector's emissions.

Therefore, the planned aid for the aviation sector is aimed not only at addressing the cyclical challenges linked to the COVID-19 crisis, but also at more structural challenges. To this end, the investment made (EUR 1,5 billion over the period 2020-2023) is far greater than the needs of short-term intervention and interventions in other sectors (the fund to support R &Dfor the automotive sector for the development of clean vehicles is thus EUR 150 million). In the light of these challenges, the choice of support for R &Dappears to be relevant. Economic literature thus points out that financing R &Din times of cyclical difficulties can be a key element in the future competitiveness of firms, and that public intervention may be essential in this respect, especially when companies may encounter difficulties in obtaining market financing for these investments (due to too high risk, financial constraints, etc.)[63].

The**rationale of the aid scheme is twofold**: to secure the skills and R &Defforts needed for future competitiveness and to support the ambitious technological shift required by the European environmental transition objectives.

1.3.2 Legal background to the exemption scheme

In order not to distort or threaten competition within the internal market or to affect trade between Member States, Article 107 of the Treaty on the Functioning of the European Union (TFEU) sets out the general framework within which State aid may be considered compatible with the internal market.

In order to assess compliance with this framework, Article 108 (3) of the TFEU provides that the State has a duty to notify any planned State aid to the Commission so that the Commission can take a decision

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60Report of the Court of Auditors (Public Support to the Aeronautical Sector)

61Airbus

62Climate Law and Resilience, Article 145.

63 Philippe Aghion, Philippe Askenazy, Nicolas Berman, Gilbert Ce, Laurent Eymard, Credit Constraints and the Cyclicality of R &DInvestment: Evidence from France, *Journal of the European Economic Association*, Volume 10, Issue 5, 1 October 2012, Pages 1001 – 1024, https://doi.org/10.1111/j.1542-4774.2012.01093.x

on the compatibility of that aid with the internal market on the basis of Article 107 TFEU.

However, certain aid may be **deemed compatible and exempted from notification** in accordance with the provisions of General Category Exemption Regulation (GBER) No 651/2014 of 17 June 2014, as amended by Commission Regulations 2017/1084 of 14 June 2017 and 2020/972 of 2 July 2020. The GBER thus specifies the criteria for the compatibility of such aid, including in particular the aid for research and development and innovation referred to in Article 25 of the GBER.

This Article lays down the conditions for the compatibility of aid for research and development projects relating to:

- The type of research carried out (fundamental, industrial, experimental development or feasibility studies);
- The categories of eligible costs;
- The aid intensity, which must not exceed a certain threshold as a percentage of the costs according to the type of research carried out and the profile of the beneficiary undertakings.

Pursuant to Article 1 of the GBER, however, the exemption from notification of schemes exceeding an average of EUR 150 million in annual aid for notification to the Commission depends on **an *ex-post*evaluation plan** on account of their scale and potential effects on competition in the internal market.

It is in this context that this aid scheme SA.59366 on aid for research and development for the decarbonisation, competitiveness and safety of air transport for the period 2020-2023 was exempted from notification.

In accordance with Article 1 of the GBER by category No 651/2014, the evaluation plan for the scheme has been notified to the European Commission. The objective of the *ex-post* evaluation described in the evaluation plan is to measure:

- The direct impact of the support on the beneficiaries, particularly in terms of the development of strategic projects, R &Dor in terms of aid for the integration of beneficiaries into the aeronautical market;
- The indirect impact of the support in terms of the impact on other undertakings in the sector or not, the inclusion of SMEs in projects, the encouragement of collaboration between undertakings and their risk-taking, and in terms of the objective of decarbonisation, competitiveness and safety of air transport;
- Proportionality and relevance of the project.

1.3.3 Objectives of the aid scheme

Aid scheme No SA.59366 was introduced in October 2020 to accompany the increase in the amounts of support for aeronautics R &Dlinked to the 'France Relance' plan announced in July 2020 by the French State. It co-finances projects carried out by operators in the sector between 20 October 2020 and 31 December 2023 (indicative annual budget) to the tune of EUR 1 billion per year. The projects selected under the support scheme are part of the CORAC roadmap, built up to 2027, and aim to remove technological bottlenecks related to the decarbonisation, competitiveness and safety of air transport.

This aid plan is granted by the Directorate-General for Civil Aviation (DGAC), which applies in particular Decree No 2018-514 of 25 June 2018 on State subsidies for investment projects and its implementing legislation, in particular the Orders of 21 August 2018 and 2 August 2019 pursuant to Articles 3 and 6 thereof.

The beneficiaries of the scheme are undertakings, irrespective of their size, having an establishment or branch in France at the time of payment of the aid. The projects concern the whole territory of France.

Approved projects may be of four types:

- Fundamental research;
- Industrial research (almost all DGAC projects fall under this category);
- Experimental development;
- Financing of infrastructure for research.

The topics of the work include64:

- Aircraft, or parts, sub-assemblies and component systems thereof;
- Technological bricks for aircraft, or parts, subassemblies and systems thereof;
- Understanding of scientific phenomena affecting flight safety;
- The impact of air transport on the environment (climate, noise, air quality, acceptability social);
- Upstream research into production and maintenance processes related to aircraft or parts, sub-assemblies and systems thereof;
- Upstream research on air traffic management systems;
- Aeronautical research infrastructures.

Depending on the type of research and the size of the enterprise, projects may receive varying aid intensity.

Table 8. Summary of the aid intensity of aid scheme No SA.59366 for projects R &Dand maximum aid65 amount

	Small enterprise	Enterprise mean	Large enterprise	Maximum amount of aid (EUR million) (1)
Fundamental research	*100 %*	*100 %*	*100 %*	40
Industrial research	*70 %*	*60 %*	*50 %*	20
In case of effective collaboration and/or wide dissemination of project results (2)	*80 %*	*75 %*	*65 %*	
Experimental development	*45 %*	*35 %*	*25 %*	15
In case of effective collaboration and/or wide dissemination of project results (2)	*60 %*	*50 %*	*40 %*	

Source: www.europe-en-france.gouv.fr/sites/default/files/sa.59366_relatif_aux_aides_a_la_recherche_et_au_developpement_pour_la_decarb

64www.europe-en-france.gouv.fr/sites/default/files/sa.59366_relatif_aux_aides_a_la_recherche_et_au_developpement_pour_la_decarbonation_la_competitivite_et_la_securite_du_transport_aerien.pdf

65The rate of support chosen by the DGAC for industrial research projects is 50 %.

onation_la_competitivite_et_la_securite_du_transport_aerien.pdf

(1) Notification of the aid to the European Commission is mandatory when the aid exceeds these amounts, expressed as a grant equivalent to Brut (GGE).

(2) There is (i) effective collaboration between companies and at least one SME, or if the project is carried out in two Member States; (II) between an undertaking and one or more research and dissemination organisations.

N.B.: Classification of enterprises according to their size as defined by the European Commission: a small enterprise employs fewer than 50 people and its turnover or balance sheet does not exceed EUR 10 million; a medium -sized enterprise employs fewer than 250 persons and its turnover does not exceed EUR 50 million or its balance sheet does not exceed EUR 43 million; a large enterprise is an enterprise that does not fall within the definition of small and medium -sized enterprises.

In this context, according to the replies to the Court of Auditors issued by the DGAC, the main aim **of the scheme is (i) to prepare for the environmental disruption of aviation (ii) while enhancing the competitiveness (reduction of production costs, acceleration of the ripening of technologies, improvement of the framework) of the sector in order to enable this environmental disruption to penetrate the market in a highly competitive environment.**

“ *With this support plan, France can therefore both **safeguard the employment of R &Dand the skills of its aviation industry**, and address as a technical and industrial leader the energy transition for all categories of aircraft, taking into account in particular the leverage effect in terms of combating greenhouse gas emissions offered by Airbus and Safran’s global leadership on short/medium haul aircraft and their engines.*” (DGAC reply to the Court of Auditors).

The projects supported by the scheme prepare the candidate technological options for the integration into future civil aircraft programmes whose launch conditions are not yet specified and which are now being considered for implementation over a time horizon from 2025 to 2035:

- **The successor to the A320**, which must (i) be energy-efficient (30 % fuel consumption savings target and be able to fly with 100 % biofuels) and (ii) prepare the transition to hydrogen as primary energy (zero CO_2). The equipment is planned to be put into service by 2035;
- **A new regional device**, which will be energy-efficient, will allow for hybrid energy consumption (fuel/electricity) or will be powered by hydrogen. The equipment is planned to be put into service around 2030;
- The **successor to the Ecureuil helicopter**, which will be energy-saving (40 % reduction in consumption), will initially enable hybrid energy consumption (fuel/electricity) and then hydrogen based energy consumption in its latest version;
- **New business appliances**, able to fly with 100 % biofuels and to be at least partially hydrogen-powered;
- **Hybrid general aviation aircraft**;
- **High-performance drones;**
- **Improving air and airport operations** by optimising aircraft trajectories to reduce CO_2 emissions (target of 5 % reduction with first effect from 2025).

The eventual commercialisation of these programmes by operators in the sector meets the challenges of decarbonisation, competitiveness and security raised by the aid scheme.

More specifically, the objectives indicated in the evaluation plan are to:

- Fostering R &Dto develop the decarbonisation, competitiveness and safety of air transport;
- Boosting employment in research and R &D;

And to a lesser extent:

- Increasing foreground and its dissemination;
- Promote the development of new products and services on the market;
- Fostering coordination between private and public actors;
- Modernise and develop the R &Dequipment pool and laboratories and promote their access for businesses.

1.3.4 means implemented in response to these objectives

Grants: Almost all projects under the scheme have a final TRL lower or equal to TRL 6, corresponding to pre-competitive research. These projects are supported under the scheme through research grants amounting to 50 % of the costs for industrial actors and 100 % for academic actors in projects aimed at creating knowledge (and not industrial). This is the case for the DGAC:

- Helping players to position themselves on the market;
- Encouraging clients to do R &T with partners rather than engaging too quickly in requests for information (RFI);
- Support collaboration, in particular with research laboratories.

It should be noted, however, that this boundary has shifted in relation to the TRL's assessment of the product/process torque (including, in particular, the consideration of productibility issues from the design stage), rather than on products/components alone (the question of the integration of components is then less significant).

Repayable advances: DGAC can also intervene (including beyond TRL 6) via repayable advances to cover the risk of operators in the sector. The DGAC, having a long-term perspective, does not have the same requirement as traditional loans in terms of repayment schedule. The repayable advances thus constitute insurance against missale and technological risk, since the beneficiaries reimburse only as and when deliveries are made. However, these repayable advances are hardly present in the new aid scheme (EUR 40 million out of EUR 1,4 billion), since the latter is mainly aimed at upstream research (up to TRL 6).

Structuring of projects and support for beneficiaries: In addition to the financial instruments, the State also intervenes to support the structuring of projects. The pyramid structure of the sector and the challenges of integrating and accepting solutions by the higher ranks may lead to significant coordination shortcomings, especially since technological developments are specific (and therefore difficult to transpose to another sector). The DGAC intervenes in this context in order to ensure better coordination, thanks in particular to the leverage of funding and its knowledge of the players and issues involved in the sector.

Project identification: Proposals from the sector are collected by the DGAC in three ways (extract from the replies to the Court of Auditors):

1. The **major industrialists directly present in the bodies of CORAC (Airbus, Airbus Helicopters, Dassault, Safran, Thales, Daher, Stelia, Liebherr Aerospace, Latecoère, Hutchinson, plus the**

ONERA public institution) frame and express directly in CORAC their project proposals, consistent with the technological roadmap for the sector developed by CORAC. These typically include proposals for partnerships with companies (including SMEs) and public laboratories that are not part of this first circle;

2. **Since June 2020, the DGAC has taken a systematic approach to contacting and collecting proposals from the major players in the sector who are not directly present in CORAC, from the large ETIs who drive their regional fabric and have a structured R &Dability, or from subsidiaries of foreign groups with production and engineering capacities in France (e.g. Collins Aerospace group).** When contacting them, their needs are collected and put into perspective with their rebound strategy, the DGAC gives them or checks that they have an insight into the aspects of the donor's strategy that are relevant for directing them; their proposals are incorporated into the DGCA's programming or merged, where more relevant, with others. **Not all companies are ready to apply for R &D- support, some because they are too vulnerable by the crisis and consolidation operations are underway, because the current situation leads to too many strategic uncertainties and because R &Dis not their priority, or because their R &Dcapacities are not sufficiently developed**.
3. **For applications for support from SMEs/mid-caps in the sector, the DGAC and the GIFAS have set up a single entry point (mainly for simplification purposes)**: the project ideas, in the form of a summary description, should be sent to CORAC-PME; a selection was then carried out collectively by the DGAC, the DGE and the GIFAS to guide the requests of SMEs/mid-caps to the most suitable system. The sorting logic is as follows:
   - requests from companies that mainly concern modernisation of the production tool, or diversification, are directed towards the GIP;
   - longer-term subjects, with a strong component of product or process innovation, or which require interaction with a client/partner/contractor, or which offer subcontracting services, are directed to the DGCA.

   Research stakeholders, in particular ONERA, are either integrated into the projects of companies in the sector (directly or following a joint framework of the project with the DGAC) or are financed directly to carry out more fundamental research aimed at developing scientific knowledge, in particular on the impact of aviation on the climate (e.g. research projects on mechanisms for training and dissipating condensation or contrails) and noise, but also on physical phenomena that are still poorly controlled (reaction to fire of composite materials, icing).

Selection process: Once financial eligibility for support has been established, in accordance with the criteria laid down in European rules, selection is made with a view to preserving cohesion and the general interest of the sector in several dimensions, in particular:

- The relevance and maturity of the technical and financial framework of the project;
- The relevance of the project to the broad political guidelines (Plan de Relance et France) (2030), and various dimensions including:
  - defined impact criteria, in particular in terms of environmental benefits, creation of collective added value at the level of the sector;
  - overall coherence and inclusiveness of the annual support programmes.

The consistency of the project with the CORAC technology roadmap is naturally examined, even if this criterion is applied in practice more strictly for projects of large companies compared to those of SMEs/mid-caps.

For the latter, the DGAC has set up a dedicated entry point with the GIFAS in order to gather their project ideas and direct them to the most relevant support mechanism and with a view to structuring subjects linked to the needs of the contractors.

With regard to the operators in the sector who are not part of CORAC (in particular the mid-caps of the regional fabric which have R &D capacity or subsidiaries of foreign groups with production and engineering capacities in France), the DGAC directly contacts and collects their proposals.

Finally, as far as academic stakeholders are concerned, they are either directly involved by industry in their (industrial) research projects or directly funded.

The DGAC intends to limit the "deadweight effects" of the support and its strategy for implementing the Recovery Plan therefore gives very high priority to companies with an existing R &Dpractice that are experiencing a fall in activity as a result of the crisis, in order to preserve their skills, the development of their own products and, more generally, their ability to integrate into future aircraft programmes.

Since the aim is to structure the sector around these future programmes, the preparation phases of which will be spread over 10 years, the synchronisation and consistency of these companies' work with the timetable and what is known to the aircraft manufacturers and integrators to date must be taken into account: the question of whether work on a particular subject should be launched now in view of the overall timetable for the sector is therefore also discussed and discussed with project promoters. Thebeneficiaries of the aid granted under the scheme thus have several characteristics which are set out in the following section.

1.4. Presentation and characterisation of the beneficiaries of the scheme

The introduction of methodologies for identifying the impact of aid targeted by the *ex-post* evaluation requires, in the first place, a characterisation of the beneficiaries of the aid on three dimensions:

- **Category of actor**: The beneficiaries of this aid may indeed be large groups.
  research laboratories, SMEs and sub-contractors based in France. In the sector, the latter can play different roles, ranging from the role of integrator, supplier, tier 1 entity or subcontractor. Beneficiaries may also come from different sectors of activity;
- **Existing collaborative dynamics** between these actors: Since the aviation sector is characterised by a pyramid organisation, the scale of the investment needed in R &Dwithin this sector makes it necessary for the various players to work together in R &Dprojects and for the DGAC to intervene in order to support and connect this multiplicity of players;
- **Typology of projects on which these actors are positioned.**

1.4.1 breakdown of aid granted by type of actors

Between October 2020 and May 2022, all types of actors in the French civil aviation value chain, meeting the criteria set out in scheme SA.59366, received aid. In 2020, these beneficiaries represented an average annual turnover of EUR 708 million (all beneficiaries combined) and almost 1800 employees66.

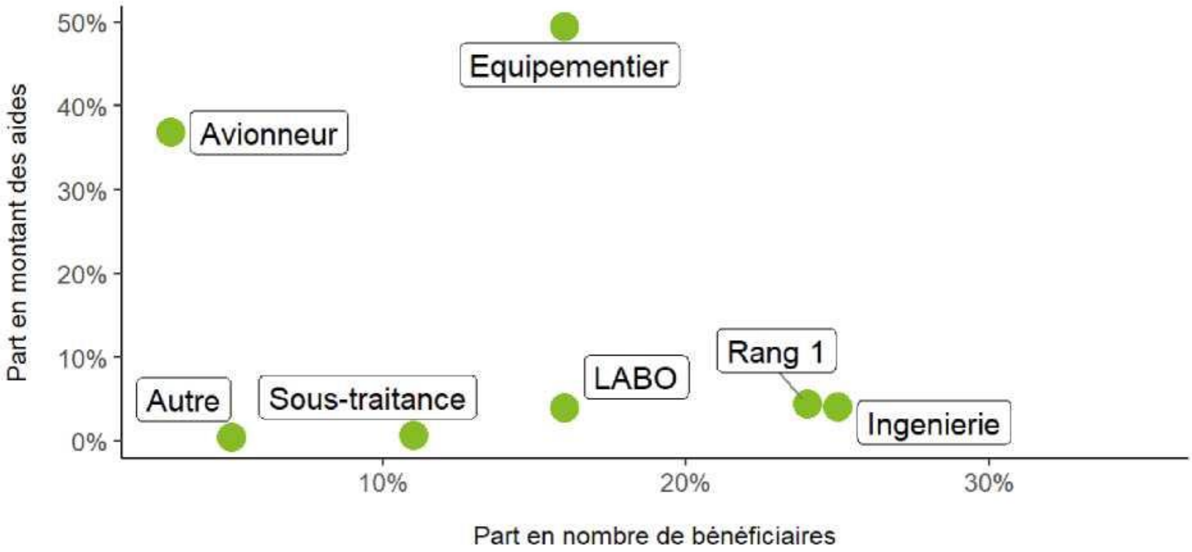
The aid granted concerned 224 beneficiaries between October 2020 and May 2022, including 7 airframe

66DIANE and Convention data.

manufacturers, 34 OEMs67, 57 engineering companies, 36 research laboratories, 54 subcontractors of rank 1 and 25 subcontractors of rank 2 or more68.

Over the period October 2020 to May 2022, the amount granted amounts to almost EUR 1 360 million. The aid concerns 89 % of the large groups (EUR 1 217 million), i.e. aircraft manufacturers, motorists and equipment manufacturers, the majority of which act as integrators in the sector. The latter (integrators) represent 15 % of the beneficiaries (in number) and receive 80 % of the total aid (of which 37 % for airframe manufacturers).

Figure 10. Distribution of aid in amount and number of beneficiaries



Source: DGAC data, Deloitte Analyses

It is the OEMs (including OEMs acting as integrators in the sector) that receive the most aid since the contracted amounts represent 49 % of the total amount of support granted over the period October 2020 to May 2022.

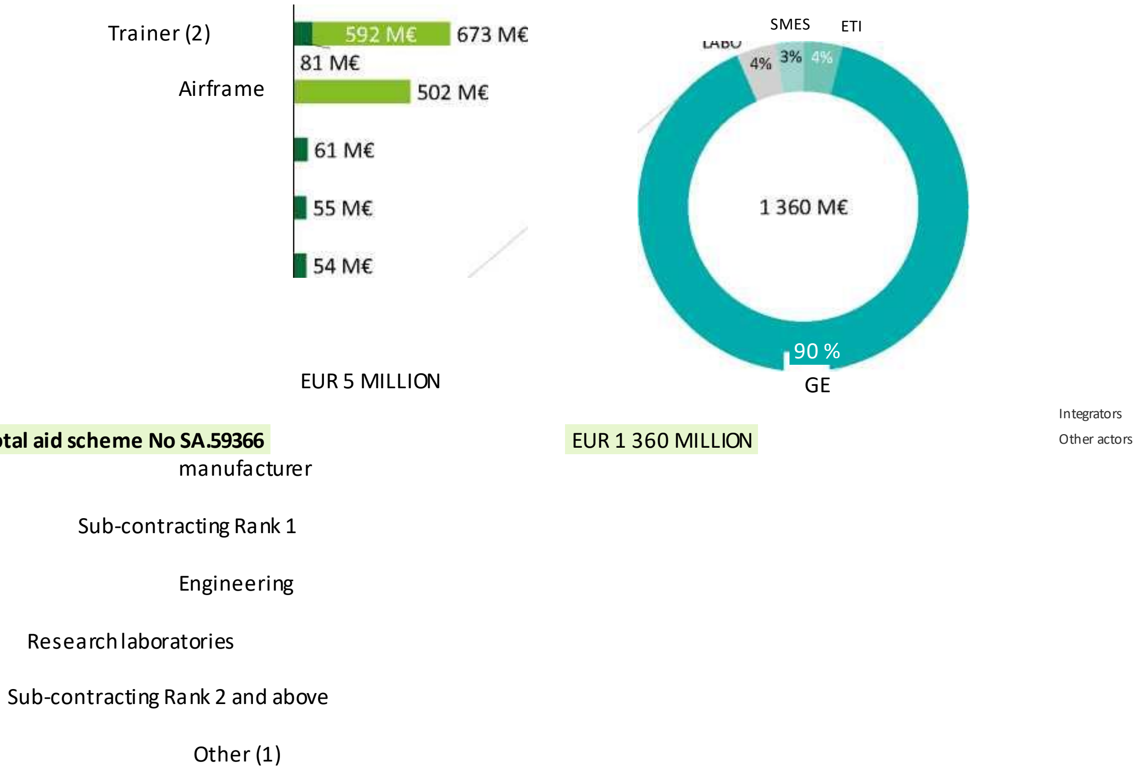
Engineering companies and tier 1 players other than OEMs, which have the highest number of beneficiaries (25 % in number of beneficiaries for each category), have a contracted amount of only 4 % of the total support (respectively for each category), as shown in the figure above.

Among the players who benefited from the scheme over the period, it was therefore the contractors (aircraft manufacturers, Tier 1 equipment manufacturers and motorists) who obtained the highest amounts of support in value terms, as shown in the figure below.

67These airframe manufacturers and some of the OEMs act as integrators within the industry. As contractors, these integrators involve other players in the sector through partnerships or through the purchase of subcontracting services.

6811 enterprises are classified as "Other".

Figure 11. Amount of support granted under aid scheme SA.59366 between October 2020 and May 2022 by type of actor and by company size[69]



Source: DGAC data, Deloitte Analyses

(1) Corresponds mainly to airlines (e.g.: Air France), space actors (e.g.: Ariane Group) or to actors not normally involved in the sector (e.g.: Orange)

(2) 88 % of the financial support for equipment manufacturers (EUR 592 million) is granted to integrators.

N.B.: Classification of types of actors by the DGCA; Enterprise size as defined by INSEE taking into account the beneficiaries' consolidated financial statements

Figure 12. Main actors benefiting from aid scheme SA.59366 between October 2020 and May 2022

Beneficiaries	Amount of support granted	Number of projects in which the beneficiary is involved
Airbus Operations	EUR 342 MILLION	50
Thales AVS France	EUR 166 MILLION	28
Safran Aircraft Engines	EUR 134 MILLION	33
Dassault Aviation	EUR 96 MILLION	18
Safran Helicopter Engines	EUR 54 MILLION	21
Airbus Helicopters	EUR 51 MILLION	19
Safran Electrical & Power	EUR 45 MILLION	13
Safran	EUR 42 MILLION	35
ONERA	EUR 39 MILLION	35
Safran Electronics & Defense	EUR 39 MILLION	10
Other beneficiaries (215 beneficiaries)	EUR 350 MILLION	

The analyses69 include the firm tranches and conditional tranches of all projects supported under the scheme.

Total aid scheme SA.59366	**EUR 1 360**

Source: DGAC data, Deloitte Analyses

All the players at the top of the sector's pyramid (aircraft manufacturers, tier 1 equipment manufacturers and motorists) received aid under the scheme. The amounts granted are seen in view of their significant participation in the effort to invest in R &T in the sector. For example, the Safran Group, which received around EUR 392 million in aid between 2020 and 2022, has self-financed its R &T by EUR 338 million in 2020, and plans to do so at an annual rate of EUR 560 million between 2021 and 202570.

However, the number of large enterprises represents only 40 % of beneficiaries, with the rest being mostly SMEs (25 %) and mid-caps (20 %). In 2020, large companies generated an average turnover of EUR 1,4 billion with almost 32 000 employees.

Table 9. Turnover and average number of employees by category of beneficiary (2020)

	Turnover (EUR M)	Number of workers
SMES	6	70
ETI	73	563
Large enterprises	1 446	3 186
Academic laboratories	— —	70

Source: DIANE Data, Deloitte Analyses

Finally, the majority of the aided entities come from the aircraft and space manufacturing sector (NAF code 3030Z) and the manufacture of navigational aids (NAF code 2651A): their aid represents 73 % of the total amount of aid, corresponding to EUR 982 million.

Table 10. Ranking of the top 10 sectors to which aid beneficiaries belong

NAF code	Sector	Amount of aid	Share of aid	Share of beneficiaries
3030Z	Aircraft and spacecraft	755	56 %	14 %
2651A	Manufacture of navigational aid apparatus	227	17 %	2 %
7219Z	Other research and experimental development on natural sciences and engineering	65	5 %	8 %
3316Z	Repair and maintenance of aircraft and spacecraft	54	4 %	0.5 %
2790Z	Manufacture of other electrical equipment	47	3 %	1 %
7010Z	Activities of head offices	46	3 %	2 %
2229A	Manufacture of plastic based technical parts	35	3 %	2 %
7112B	Engineering, technical consultancy	30	2 %	15 %
2711Z	Manufacture of electric motors, generators and transformers	11	1 %	0.5 %
6202A	It systems and software consultancy	9	1 %	3 %

Source: DGAC and DIANE data, Deloitte analyses

70Source: Capital Market Day Safran – Driving Innovation for Sustainable Growth – December 2021.

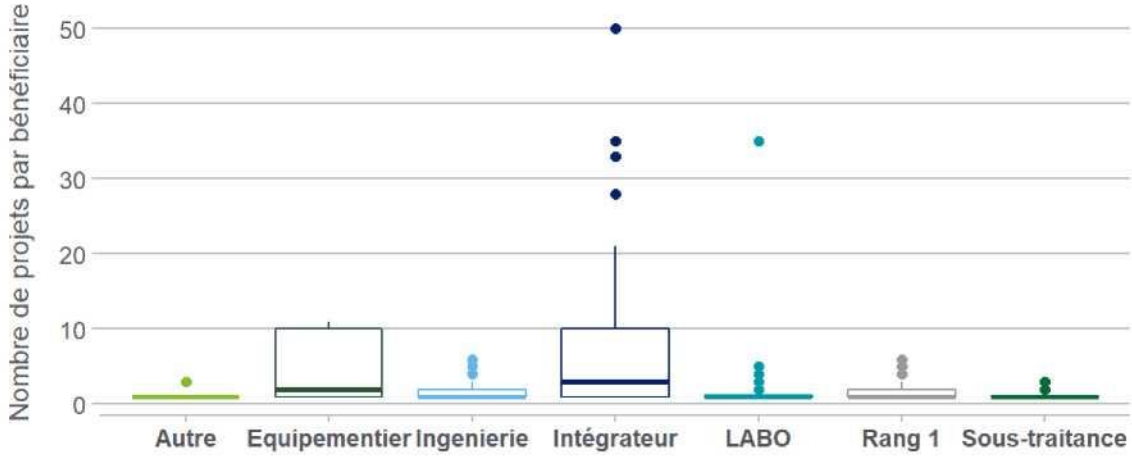
1.4.2 Distribution of beneficiaries on supported projects and in terms of collaboration

Beneficiaries may participate in several projects under the scheme: they participate in up to 50 projects (Airbus Operations), with an average of almost three projects per actor. However, these figures are divided differently according to the legal classification of the aid beneficiaries: large enterprises are the beneficiaries with the highest level of participation in projects with on average almost five (5) projects per actor supported by the aid scheme for this type of enterprise.

SMEs, on the other hand, participate on average in one (1) project per actor, where mid-caps are two (2) participations per actor on average. The academic laboratories that participate on average in two (2) projects per actor are in a maximum of 35 projects, mainly thanks to ONERA.

Considering the role played by beneficiaries in the sector, integrators have the highest level of participation in projects, with on average almost 9 projects per actor. OEMs participate on average in almost five (5) projects, while the rest of the actors (engineering companies, tier 1 subcontractors and higher-ranking subcontractors) participate on average in less than two (2) projects.

Figure 13. Distribution of the number of projects by role in the beneficiary sector



Source: DGAC data, Deloitte Analyses

Interpretation note: The pavements represent the interquartile gap with the bs, which represents the[25th] percentile, the middle represents the median (50[rd] percentile) and the top represents the[75th] percentile. Points represent extreme values associated with distribution.

Projects approved under the scheme have also often involved multiple beneficiaries: indeed, the projects supported involve up to 25 beneficiary actors working together on the same project.

One project has an average of four (4) participants and 50 % of the projects have more than two (2) participants. These projects therefore encouraged and encouraged collaboration, as between October 2020 and May 2022 more than a third of the projects involved at least five (5) beneficiaries.

Table 11. Level of collaboration on projects

Number of beneficiaries per project	% of total support granted	# of projects
A	34 %	58
Two	12 %	32
Three	9 %	25
Four	6 %	16
Five	6 %	11
Six	6 %	9
Seven	2 %	4
Over 8	24 %	21
Total aid scheme SA.59366	**100 %**	**176**

Source: DGAC data, Deloitte Analyses

The organisation of the French industry promotes and encourages this collaboration. Between October 2020 and May 2022, almost a quarter of the projects involved more than five (5) beneficiaries. The CORAC guidelines under the aid scheme promote the formation of consortia led by large groups including SMEs and mid-caps in the sector. By the end of May 2022, out of the 165 projects supported involving at least one large enterprise7172, 52 led to partnerships with SMEs or mid-caps.

1.4.3 Breakdown of aid granted by type of project

Main projects supported

Between October 2020 and May 2022, 176 projects were supported by aid scheme SA.59366.

Table 12. Main projects supported between October 2020 and May 2022

Project name (1)	Amount of support (IN EURO)	Number of beneficiaries
ECOPROP – TF	38 310 500	25
PEARL – TF	36 089 500	9
PASTEL – TF	31 548 500	8
CAPTAIN – TF	27 934 000	13
FINDER – TF	26 684 500	20
STOHYC – TF	25 303 500	14
ONE WAY – TF	23 492 500	14
ONE VOICE OOC – TF	23 436 000	6
TUCANS – TF	22 525 000	21
COMAT – TF	19 996 000	1
166 other projects	1 084 293 914	692
Total aid scheme SA.59366	**1 359 613 914**	**823**

Source: DGAC data, Deloitte Analyses

(1) 'TF' means 'firm tranche'.

These projects received on average almost EUR 8 million in aid, with a large disparity in the amounts granted: while the ECOPROP[72] project was supported with EUR 38,3 million, the project

Eva[73] was EUR 0,6 million. The distribution of aid amounts is shown by the following graph:

7111 projects did not include large enterprises, of which 2 were only carried out by research laboratories.
The ECOPROP project72 brings together 25 private companies (subcontractors, engineering companies, suppliers) around Airbus and Safran. Its objective is to design a decarbonised propulsion system.

Figure 14. Distribution of scheme funds by project size between October 2020 and May 2022

Project Size	Share of EUR 1,3 billion of support allocated	Number of projects
Less than 5	13 %	75
Between EUR 5 million and EUR 10 million	30 %	57
Between EUR 10 million and EUR 20 million	38 %	35
Between EUR 20 million and EUR 40 million	19 %	9

Source: DGAC data, Deloitte Analyses

The aid scheme has made it possible to support projects of varying sizes, ranging from less than EUR 5 million to EUR 40 million. 75 % of the projects financed (132 in total) were smaller than EUR 10 million.
5 % of them (9 in total, all multi-partners) were larger than EUR 20 million. In this sense, the scheme selects both many small projects and projects of significant size.

Projects worth more than EUR 5 million account for 87 % of the aid allocated, reflecting the significant financial effort needed to meet the research needs of the aeronautical industry.

Maturity of supported projects (TRL levels and project duration)

Depending on the technological brick, a significant period may be required between basic research, the development of technology and its industrialisation. The Technology Readiness Level (TRL) scale is used to standardise these typical R & D steps:

- **TRL 1 to 4** correspond to the research stages of the principle with proof of concept;
- **TRL 5 and TRL 6** correspond to advanced research stages and technological demonstrations;
- **TRL 7 to 9** correspond to the qualification and technological operational stages7374.

Each of the projects analysed includes one or more technological bricks, at least one of which has an early stage of maturity characteristic of the scope of the R &T, i.e. with an initial TRL of less than 675.

The EVA73 project, led by Latecoère, University Toulouse III and INPT, focuses on the design of a new door model.
74https://www.entreprises.gouv.fr/files/files/directions_services/politique-et-enjeux/innovation/tc2015/technologies-cles-2015-Annex.pdf
75Repayable advances may be used to support projects with a final TRL higher than TRL 6 (source: DGAC).

Table 13. Initial TRL and average duration of projects financed between October 2020 and May 2022 and analysed in June 2022

Initial TRL of the least mature technological brick of the project	Support amount (MEUR)	Number of projects
TRL1	588	69
TRL2	375	52
TRL3	108	13
TRL4	67	6
n.a (1)	222	36
Total aid scheme SA.59366	**1 360**	**176**

Source: DGAC data, Deloitte Analyses
(1) n.a = TRL not available in direct reading

The aid scheme is a vehicle for the development of bricks to respond to technological disruptions. For example, it enabled Airbus Helicopters to accelerate the development of a project bringing together a set of technologies to support tomorrow's helicopter ("Flightlab"). Starting from a TRL3 at the time of the France Relance plan, the project reached a TRL5 two years later. The target of a TRL6 is set for 2024 with the incorporation of these technologies into a product placed on the market by the end of the decade76.

Distribution of aid by technological challenges and levers

The aid scheme funds are in line with the three (3) technological axes defined in the CORAC Roadmap (see section 1.2.2).

Table 14. Distribution of aid amounts between October 2020 and May 2022 according to the technological axes defined in the CORAC roadmap

Technological Axes – CORAC Roadmap	Amount of support (MEUR)	Share of support	Number of projects
Energy revolution	551	41 %	75
Revolution of operations	318	23 %	34
Competitiveness revolution	249	18 %	25
n.a (1)	242	18 %	42
Total aid scheme SA.59366	**1 360**	**100 %**	**176**

Source: DGAC data – Deloitte analysis
(1) n.a = Unidentifiable relevant developments

N.B.: Projects may address several technological axes of the CORAC roadmap. It is recalled that: the decarbonisation objective is not only present in the "energy revolution", but also in the "energy revolution" "operations", and to a lesser extent "competitiveness".

Within the scope analysed, almost half of the aid (49 %) relates to projects aimed at developing technologies in line with **the 'Energy Revolution' axis** of the CORAC roadmap.

More specifically, within this axis, around 43 % of the aid amounts are aimed at making aircraft lighter and improving aero-dynamism, while 24 % relates to reducing fuel consumption of engines. The rest of the projects under this axis focus on technologies with a longer-term development and industrialisation

76Interviews with a representative of Airbus Helicopters – June 2022.

horizon, such as the use of hydrogen in aircraft.

With regard to **the 'Operations Revolution' axis** of the Roadmap, which accounts for almost 30 % of the aid granted, the scheme has mainly supported projects to assist pilotage operations, but also to optimise air operations to reduce emissions. In the short term, they aim to introduce aids for manual flight operations (sensors, review of flight controls). In the longer term, technological change should make it possible to converge towards greater autonomy of aircraft and better understanding and consideration of the environmental impact of flights in order to reduce it.

Finally, the projects related to **the competitiveness axis of** the CORAC Roadmap focus on (mainly digital) technological solutions that seek to improve collaboration between industry actors and reduce cycle times, both in aircraft design and in aircraft manufacturing.

The CORAC roadmap, which includes these three technological axes, takes as a priority "the environmental transition of aviation, with the ambition of making French and European industry a pioneer in the decarbonisation of air transport"[77]. With this in mind, major players such as the Safran Group have committed themselves, for example, to their investors to devote a significant proportion of their R &T efforts to the challenges of decarbonisation[78].

Thus, the scheme is fully consistent with the CORAC roadmap, through these three technological axes, addressing the challenges of competitiveness, security and decarbonisation.

Chapter 2. *Ad hoc*analysis methodology

The *ad hoc* analysis methodology aims to allow for a detailed analysis of the performance of the aid scheme and its ability to change the behaviour of actors. It is complementary to the econometric analysis (Chapter 3), on which it can also capitalise.

The theory of change in the evaluation of public policies is a[79] widely accepted methodology. It is particularly relevant in the context of this assessment:

- The sector is characterised by a particular structure, which is very vertical, and collaborations play an important role. They often take the form of lasting relationships, the assessment of which involves mobilising qualitative elements in order to understand their scope, importance and potential effects of the aid scheme;
- The aid scheme supports projects well in advance of the marketing phase (which are below TRL 6), with strong complementarity issues between technologies and projects, long maturing times, significant technical and commercial risks. In order to assess the impact of the projects and the possibility for those involved to make such investments in the absence of the aid scheme, detailed information on the various projects must be collected. Furthermore, the quantitative measurement of impacts will be complex because of the time involved in

77 https://aerorecherchecorac.com/feuille-de-route-corac/

78 In its 2021 Capital Market Day – Driving innovation for sustainable growth, Safran committed its investors to allocate 75 % of its self-financed R &T investments to decarbonisation efforts. This commitment is audited by their auditors as a non-financial commitment.

79 See for example the Evasled guide on evaluation methods and techniques published by the European Commission (see https://ec.europa.eu/regional_policy/en/policy/evaluations/guidance/).

researching and producing measurable results (patents, publications, and a fortiori, products and turnover). It is therefore essential to have a good qualitative understanding of the development of projects and their post-intervention prospects;

- Finally, the aid scheme is part of a particular context for the sector due to the COVID-19 crisis and its impact (see below) and more generally, uncertainties about the future of air transport in the context of an environmental transition. The loss of turnover has a strong impact on innovation activities, which are largely financed on the basis of economic results. The particular context of the sector, which was the industrial sector most affected by the COVID-19 crisis, must be taken into account when assessing the performance of the aid scheme.

For these various reasons, an analysis complementary to the purely quantitative analysis carried out elsewhere is necessary. The use of the theory of change appears to be important in this respect by its structuring, which allows for a form of qualitative causal analysis to supplement and clarify the quantitative causal analysis of Chapter 3. The use of this *ad hoc* evaluation methodology is also confirmed directly in the evaluation plan for the aid scheme.

The challenge of the evaluation will be:

- Identify and measure/assess the direct and indirect impacts of the various projects and assess the proportionality and relevance of the aid scheme;

- Analyse the role of the aid scheme in achieving the results obtained (causality), taking into account (i) the context in which the DGCA's intervention under the aid scheme took place, but also (ii) the various funding granted elsewhere which may contribute to these results;
- Assess the extent to which the positive effects appear to outweigh the potential distortions created (distortions of competition, distortions linked to a particular focus on certain technologies which may dry up other load-bearing tanks, etc.).

2.1. Overall presentation of the methodology of the *ad hoc*analysis

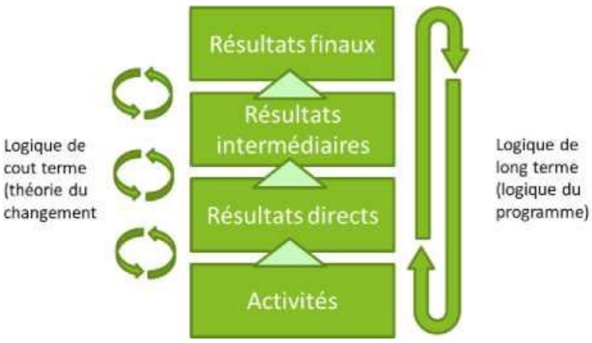
Figure 15. Presentation of the theory of change

Theory of change

Theories of change can be seen as the story of what should 'arrive' in the arrows linking the boxes of a traditional logical model. As a general rule, a theory of change includes:

- *A logical model or a chain of results;*
- *Assumptions and a definition of risks and sometimes the mechanisms associated with each link of the logical model or the chain of results;*
- *An explanation of the external factors that may influence the expected results;*
- *Empirical evidence supporting assumptions and the definition of risks and external factors.*

Schematic representation of logical analysis according to the theory of change



Source: Secretariat of the Treasury Council of Canada, 2012

The ad *hoc analysis was structured* according to the following steps:

- A prior analysis of the particular positioning of the aid scheme in order to identify its logical model (see 2.1.1 and 2.1.2) and the underlying assumptions that can be tested. It should be noted that this impact logic is focused on the link between activities and impacts. The objectives of the aid scheme have already been identified in the first part of this report;
- Formalisation of the evaluation questions allowing further analysis of the points of interest identified in order to assess the performance of the aid scheme, and in particular the changes it has brought about and their consequences in accordance with the logical model (see 2.1.1 and 2.1.2);
- Defining the arrangements for collecting information to answer the questions previously identified (see 2.2 and Annex 2).

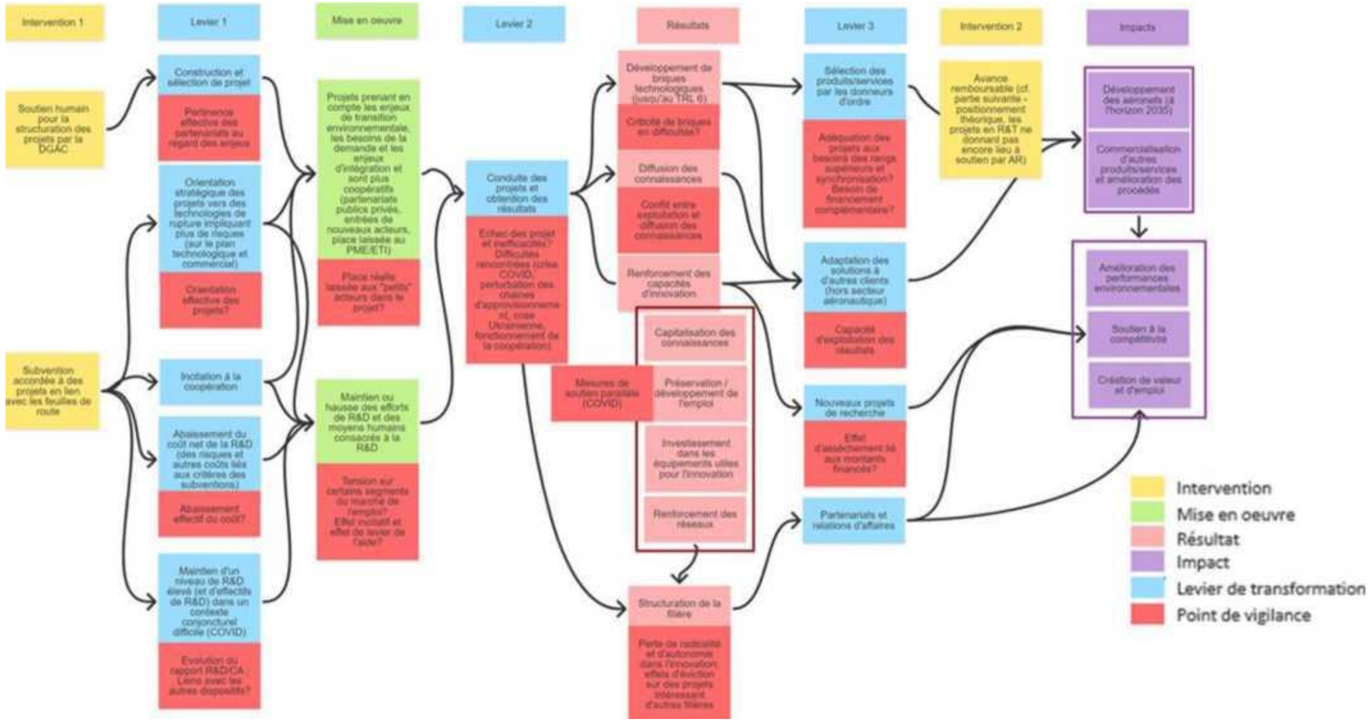
Structuring of the

This structure will guide the *ad hoc* evaluation and must be discussed and validated by the European Commission before the evaluation system is generalised. The implementation of the collection system will make it possible to have all the information needed to answer the questions as set out in the evaluation grid in Annex 3.

2.1.1 Implementation, results, expected impacts and presumed role of the scheme (focus on grants)

The logical intervention diagram presents the main assumptions that will transform the action into impacts and the first points of vigilance to be taken into account. This part concerns grants paid under 166 projects (up to date), focusing on a TRL at the end of the project lower than the TRL 6 (i.e. 97.6 % of the 170 projects representing 97.3 % of the planned aid).

Figure 16. Impact logical diagram (focus grant)



Source: G.A.C.

Interpretation note: This diagram shows the logical chain between intervention (in yellow), results (rosé) and impacts (violet), detailing the levers through which each stage leads to the next step (in blue) and the points of vigilance to be analysed (in red). The order within each of the (vertical) categories is mandatory and does not reflect a hierarchy. These different aspects are detailed below.

2.1.1.1 Expected from the implementation of the aid scheme

Presentation

The operational expectations associated with the establishment of the aid scheme fall into two categories:

- . The implementation of projects in the target: (I) in the technological guidelines referred to, (ii) responding to the needs of demand and (iii) likely to be more open, more partnership-based.

This achievement is directly linked to the method of project selection and to one of the overall objectives of the aid scheme: fostering R &Dto develop the decarbonisation, competitiveness and safety of air transport.

Technological focus (i): The aid scheme must make it possible to bring about a necessary technological break in order to meet the challenges of decarbonisation, the safety of air transport and the competitiveness of the players (which is essential to ensure the effective use of decarbonised solutions). The targeting of the aid scheme calls for several questions which may be the subject of evaluation questions:

- Links between funded projects and major roadmaps (including CORAC, and primary targeting), including the issue of overrepresentation of certain technological fields or, on the contrary, under-investment in certain fields;
- The disruptive nature and/or strategic dimension of such projects and the commercial or technological risks involved;
- The opportunistic nature of some of the developments (anticipation of work already planned, including in the short and medium term).

Focus request (ii): In a very pyramidal context, the effective exploitation of developed technologies generally requires the benefit of a payer. In this context, the presence of a contractor (who will not necessarily be the one with whom the actual marketing will be carried out) among the partners or the existence of a 'sponsor' in a project makes it possible to take due account of the expectations of potential customers and is a factor of success for the actual marketing of the products, services developed in the context of the projects. However, this calls for a number of questions:

- To what extent is this practice widespread?
- Does the involvement of demand in projects make it possible to have products in line with the expectations of potential customers (higher ranking in the sector)?
- Can this involvement limit the ambition of certain players in the sector in terms of innovation?

Focus on the cooperative dimension (iii): Thanks to the incentive effect of the grants and the action of the DGAC, the projects are more open than they would have been in the absence of the aid scheme. In particular, efforts have been made towards SMEs/mid-caps and laboratories.

The points of care to be taken in this regard are:

- To what extent are those holdings actually higher under the aid scheme than they would have been in the absence of the funding and the action of the DGAC?
- Could collaborations find their place outside this framework (via other types of funding or without

funding)?

- What space is given to "small players" (especially SMEs and laboratories): is participation balanced in terms of volume, is the project partnership-based or is it part of a context of high dependence?

2. Increasing R &Dexpenditure and human resources for R &D@@

This result is important because it is directly linked to the actual incentive effect of the aid scheme and, more specifically, its spillover effects on R &D. It is based on the lowering of the cost of R &Dallowed by the grant (which must be weighted in particular against the higher risks taken in the context of these projects), by providing funding in a context where cashflow and/or financial constraints could reduce the financing capacity of R &D.

However, it will be necessary to be cautious in analysing these effects due to the existence of other schemes contributing to them. In addition, R &T's efforts under the aid scheme could be made to the detriment of other research projects. It is therefore essential to monitor the level of R &T or possibly overall R &Dof the beneficiaries and to analyse the spill-over effects economically.

These various factors need to be deepened in a context where, due to the COVID-19 crisis, in the absence of the intervention, a reduction in R &Dcould have occurred. Conversely, attention should also be paid to labour constraints that may have an inflationary effect on certain skills and thus reduce the efficiency of the support scheme.

Evaluation questions (green items correspond to added questions)

Evaluation plan questions related to implementation expectations and links to the evaluation matrix Annex 3:

- Did the aid lead to the development of strategic projects for the beneficiaries? Doestaking account of donors' expectations make innovation efforts more effective? **(Q1)**
- Did the aid lead to projects that could not have been launched without the aid or in a much longer period? **(Q4)**
- Has the aid made it possible to integrate SMEs into large-scale projects? **(Q11)**
- Has the aid allowed the beneficiaries in the context of the COVID-19 pandemic to protect their R &D-strategy? Has it allowed beneficiaries to increase their R &D-related expenditure? **(Q5)**
- Has the aid made it possible to strengthen the collaboration and risk-taking of beneficiaries, in particular on public-private partnerships? (**Q12**)
- Was the aid proportionate to the issues addressed? **(Q14)**
- Would it be possible to achieve the same result with less aid or in a different form? **(Q14)**

2.1.1.2 results

Presentation

The research carried out in the context of the projects will lead, directly or indirectly, to various results:

Development of technological bricks: This result is at the heart of project expectations and more generally of the aid scheme (see below). Indeed, the development of zero-emission aircraft requires a technological leap in many components in order to reduce CO_2 emissions wherever possible and trigger the necessary technological breaks. The same may also apply to the other objectives of the programme, air transport safety and the competitiveness of actors and products and/or services developed.

Dissemination of knowledge: The knowledge created in the course of the work will be disseminated, whether through presentations at seminars, publications, patents and, more generally, through the dissemination activities undertaken. This dissemination of knowledge can benefit other players in the aviation sector or even in other sectors. Rather, it is done by academic players (especially in a context of intense international competition), which represent a small proportion of beneficiaries.

This impact in terms of dissemination of knowledge raises two types of questions:

- Possible conflicts between the interests of academic actors and, more generally, between dissemination of knowledge and exploitation/appropriation by the industry, particularly pending the filing of patents;
- The challenges associated with the enforcement of intellectual property in a context of asymmetry between partners, in particular in relation to potential customer supplier relationships.

Strengthening innovation capacity: Strengthening the capacity for future innovation is an essential element of the support scheme. On the one hand, since most of the projects leading to TRL 6, significant research and development efforts still need to be made in order to bring the proposed solutions to the market. On the other hand, because the radicality of the innovations sought is likely to provide future research opportunities that will build on the knowledge and skills developed within the project, making it an important element to consider. This is all the more pronounced given that the aid scheme operates in a deteriorating cyclical context (see below). In this context, the risks of a loss of human resources with significant effects on the innovation capacity of enterprises are significant. Finally, the strengthening of networks enabled by these projects (be it between academic and private actors, or simply between industrial players), can lead to future R & D collaborations.

The assessment of the impact of the support scheme on building innovation capacity calls for an important watchdog: As before, other schemes can help to maintain employment, and it is necessary to identify the precise contribution of the aid scheme.

Structure of the chain of production: The issue of structuring the sector is essential in the context of aeronautics. The methods of coordination within the sector between the various companies and the role of suppliers have evolved significantly towards greater autonomy and responsibility in driving innovation efforts. However, a technology developed by an industry can only become a product/service if it is adopted by the higher-ranking customer, which is close to the airframe manufacturers. This requires advanced methods of coordination in order to prevent poor research guidelines which would not *ultimately* create economic or social value. Through its cooperative dimension, the desire to pay attention to the needs of demand (upstream/senior industry), the support it provides to SMEs and mid-caps in R &T, low-TRL, high-risk and long-profitable projects, the aid scheme contributes to the transformations of relations within the sector. This structure may also raise questions about:

- Its effects in terms of radicality and autonomy in innovation: the inclusion of research strategies in those of the higher ranks which could limit the ambitions of the beneficiaries;
- The exclusionary effects this may have on interesting projects in sectors other than aeronautics.

It should be noted that these results must also be assessed in the light of the smooth running of the project.

The results may have been affected by the risks inherent in R &T, the cooperative dimension of projects, and more cyclical effects of the COVID-19 crisis on the functioning of actors and on supply chains (in particular in components and equipment). The effect of labour constraints on the smooth running of projects must also remain a point of attention in a context of rapid recovery of activity.

Evaluation questions (green items correspond to questions added, in orange, to modified questions)

Related evaluation plan questions and links to the evaluation matrix Annex 3:

- Has the aid made it possible to remove technological lock-ins encountered by businesses? **(Q2)**
- Has the aid increased the innovation capacity of the beneficiaries and in particular the knowledge base and skills? **(Q3)**
- Has the aid had any effect on employment within the beneficiary companies (recruitment, retention of posts)? **(Q5)**
- Did the aid enable the beneficiaries to enter the aviation market? **(Q8)**
- Has the aid had any impact (in particular in terms of dissemination of knowledge) on the activities of other undertakings in the same sector or in other sectors? What are the risks? Does this bring benefits to the project partners. **(Q10)**

2.1.1.3 impact of the aid scheme

Presentation

The development of the technological bricks allowed by the regime, the strengthening of innovation capacities and the structuring of the sector should ultimately lead to economic, environmental and societal impacts. In particular, this should contribute to the emergence of solutions for decarbonised, secure and competitive aviation that can reduce CO_2 emissions both in Europe and globally through the commercialisation of solutions.

These expected impacts, in line with the objectives of the aid scheme, are expected to be on a rather distant horizon (expected start of marketing of zero-emission aircraft by 2035). Indeed, the funded projects are R &T and the aeronautical industry is characterised by long cycles, affecting operation. However, some results could be exploited more quickly (either because they can be included in existing aircraft generations or because they are part of process solutions, services that can be used in existing lines and developments).

This distance between R &T work and the marketing of solutions makes it impossible to measure these impacts in the context of the evaluation. As much as possible, it is possible to provide major exploitation prospects, as well as the potential benefits of the different technologies developed in the projects. In this context, particular attention will be paid to the potential environmental and economic impacts: improving performance is at the heart of the support scheme.

- In terms of environmental (or safety) performance, at TRL level, it should be possible to have a good assessment (at the end of the project) of the technical performance developed. However, this vision can only be obtained from integrators, as the performance of individual components makes little sense. Only the improvement of aircraft performance is really significant and depends on trade-offs based on integration constraints.
- As regards the competitiveness performance associated with the processes implemented, an impact assessment is possible, but will remain very imprecise due to the level of end-of-project TRL and the variability (on actual productivity gains) inherent in the implementation of productivity-enhancing technologies.

- With regard to economic impacts, the level of TRL at the end of the project will not make it possible to judge the turnover or potential jobs that the project is expected to generate. To assess commercial impacts, only forward-looking actors or the anticipated business model can be considered.

The aid scheme is likely to generate impacts through four main levers, the likelihood of which will have to be assessed in order to analyse the causality of the scheme:

- Effective exploitation of the results by contractors (higher-ranking players in the sector). This is particularly relevant when a contractor is a partner of the same project or where sponsors are involved in projects;
- Adaptation of the solution to other customers (in particular outside the aviation sector). This less likely method of exploitation will be highly dependent on the particularities of the different solutions and the business plans of the beneficiaries;
- Launching new research projects: This type of impact is closely linked to strengthening the innovation capacity of actors. The challenge here is to assess whether beneficiaries have future R &T- or R &Dprojects in the near future. Given its mass and accelerator effect, the aid scheme may have the effect of draining the future R &T capacities of some of the actors (especially the smaller ones). Conversely, the need to transform the results obtained into useable products/services or processes could lead to an increase in R &Defforts in the coming years. This could see a shift in efforts from upstream to downstream and a continuation or even strengthening of innovation efforts;
- Lastly, the structure involved, in particular through the aid scheme, may lead to the emergence of closer partnerships which should lead to a strengthening of the competitiveness of the sector.

Another important dimension of these impacts is the technological complementarities and the ability of the different technologies to respond, through their combination and synchronicity, to the challenge of zero-emission aircraft. This is an essential forward-looking point that will need to be further developed with the integrators: In the light of developments on the various projects, are the main avenues for decarbonising aviation still relevant? Is their timetable maintained? Have the uncertainties surrounding the marketing of such an aircraft in 2035 been reduced or increased two years after the start of the first projects?

Finally, one point of vigilance should be the implications of financing R &T under the scheme on possible distortions of competition. Given the level of TRL targeted by the projects, prior to pre-competitive research, the associated risks should remain limited, but a dedicated analysis will be carried out.

Evaluation questions (green items correspond to added questions)

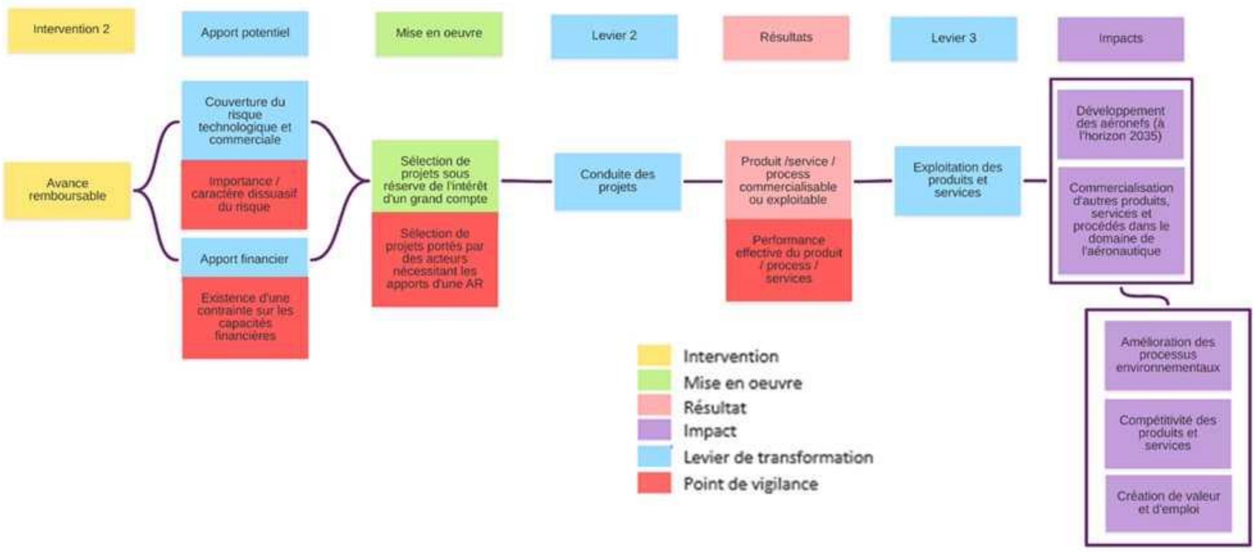
Evaluation plan questions related to:

- To what extent should it lead to the development of new products/technologies at the end of the project? (Q7)
- Has the aid had a potential negative impact on trade or competition in the air transport sector or in other sectors? **(Q9)**
- Has the aid contributed to achieving the objectives of decarbonisation, competitiveness and air transport safety as defined in the aid scheme? **(Q13)**
- Would it be possible to achieve the same result with less aid or in a different form? Was the aid proportionate to the issues addressed? (**Q14**)

2.1.2 the case of repayable advances (focus on repayable advances)

This section follows the same logic as the previous section, but focuses on the repayable advances paid to 4 projects (up to date), i.e. 2.3 % of projects representing 2.7 % of aid. These projects correspond to post-TRL 6 projects where risks remain at the level of technological developments and where commercial risks become particularly high (although controlled by the prior interest of a large account).

Figure 17. Logical impact diagram (focus on reimbursable advances)



Source: G.A.C.

Interpretation note: This diagram shows the logical chain between intervention (in yellow), results (rosé) and impacts (violet), detailing the levers through which each stage leads to the next step (in blue) and the points of vigilance to be analysed (in red). The order within each of the (vertical) categories is mandatory and does not reflect a hierarchy. These different aspects are detailed below.

<u>Presentation</u>

The financing needs for the post-TRL6 development phase are very much higher than the financing needs of the R & T. In this phase, the technological risks associated with the development of solutions and their industrialisation (adjustment of products to production conditions, establishment and optimisation of processes) are present with potentially significant impacts on marketing (postponement of placing on the market or delivery to the integrator, final cost of production). At the end of the development process, this trade dimension is particularly important for highly innovative solutions for the market, such as those covered by the programme.

The operational expectations associated with the repayable advances are:

- A commitment of innovation projects (R &D) aimed at the placing on the market of products, processes or services corresponding to the objectives of the support scheme, primarily to contribute to the decarbonisation of the aviation sector. Due to the risks and importance of the funding needed for this phase (significantly higher than for R &T), a beneficiary may be withdrawing from committing the project (or not having access to the necessary funding), and the reduction of the risk allowed by the repayable advance may remove this difficulty;

- An increase in R &Dexpenditure and human resources for R &D: Since funding is targeted at innovative projects, the aid scheme is intended to support R &Dexpenditure and actual R &Din a difficult economic environment.

These various factors need to be deepened in a context where, as before, a decrease in R &Dcould have occurred due to the COVID-19 crisis. Conversely, the reduction of technical risks opens up the possibility of private financing of R &D.The challenge of the actual changes in behaviour allowed by the aid is a point of vigilance in this regard.

In terms of results and impacts, projects involving repayable advances should result in the placing on the market/exploitation of products, services and processes. These products, services and processes will then create economic and environmental value. The evaluation should provide an understanding of the extent to which projects have improved the economic positioning of beneficiaries and create economic and environmental value.

Particular attention will be paid to the competitive impact of repayable advances. The closeness of the market in the repayable advance projects entails risks of distortion of competition which, unlike upstream research, pre-TRL6, in which these risks are relatively negligible, must be further developed.

Evaluation questions

Evaluation plan questions related to implementation expectations:

- To what extent should it lead to the development of new products/technologies at the end of the project? (Q7)
- Has the aid had a potential negative impact on trade or competition in the air transport sector or in other sectors? **(Q9)**
- Would it be possible to achieve the same result with less aid or in a different form? Was the aid proportionate to the issues addressed? **(Q14)**

2.2. Presentation of the information collection strategy

The answer to these evaluation questions requires the mobilisation of collection tools to gather a number of indicators. In order to ensure that these indicators are complete and that the collection tools are adequate, an evaluation matrix has been prepared and is detailed in Annex 3. This matrix presents for each evaluation question the evaluation criteria, indicators considered and the tools for collecting mobilised resources.

The main collection tools used in the *ad hoc* evaluation are:

- Processing of documents and programme data already available and exploitation of sectoral and business data available in public statistics (see indicators listed below);
- A questionnaire enabling a broad collection of information at the level of individual projects and beneficiaries;
- Interviews with beneficiaries to provide qualitative feedback.

These tools may be used either directly to answer the evaluation questions or indirectly through case studies to be carried out in order to deepen in a more comprehensive manner the particular angles of interest of the aid scheme (horizontal perspective).

2.2.1 Questionnaire to beneficiaries and project promoters

Reporting data or data from the CASD (public statistics and administrative data) will not be able to fill in all quantitative indicators (e.g. on publications) or may contain insufficiently updated information (e.g. TRL levels, patents). Furthermore, the use of closed qualitative questions allows statistical processing to be carried out to measure the qualitative effects.

Thus, in order to answer the evaluation questions, a questionnaire will be distributed to:

- Beneficiaries (identified by the siren code) – **full survey;**
- Project leaders within beneficiaries – **sampled survey.**

Sampling should reduce the administrative burden associated with the evaluation on beneficiaries. The cross-check between projects and beneficiaries gives a total of 655 potential respondents (to date).

The table below shows the size of the survey to be carried out according to the margin of error considered acceptable: for a margin of error of 10 %, the average representative number of jobs created or saved will be ± 10 % of the survey result.

Table 15. Sizing of the survey according to the expected response rate and the margin of error

	Number of invitations required for a 95 % confidence interval		
Response rate	Minimum	Intermediate	Maximum
100 %	39	131	236
75 %	51	175	315
60 %	64	219	393
50 %	77	262	472
40 %	96	328	590
30 %	129	437	786
Margin of error	15 %	10 %	7.5 %

Source: G.A.C.

During the pilot phase, the response rate obtained on the questionnaire was 83 %, indicating a strong stakeholder involvement in the pilot phase. Therefore, under the reasonable assumption of a response rate of between 50 % and 75 %, a questionnaire sent to 150-200 participants will allow a cost (for respondents)/profit (in terms of reliability of results) ratio relevant for the evaluation.

The selection of the requested beneficiaries will be made from the sub-sample of projects started in 2020 and 2021 (in order to ensure a backsliding on the commitment of the projects), randomly by project (in order to maintain the possibility of consolidated analysis at project level) according to (in order of priority):

- Type of participating beneficiary (check of representativeness of respondents): Large companies, SMEs, mid-caps, Laboratory;
- The number of participants in the project;
- The area of the project (based on an aggregated level of technical areas of intervention).

A questionnaire was drawn up as part of the scoping phase and distributed in Excel format in order to collect the feedback needed for the pilot phase and to conduct a test of the questionnaire in order to enhance its quality (clarify questions or answer options, etc.). The questionnaire taking these comments into account is available in Annex 2.

Following the conclusion of the pilot phase, a data collection interface will contain the questions set out in the questionnaire. The different tabs of the tool will adapt to the user, who will only have access to the pre-filled questions and data of his/her entity, in order to preserve the confidentiality of the data of the other beneficiary entities.

2.2.2 Collection of data per interview

The interviews are complementary to the processing of the data resulting from the reporting and the questionnaire. The information collected is of a qualitative nature and unlike the questionnaire, which is based on questions closed to pre-codified answers, the interview will allow for an open exchange. This is important for contextualising the beneficiary's situation and deepening the project, its potential results and impacts. The interview will also provide a better understanding of the extent to which the aid scheme has actually played a key role in achieving measured results. As such, it is an indispensable tool for answering the evaluation questions in the context of the *ad hoc* evaluation component.

With this in mind, around 50 semi-directional interviews with the beneficiaries of the aid scheme are planned in accordance with the following approach:

- Interviews with officials (directors, R &T managers, partnership officers, CORAC members, etc.) within the beneficiaries: These interviews will involve the central actors (Airbus, Dassault, Airbus Helicopters, Daher), some of the tier 1 subcontractors and stakeholders representing other types of beneficiaries (SMEs, Laboratory). Because of their role in structuring the sector and creating impacts, these interviews are essential in order to have a broad view of the impacts and the role of the scheme in relation to the major challenges facing the sector (economic situation, structuring, environmental transition). To this end, exchanges have already been conducted (13 interviews carried out) targeting CORAC members in order to better understand the overall challenges of the aid scheme for structuring the sector and the progress of its roadmap for the development of decarbonised and competitive air transport;
- Interviews with a selection of project managers (six interviews carried out) with a view to collecting a more operational view of the DGAC's operation, from the setting up of the projects to the prospects of exploitation;
- Interviews with a competitiveness centre (Aerospace Valley) and industry representatives (GIFAS, AeroPME, CORAC) for a total of four interviews carried out with a view to collecting information at sectoral level, particularly in terms of structuring research activities and, more generally, structuring the sector and the relationship between the various levels of the value chain.

Part of the interviews will also be used to meet the needs of case studies (see next section). Thus, in the context of the pilot case study, seven of the interviews conducted included a part of questions relating to the case study, in order to better understand the impact of the support scheme on industry/laboratory partnerships and their importance for the work carried out and the beneficiaries.

The mix of these interviews and the progress of these exchanges are presented in the table below.

Table 16. Breakdown of interviews by type of actor (the objectives listed do not include the specific questions asked in the context of the case studies)

Positioning of the interviewed actor	Objective	Number of interviews offered	Number of interviews already carried out

Managers within the beneficiaries (manager, R &T manager, cooperation officer)	Issues at stake in the sector and impact on business? Role of the aid scheme in advancing the technology roadmap of the company and the sector? Prospects in terms of exploitation at company level and potential impacts? Ability to undertake the planned investments in the absence of the aid scheme? Place of the aid scheme in the different support for R &T and R &D and complementarity?	25	13
Beneficiary Project Leaders	How the project is set up? Risks associated with the project (technical and commercial)? Role of partners? Ability to commit projects without the aid scheme? Project summary and difficulties encountered (in particular COVID-19)? Prospects and obstacles to exploiting the results of the project? Results and impacts of the project?	20	6
Network actors	Challenges in the sector (structuring, economic situation, environmental transition)? Importance of the aid scheme in relation to these issues? Organisation of project selection and opening to the different types of participants? Complementarities with other existing actions/schemes?	5	3
Total		50	22

Source: G.A.C.

2.2.3 Case study

2.2.3.1 Objectives and list of case studies

The purpose of the case studies is to conduct a targeted analysis on an issue of relevance for the evaluation of the aid scheme. They are thus involved in answering the evaluation questions, with a view to transverse analysis. The same case study can help answer several evaluation questions on its scope.

It is planned to conduct five (5) case studies on the following topics:

- Contribution of the aid scheme to the development of cooperation between industrial and academic actors and the impact of such cooperation;
- Impact of the COVID-19 crisis on the sectors and implications of R &T/R &D;
- Impact of the aid scheme on the structuring of the sector and the development of cooperation between actors along the value chain;
- Analysis of the non-participation of undertakings in the financing of projects under the aid scheme;
- Analysis of the challenges involved in transforming technologies into products/services/processes and the role and impact of reimbursable advances.

2.2.3.2 Case Study Methodology

Each case study will use the different sources of information collected or accessible to analyse the problem. The analysis will focus on several projects relevant to the issue addressed.

- Economic literature: The economic literature will make it possible to draw up an initial theoretical framework of the issues at stake and provide analytical keys;

- Government statistics: Public statistics will be used to put into perspective, where necessary, the challenges from a more macroeconomic perspective;
- Statistics from data on the aid scheme: These statistics will make it possible to measure the scope of the analyses carried out (for example, the number of projects or beneficiaries concerned by the problem being studied);
- Responses to interviews: The interviews will provide the qualitative material needed to address the issue;
- Questionnaire response: The questionnaire will make it possible to size the qualitative elements addressed and to examine certain qualitative aspects;

  Project documents: The documents contain a wealth of information on the projects and will be used to analyse projects in the range of issues discussed.

Each case study will take between 7 and 12 pages as required and will be structured in the following format (which may be adjusted according to the specific needs of each case study):

1. Summary literature review;
2. A quick overview of macroeconomic challenges;
3. Overview of the intervention under the support scheme;
4. Analysis of the problem on the basis of the projects;
5. Conclusion.

Chapter 3. Econometric analysis methodology

Counterfactual econometric methods are the approach most often advocated by the European Commission to determine the causal impact of an aid scheme.

The evaluation plan thus provides for a counterfactual analysis[80] limited to SMEs and mid-caps in the aviation manufacturing sector. It proposes to confine itself to these companies, since ' *the latter occupy [...] a separate place in the value chain of the sector: the share of enterprises supported is relatively small (from around 15 to 20 %, out of a total of one thousand companies, which still allows for a meaningful sample) and their business model is more focused on the short term, as their size does not allow investments over more than a decade, which are the norm among large groups*"[81].

In this context, the evaluation plan proposes to use the dual matching method to measure the impact of the support plan on the beneficiary SMEs and mid-caps. The double differences method is one of the

80In the context of the evaluation of an aid scheme, those analyses consist of constructing a so-called 'counterfactual' scenario whereby the beneficiaries would not have received the aid.
81Notification of the evaluation plan for the scheme exempted from notification No 59366 on aid for research and development for the decarbonisation, competitiveness and safety of air transport for the period 2020-2023, p. 7.

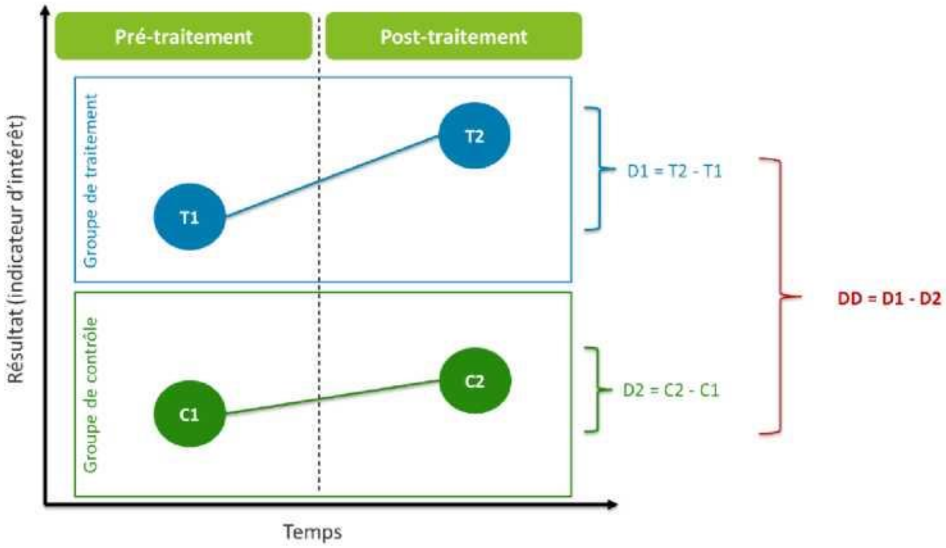
methods recommended by the European Commission in its methodological guide for the evaluation of state aid. Annex 4 to the report presents the classic approach to the implementation of the double differences method, as well as a review of the most recent literature around it. It also recalls the matching methods used for the selection of the control group82.

3.1. Implementation of the evaluation methodology

The double differences method used in the evaluation plan to carry out the counterfactual econometric analysis is to estimate the effect of an aid scheme by comparing the results of the beneficiaries of the scheme with those of a monitoring group, composed of non-beneficiaries, before and after the introduction of the scheme.

The simplest version of this method is illustrated by the figure below. The first step is to compare the interest indicator for beneficiaries (treatment group) in the period before the scheme (Q1) and during the period of the scheme (Q2). The difference between these two results (Q2 – Q1) makes it possible to determine the evolution of the indicator for beneficiaries from one period to another (D1). The next step is to carry out the same exercise, but for the comparison group, to obtain (D2 = C2 – C1) in the figure below. Finally, the difference between these two differences called double difference (DD = D1 – D2) makes it possible to determine whether there is a difference in the evolution of the results of the two groups that could be attributed to the scheme.

Figure 18. Explanatory diagram of the double differences method



Source: Deloitte Finance

The implementation of this method requires:

1. Define the result indicators on which the impact of the scheme is to be measured;
2. Define the treatment variable to83 measure the incentive impact of the scheme;
3. Select a comparison group relevant for the evaluation, the characteristics of which are similar to those of the enterprises receiving the treatment. The choice of this comparison group is the

Matching82 methods use statistical techniques to produce an 'artificial' control group by looking for another untreated individual (or group of untreated individuals) for each treated individual with observable characteristics as close as possible.
In83 the context of counterfactual methods, the variable of treatment (or treatment) is called the variable whose effect is to be measured. In the context of the evaluation of an aid scheme, it therefore corresponds to the aid scheme itself.

major challenge for the implementation of the methodology;

4. Identify the control variables needed to be included in the model to ensure that the estimate made measures the effect of the assessed regime and is not biased by other factors external to the regime. These control variables may be used in whole or in part for the selection of the control group as part of a matching procedure.

The analysis of the different blocks needed to implement the double differences method mentioned above is discussed in the following sub-sections.

3.1.1 Choice of indicators

As stated in the introduction, the assessment of the impact of the aid scheme requires, as a first step, the identification of the relevant indicators on which the aid is likely to have an effect. Once these relevant indicators have been identified, in order to implement the double differences method, it is necessary to verify that they are available both to the aid beneficiaries and to the comparison group, as well as over a sufficiently long period to monitor these indicators during and outside the period covered by the scheme.

3.1.1.1 Identification of relevant indicators

The effects of R &D- and innovation aid are first directly measured at the level of its beneficiaries. The direct effects measured correspond to the leverage effects of the scheme on:

- The resources used to innovate (**additionality of the input**);
- Results in terms of innovation or economic performance (**additionality of output**);
- Cooperative behaviour (**behavioural additionality**).

In the present case, in view of the characteristics of the scheme and the sector, the indicators which it seems appropriate to examine in this case relate to:

- R &D: expenditure, employment, etc.;
- Increasing knowledge;
- Collaborations created through the supported projects.

3.1.1.2 Availability of data for the implementation of econometric analysis

Once the nature of the indicators relevant for the assessment of the plan has been identified, their availability in both the entity and time dimensions should be verified:

- **Entity dimension:** In practice, one of the issues at stake in counterfactual econometric methods is the availability of data for both the aid beneficiaries and the comparator group. As the Commission states in its methodological guide: ' *With the exception of data relating to aid applications (including data from eliminated applicants where available), the sources of information relating to aid beneficiaries and to the control group must be the same, for reasons of comparability of data*'84.

- **Temporal dimension: The** indicators available for the two groups to be compared should be available over a sufficiently long period covering both the period for which the assessment is conducted (October 2020 to 2023) and a period before and/or after the assessment. In the present case, since the scheme is ongoing at the time of the assessment, it is necessary to have indicators for the period before and during the scheme. The latter seems particularly demanding

European84 Commission (2014), Commission Staff Working Document, Common Methodology for State Aid Assessment, SWD (2014), p. 10.

given the time lag in making available public data or data subject to statistical confidentiality.

The table below lists the indicators identified at enterprise or establishment level with their source and availability period at the time of preparation of this report85.

As85 publications and co-publications are only relevant for academic laboratories, they will not be considered in econometric analysis.

Table 17. List of potential indicators for the implementation of econometric analysis

Nature of the effect	Effect	Indicator	Base of data source	Availability Period	Frequency	Granularity
Additionality of input	*Fostering R &Dactivities*	**Total expenditure R &D@@**	R &DSurvey	1980-2019	Yearly	Enterprise
			ISC survey	1990-2018	Bi-annual	Enterprise
			GECIR base	2008-2020	Yearly	Enterprise
			DIANE[86]	2015-2021[87]	Yearly	Enterprise
		Share of private financing R &D@@	R &DSurvey	1980-2019	Yearly	Enterprise
	Stimulate employment in R &D@@	**Number of R & D jobs (direct and indirect) created or maintained through the aid**	R &DSurvey	1980-2019	Yearly	Enterprise
			DADS/BTS-posts base	1993-2020	Yearly	Establishment, employee
			DPAE base	2004-2021	Yearly	Establishment, employee
			BMO survey	2019-2020[88]	Yearly	Enterprise
Additionality of output	*Increasing knowledge news and dissemination*	**Number of patents[89]**	R &DSurvey	1980-2019	Yearly	Enterprise
			PATSTAT	2005 — spring 2022	Every 6 months.	Patent
Additionality psychology	*Promoting coordination between private actors and audiences*	**Share of R &D@@ carried out under — contracting or partnership with enterprises or laboratories audiences**	R &DSurvey	1980-2019	Yearly	Enterprise
			GECIR base	2008-2020	Yearly	Enterprise

Source: Deloitte Finance analysis

In practice, the temporal availability of data at the start of the evaluation should be questioned. Between the preparation of this report (September 2022) and the start date of the implementation of the econometric analysis (January 2023) some indicators may become available. In addition, as some data sources are surveys, the coverage of beneficiaries of the scheme in these surveys is a source of uncertainty. This can only be verified at the time of access to the data.

On the basis of the information known to date:

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[86] On the basis of preliminary data collection, it would appear that the information on R &D-related costs contained in DIANE is rarely provided for the beneficiaries of the scheme.
[87] Varying availability from one enterprise to another.
[88] Availability as indicated on the CASD site. The availability of disaggregated data before 2019 is being checked with the responsible services (Pôle Emploi).
[89] Another data source exists for this indicator: open source databases on publications and patents. However, the open source bases are very incomplete and time-lag.

- Econometric analysis of**R &Demployment indicators seems possible;**
- There is a high degree of uncertainty regarding the **analysis of R &Dand will** be analysed only subject to the availability of relevant data at the time of the assessment;
- There are also uncertainties regarding **patent** indicators. In view of the nature of the projects concerned by the scheme (R &D-upstream of innovation and production), the relevance of patent indicators will be checked on the basis of the replies to the questionnaire which will be sent to the beneficiaries as part of the *ad hoc* analysis part of the evaluation (see Chapter 2).

The most promising sources for each category of indicators are listed and commented on in the table below.

Table 18. Review of indicators that may be available for analysis econometric

Category indicator	Trade database source	Comment
Employment R &D@@	Survey Besoins en Main d'oeuvre (BMO)	It is currently only available until 2020, but it gives the employment prospects for the following year (it is therefore possible to have the prospects for 2021 in 2020). The employment category to be used would be 'engineers and study managers, R &D(industry)'. However, these disaggregated data are not available for more than 2 consecutive years due to GDPR requirements of the holding organisation.90
	Pre-employment declarations (DPAE)	The database is available until 2021. However, it would not allow: identifying specific posts in R &DThis data source will therefore not be given priority. The timing of making the 2022 data available must be checked with the responsible body.
	Base All Employees (BTS post)	It would make it possible to identify the nature of the employment, thus the R &D-related posts. However, 2020 was published in June 2022 (two year lag). Timing the 2021 data will be made available in relation to the time of assessment to be checked with the responsible bodies.
	R &DSurvey	It is available until 2019 and is made available with a two-year delay. The maximum that can be envisaged to be retrieved at the time of the evaluation concerns the information relating to the year 2020. It therefore does not seem to be workable as a source of variables to be explained.

However, these90 data could be used in a descriptive analysis.

Expenditure of R &D@@	DIANE	It has a coverage of 2021 (depending on the company), but information on R &Dexpenditure is only very rarely provided for the beneficiaries of the scheme.
	R &DSurvey	Not usable (see comment above).
	Survey Capacity to innovation and Strategy (CIS)	It contains information on the amounts of R &D, but not in advance. systematically (only for responding companies that they have innovated). This point would have been corrected from 2018, but a request for confirmation must be made to the department responsible.
	Trade database GECIR	It is currently available until 2020. One might hope to have 2021 (which remains to be confirmed), but this database has the limit of providing only R & D-eligible expenditure under the CIR (which is capped).
Patents	R &D; ISC survey	Not usable (see comments above).
	PATSTAT	To be considered, but they present processing difficulties given absence identifier (SIRET/Siren) and homogeneity for labels companies/establishments. This would create a high degree of uncertainty as to the reliability of the data, in a context where the effect on patents would have to be secondary given the TRL levels targeted by the regime.

Source: Deloitte Finance analysis

On the basis of these elements, the following table takes stock of the possibility of using the data sources indicated in Table 18 at the time of the assessment.

Table 19. Review of the source databases that could be used in the framework of the evaluation

Nature of the effect	Effect	Indicator	Trade database source	Data that can be used for evaluation
Additionality of input	*Promoting R &Dactivities*	**Total R &Dexpenditure**	R &DSurvey	No
			ISC survey	To be confirmed
			GECIR base	To be confirmed
			DIANE	No
		Share of private R &Dfinancing	R &DSurvey	No
	Boosting employment in R &D@@	**Number of R &Djobs (direct and indirect) created or maintained through the aid**	R &DSurvey	No
			DADS/BTS base – posts	To be confirmed
			DPAE base	Yes (non-specific R &D)
			BMO survey	To be confirmed
		Number of patents	R &DSurvey	No
Additionality of	*Increasing*			

output	*foreground and its dissemination*		PATSTAT	To be confirmed
Behavioural additionality	*Fostering coordination between private and public actors*	**Share of R &Dcarried out through subcontracting or partnership with public enterprises or laboratories**	R &DSurvey GECIR base	No To be confirmed

Source: Deloitte Finance analysis

3.1.2 Treatment variable

When assessing the impact of an aid scheme, consideration shall be given to its incentive effect on the beneficiaries, and thus to the timing of its effects and the mechanisms through which the scheme operates. In practice, this incentive effect is measured in the econometric analysis using a so-called "treatment variable"91.

The most recent economic and econometric literature has highlighted that the use of the double differences method may be biased when it comes out of the classic framework where all individuals/entities are treated at the same time and with the same intensity. This is particularly the case where the characteristics or specificities of a scheme introduce so-called 'heterogeneous' effects (the effect of the aid is different depending on the beneficiary)92.

In this context, the question arises of the choice of the most relevant treatment variable to capture the incentive effect of the aid in the econometric analysis.

3.1.2.1 Characteristics and timing of aid

The scheme under assessment has certain specificities which require an adjustment of the treatment variable compared to the standard (and simplest) case of implementation of the double differences method. Indeed, the aid paid differs from one beneficiary to another at different levels detailed below.

- **Multiplicity of projects: Projects**supported under the scheme involve several actors at the same time and some beneficiaries can contribute to several projects. For example, as airframe manufacturers or engine manufacturers have central roles in the articulation of R &Din the sector, the latter are present in many projects supported by the scheme. But not only the major players in the sector are involved in several projects. As some subcontractors are specialised in specific areas, SMEs and mid-caps in the sector may also have to contribute to several projects. Thus, participation in several projects for some beneficiaries affects the amount of aid they receive over time.

- **Timing of payments: The**multiplicity of projects supported also leads to a difference in the timing of granting aid to beneficiaries. The aid scheme supports 176 projects in the period from October 2020 to May 2022. Each of these projects starts on a different date and has its own payment schedule. Each project is subject to the signature of an agreement which brings together all the information concerning the project. The agreement specifies the planned timetable with a T0 date corresponding to the start of execution of the works and a T1 date corresponding to the date of

In91 the context of counterfactual methods, the variable of treatment (or treatment) is called the variable whose effect is to be measured. In the context of the evaluation of an aid scheme, it therefore corresponds to the aid scheme itself.
92Annex 4 briefly presents the existing biases when using a dual differences model to study a programme/regime with heterogeneous effects and presents new developments in the literature proposing corrections for these biases.

notification of the agreement[93]. Thus, due to the multiplicity of projects supported and the period over which the scheme extends, not all beneficiaries receive the aid at the same time.

- **Amount of aid per beneficiary:** The amount of support under the scheme is not the same for all beneficiaries. In practice, the final amount depends on the beneficiary's role in a project (the amount it decides to co-finance), but also on the number of projects in which the beneficiary participates. For example, Airbus and Dassault, which are airframe manufacturers, or Safran, which is a motorist, often have key roles in carrying out projects and make larger investments than sub-contracting SMEs or mid-caps. Similarly, and depending on the projects and their role, the amount of aid paid differs among SMEs and mid-caps. Thus, beneficiaries with larger roles in projects usually receive a higher amount of aid.

The amount and timing of the aid scheme are therefore different for each beneficiary. It is therefore very likely that the scheme has heterogeneous effects which it will be necessary to take into account in the implementation of the evaluation method and according to the treatment variable defined (see Annex 4).

3.1.2.2 Definition of the processing variable

In the present case, on the basis of the above description of the aid scheme, it is possible to define the treatment in several ways:

1. By a dichotomic variable making it possible to identify for each beneficiary the date from which he benefits from the scheme (e.g. the date of commencement of the work or the date of notification of the agreement for the first project in which the beneficiary participates).
    - It would be equal to 0 for beneficiaries before the date of notification of the agreement/start of work on the first project in which they participate, as well as for undertakings in the control group throughout the analysis period;
    - It would be equal to 1 for beneficiaries from the date of notification of the agreement/start of work of the first project in which the beneficiary participates.
2. The total amount of aid granted to the beneficiary under the scheme for all projects. In that case, the date of application of the processing operation would be the date of commencement of the works or the date of notification of the agreement for the first project in which the beneficiary participates. This definition would allow the introduction of a different aid intensity per beneficiary.
3. The amount of aid adjusted by the timing of the projects. Thus, the amount of aid relating to the first project in which a beneficiary participates on the date of signature of the corresponding agreement/start of work would first be taken into account. Next, where beneficiaries participate in more than one project, that amount would be adjusted by adding up the amount of aid for subsequent projects to the corresponding processing dates. This option would capture the overall incentive effect of the aid and a change in intensity in case of participation in more than one project.
4. It would also be possible to define the treatment variable as proposed in option 3 above, also taking into account the theoretical timetable for the payment of aid provided for in the various agreements.
5. Finally, it would also be possible to define the treatment variable as the actual amounts of aid paid

93 Payments may start only from the date T1, which shall be no more than 8 months after Q0.

on invoice after the progress of the work was noted at each project monitoring committee.

Options (4) and (5) appear too fine in time compared to the expected incentive effects of the scheme. In addition, given the following factors, it seems appropriate to favour simplicity in the choice of treatment variable and to focus more on the choice of control group:

- Constraints in the availability of data;
- Indicators available on an annual basis;
- Relatively short time after treatment (treatment starts at the earliest in October 2020);
- "Reduced" number of beneficiaries.

Thus, it is envisaged that the dichotomic variable equal to 1 should be used as the main treatment variable from the moment when a beneficiary is considered to be treated. Alternative model specifications may test the sensitivity of the results by using as a treatment variable the total amount of aid granted to each beneficiary. In this case, it will have to be related to the amount of R &Dexpenditure or to the company's turnover at the beginning of the period.

As regards the processing date, it seems preferable to use the starting date of the works (Q0) to better capture the incentive effect of the aid and the anticipatory effects. Indeed, the programme has been widely disseminated and/or discussions with DGAC start before the date of signature of the agreement. The date of signature of the agreement presents the risk of not sufficiently measuring the effects of the scheme and the anticipatory effects by undertakings.

Sensitivity tests will also be possible using time windows that vary from the date of notification of the agreement (Q1-3 months, Q1-6 months, etc.).

3.1.3 Selection of the comparison group and control variables

In the context of counterfactual methods, the quality of the comparison group is a fundamental condition for the validity of the assessment, even more than the evaluation method itself. Indeed, as the European Commission points out in its methodological guide: " *It is the quality of this monitoring group that will determine the validity of the assessment*"94.

In order to ensure the validity of counterfactual methods, including double differences, the individuals present in the comparison group must have similar characteristics to the individuals benefiting from the scheme.

- When participation in an aid programme is random, a control group composed of the non-beneficiaries of the scheme naturally emerges.
- On the other hand, where participation in an aid programme is not random, the beneficiaries are then selected on the basis of certain criteria. In that case, the use of non-beneficiaries as a control group reveals a selection bias due to the risk that non-beneficiaries may have different characteristics from those of the beneficiaries. The challenge of identifying the control group becomes all the more important when the beneficiaries themselves decide whether or not to participate in an aid scheme. As the European Commission recalls in its methodological guide: " *It is essential that the undertakings in the control group... be part of that group for reasons which have no effect on the results measured. That condition risks not being met where the undertakings have self-selected themselves and have themselves voluntarily decided not to apply for aid95.'*

European94 Commission (2014), Commission Staff Working Document, Common Methodology for State Aid Assessment, SWD (2014), p. 7.
European95 Commission (2014), Commission Staff Working Document, Common Methodology for State Aid Assessment, SWD (2014), p. 8.

In practice, the construction of a relevant monitoring group therefore requires an analysis of several factors that determine its validity and the scope of possible candidates. In particular, attention is paid to the specificities of the process of granting aid under the scheme (3.1.3.1), the scope of the undertakings to be considered (3.1.3.2) and the key characteristics of the beneficiaries that will need to be found in the undertakings in the comparator group (3.1.3.3).

3.1.3.1. Specific features of the scheme

In the present case, participation in the aid programme is not random. As described in Chapter 2 of this report (framework for the *ad hoc*evaluation), the granting of aid is the result of a process of structuring projects and selecting them involving decisions by the beneficiaries and the DGCA:

- Beneficiaries must first decide to participate in one or more R & T project (s), draw up a proposal and request state support (self-selection). In this context, the DGAC takes action to ensure better coordination, thanks in particular to its knowledge of the players and issues involved in the sector;
- As specified in section 1.3.4, the DGAC decides whether or not to co-finance projects according to the following criteria:
    - The relevance and consistency of the proposed projects with the Industry Roadmap;
    - The technical maturity of the projects and that of the consortium if the project is not mono beneficiary
    - The existence of a practice of R &D/R &T by the undertaking96;
    - The existence of an establishment of the undertaking in France97;

    The financial soundness of each undertaking98(financial eligibility under the GBER and financial capacity to carry out the project).

The practice of R &D/R &Tand elements on the financial soundness of firms are therefore key features of the beneficiaries to be used in the matching stage (see subsection 3.1.3.3).

3.1.3.2. Scope of undertakings to be considered

The choice of the relevant comparison group also requires an analysis of the scope of the scheme in terms of the typology of the beneficiaries and the sectors of activity concerned. A first characterisation exercise shows that the beneficiary companies are of all sizes and belong to various sectors. This makes it possible to inform the choice of undertakings that can be considered sufficiently comparable to the beneficiaries, as well as to identify factors external to the scheme that could distort estimates.

In terms of enterprise typology, as of May 2022, the scheme was concentrated around 225 beneficiaries, of which 25 % were SMEs, 19 % were mid-cap companies, 40 % were large companies and 16 % were academic laboratories. As stated in Chapter 1 of the report, these types of enterprises represent respectively 3 %, 4 %, 89 % and 4 % of the total amount of aid. The following figure shows the positioning

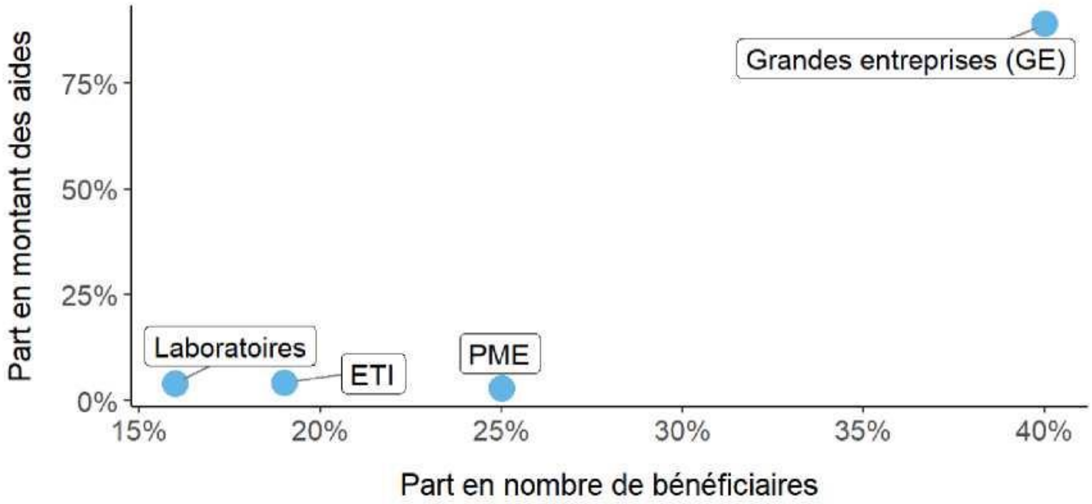
The support scheme96 focuses on support for R &D: DGAC cannot support companies with no internal R &Dcapabilities.

97According to the GBER, it is not required that the company has its registered office in France. It is sufficient to have a location.

98As specified in the project appraisal reports, the DGAC analyses, for each of the project's industrial partners, the financial results for the last two financial years on the basis of the tax measures provided with their application for support. In line with the requirements of the GBER, it verifies that it is not to be classified as a 'firm in difficulty' within the meaning of the SA. 59366 scheme by checking that it is not subject to collective insolvency proceedings, that half of the subscribed share capital has not disappeared due to accumulated losses and, for non-SME industrial partners, that since the previous two years the debt to equity ratio is below 7,5 and that the interest coverage ratio, calculated on the basis of the EBITDA, is higher than 1. Furthermore, the analysis makes it possible to assess objectively the financial situation of the industrial partners by looking in particular at operating performance (changes in turnover and economic rates of return), the robustness of the financial structure, the level of indebtedness and the cash position.

of these enterprise typologies according to the proportions in both dimensions.

Figure 19. Share in aid amounts and number of beneficiaries for each type of entity



Source: DGAC data, Deloitte Finance Analysis

It can be seen that large companies account for a very large proportion of beneficiaries, not only in terms of number, but above all in terms of the amount of aid received. The challenge for this type of business will be to find comparable companies in view of their position in the value chain of the sector. This position often goes hand in hand with a large size and specific features that make them unique on the basis of the criteria that will be considered crucial for the validity of comparisons under the double differences method (see section 3.1.3.3).

Thus, the scope of the analysis will include SMEs, mid-caps and large companies for which it will be possible to find comparable companies at the matching stage. The four major integrators in the sector (Airbus, Safran Aircraft Engines, Thales AVS and Dassault) will probably be excluded from the econometric analysis if they cannot find comparable products even outside the sector. It will be possible to test the existence of heterogeneous effects per type of company depending on the sample that will ultimately be selected for the post-matching analysis.

In terms of sectoral scope, while the aid scheme is targeted at companies that are part of R &D/R &Tprojects on issues related to decarbonisation, safety and competitiveness specific to the aviation sector, the beneficiaries in practice belong to various sectors of the economy ranging from aerospace and aerospace manufacturing to the manufacture of screws and bolts, software programming, paints, varnishes, inks and mastics. The following table shows the four sectors most represented as a proportion of the total amount of aid (see Table 10 in section 1.4.1 for the ranking of the top 10 sectors). Together, they account for more than 80 % of aid. Table 23 in Annex 5 shows the complete list of the 53 sectors represented among the beneficiaries of the scheme.

Table 20. Overview of the sectors most represented under the scheme

NAF	Description:	Amount of aid (MEUR)	Share of aid (%)	Share in number of beneficiaries (%)
3030Z	Aircraft and spacecraft	755	56 %	14 %
2651A	Manufacture of navigational aid apparatus	227	17 %	2 %

7219Z	Other research and experimental development on natural sciences and engineering	65	5 %	8 %
3316Z	Repair and maintenance of aircraft and spacecraft	54	4 %	0.5 %

Source: DGAC and Diane + data, Deloitte Finance analysis

In view of the diversity of the sectors represented, the question arises as to whether it is appropriate to restrict econometric analysis only to undertakings in the aeronautical and space manufacturing sector as provided for in the evaluation plan, or whether, on the contrary, it would be appropriate to extend the scope to all the sectors represented by the beneficiaries.

In this connection, it is important to point out that the indicators of interest do not relate to long-term results or performance. Thus, the protracted characteristics of the sector (in particular its long R &Dcycles) do not constitute a difficulty in extending the control group to other sectors. Furthermore, as the key characteristics of the beneficiaries are well identified and their specificities can be taken into account with the help of observable data elements, there is also no reason to exclude from the control group companies from other sectors/sectors99.

The inclusion of all undertakings in the scope of the assessment is therefore conceivable, unless shocks are identified during the period that would affect the group of beneficiaries and the control group separately. In this case, it will be necessary to introduce control variables to take account of these differentiated impacts or to restrict the two groups to sectors where the impacts of major shocks occurring during the period are similar.

The two main shocks that could distort the analysis of the double differences identified at this stage are the COVID-19 health crisis and the recovery plan subsequently put in place by the French government, which includes the assessed scheme (see subsection 3.1.4.1).

Thus, two approaches seem possible to choose the relevant sectoral scope. They are briefly described below:

2. Sectoral perimeter restriction with subsequent matching
   - Initially analyse the magnitude of the impact of the COVID-19 health crisis and the coverage of the recovery plan on the basis of qualitative and quantitative elements at sector level (e.g. fall in turnover, recovery in turnover after the crisis);
   - Secondly, to limit the scope of the monitoring group to sectors with similar COVID-19 impacts and relative coverage of the recovery plan;
   - Finally, matching companies in these sectors with similar observable characteristics.
3. Analysis of indicators in relation to turnover over the extended scope

   This alternative approach would consist of considering all sectors represented by the beneficiaries for matching and analysing the indicators of interest in relation to the turnover of the undertaking. The underlying assumption is that the relationship between the interest variable and turnover is linear. The relevance of this assumption is uncertain as most of the beneficiary companies are not mono-product and could thus have a different impact on their activity and indicators depending on the markets/sectors they cover.

3.1.3.3. Characteristics of beneficiaries

On the basis of the elements discussed in the two previous sub-sections, it is possible to identify the

99Moreover, it is an approach often used in economic literature. See for example Aguiar &Gagnepain (2017).

individual characteristics necessary for a relevant matching. In particular, the size of the undertaking (staff numbers and turnover), its indicators of financial soundness, and its pre-scheme R &Dintensity are clear from what are the most important criteria to be considered.

The table below summarises existing data sources that are likely to provide information on observable characteristics of enterprises. They would be used to recover the variables necessary for the formation of the monitoring group under the matching method provided for in the evaluation plan. The majority of the data are available until

2019, which would be sufficient as the scheme starts in October 2020 and the variables taken into account for the creation of the control group have to be compared before processing. Furthermore, subject to temporal availability, these variables could also be used as control variables in estimates.

Table 21. List of characteristics and sources for matching

Nature of the characteristics	Trade database	Period	Frequency	Granularity
R &D characteristics	R &D Survey	1980-2019	Yearly	Enterprise
	ISC survey	1990-2018	Bi-annual	Enterprise
	Diane (non-beneficiaries)	2015-2021[20]	Yearly	Enterprise
Employment characteristics	DADS/BTS base – posts	1993-2020	Yearly	Establishment, employee
	DPAE base	2004-2021	Yearly	Establishment, employee
	BMO survey	2019-2020[100]	Yearly	Enterprise
	R &D Survey	1980-2019	Yearly	Enterprise
Financial and accounting characteristics	FARE	2008-2019	Yearly	Enterprise
	Fiscal esets: BIC-IS	2016-2020	Yearly	Enterprise
	DIANE	2015-2021[101]	Yearly	Enterprise
Membership of a group	LIFI	2012-2019	Yearly	Enterprise
	DIANE	2015-2021[20]	Yearly	Enterprise
Sector of activity	DIANE	2015-2021[20]	Yearly	Enterprise
	FARE	2008-2019	Yearly	Enterprise
COVID impacts	ACEMO-COVID	2020-2022	Monthly	Enterprise

Source: Deloitte research and analysis

Table 24 in Annex 5 gives details of the variables that could be mobilised under the matching method.

3.1.4 control variables and potential challenges

In addition to the methodological challenge of the concomitance of the COVID-19 crisis and the recovery plan of which the scheme forms part, the question arises of other factors which might have a differentiated development or effect between the group of beneficiaries and the control group and which should be taken into account in the analysis.

Other aid to the sector which takes place at the same time as the scheme and the existence of a previous

100 Availability as indicated on the CASD site. The availability of disaggregated data before 2019 is being checked with the responsible services (Pôle Emploi).
101 Varying availability from one enterprise to another.

scheme are the main challenges identified at this stage (3.1.4.1). An additional challenge is introduced by the timing of the evaluation with regard to the timing of the expected effects of the scheme (3.1.4.2).

3.1.4.1 Other aid to the sector

In the context of counterfactual methods, in order to ensure that the assessment of the effects of the aid scheme does measure the intended effect, it is important to monitor the effects of any other aid received by the beneficiaries or by the individuals present in the control group. As the European Commission recalls in its methodological guide: ' *the impact of multiple aid – whether granted under one or more schemes or ad hoc aid – must also be monitored. Indeed, if non-beneficiaries of a programme receive aid under other programmes, or if beneficiaries of one programme receive additional aid under other programmes, the assessment of the effects of the observed aid scheme is likely to be distorted102.*"

In the present case, the scheme under assessment comes in the context of the COVID-19 crisis, in which the State and governmental and territorial bodies have strongly supported the aviation sector, which has been particularly affected by the crisis. Table 5 in Chapter 1 summarises the aid received by the sector in parallel with the scheme under assessment, and Table 25 in Annex 5 presents a complete list of aid to the aviation sector.

A priori, none of this aid would have a direct impact on R &D. However, it could have indirect effects (e.g. partial activity). If this is the case, it is necessary to discuss/verify whether this effect may be different between the group of beneficiaries and the control group.

In the case of COVID-19 aid, one way of controlling is to restrict groups of beneficiaries and controls to sectors with similar COVID-19 impacts (see Section 3.1.3.2). For other aid, it will be necessary to check whether it is allocated in a targeted manner, its magnitude and to have a similar approach to that proposed for COVID-19 aid.

Similarly, it seems important to check by R &D-specific aid from the GECIR and/or CORDIS database (subject to availability in 2021 at the time of the evaluation).

Finally, the scheme assessed follows on from a previous support scheme for the sector which took place between 2017 and 2020, amounting to approximately EUR 430 million. When the evaluation method is put in place, it will be necessary to monitor this previous system. Several possibilities can be considered depending on the proportion of beneficiaries of the current scheme who benefited from the previous scheme:

a) Include a control variable with the amounts of aid granted;

b) Introduce a second processing variable;

c) Include a dichotomy variable to assess possible heterogeneous effects between the beneficiaries of the two schemes and those who only benefited from this scheme.

3.1.4.2 Timing of the evaluation

Another key issue to consider is the timing of carrying out the evaluation. There is always a more or less long time lag between the setting up of an aid scheme and the realisation of its effects. In order for the evaluation to produce significant results, it must be carried out once the effects have been achieved. This evaluation covers an aid scheme covering the period from October 2020 to 2023 and will be carried out at the beginning of 2023 (up to data covering the year 2021). It is possible that the gap between the aid

European102 Commission (2014), Commission Staff Working Document, Common Methodology for State Aid Assessment, SWD (2014), p. 9.

administration and its effect is greater and that it is therefore difficult to measure a significant effect of the scheme on the basis of econometric analysis.

3.2. Review of the implementation of the econometric evaluation method

This chapter discusses the main issues and methodological choices needed for the implementation of the double differences method in the evaluation of the scheme exempted from notification No SA.59366. On the basis of the information available at the time of the preparation of the report and in advance of access to the detailed data to carry out the analysis, it provides an overview of which the main policy choices and approaches are summarised below:

Choice of relevant result indicators

Given the nature of the scheme and the timing imposed by the evaluation plan, the following three categories of indicators seem relevant for the econometric analysis:

- Employment in R &D;
- R &Dexpenditure;
- Patents and publications.

Their exploitation depends on their cross-sectional availability (both for the group of beneficiaries and for the control group), and in time (during and before the scheme). At this stage, it seems that only R &Demployment indicators will be available on both dimensions at the time of the evaluation.

Definition of the processing variable

Given the specific features of the scheme (timing of granting the aid, participation in several projects, different amount of aid per beneficiary), it seems appropriate to:

- Use in the main model as a processing variable a dichotomic variable equal to 1 from the moment a beneficiary is considered to be treated;
- Conduct sensitivity tests by considering the total amount of aid granted to each beneficiary (in relation to R &D expenditure and company turnover at the beginning of the period);
- Take the start date of the work (Q0) as the start date of the treatment to better capture the incentive effect of the aid and the anticipatory effects;
- Perform robustness tests using alternative treatment dates on the basis of time windows that vary from the date of signature of the agreement (Q1, Q1-3 months, Q1-6 months, etc.).

Selection of the control group

The choice of the relevant control group requires verifying the characteristics of the undertakings and sectors covered by the scheme and reflecting on the shocks over the period that could affect the beneficiary group and the control group separately.

- As regards the scope of the companies, the evaluation plan included an econometric analysis limited to SMEs and mid-caps, which account for 7 % of the total aid. In an econometric analysis, the criterion for excluding large companies from the assessment is only the difficulty in finding comparable undertakings. For example, we propose to extend the sample to large companies for which it will be possible to find comparable companies at the time of the matching exercise.

Depending on the sample of companies finally selected, it will be possible to:

- Include a control variable for belonging to a large group;
- To test if there are heterogeneous effects per enterprise category (SMEs, mid-caps, GE).

- Matching variables for the selection of relevant comparison companies should in all cases include:
  - The size of enterprises (headcount and turnover);
  - Indicators of financial soundness;
  - The fact that companies were already doing R &Dbefore the scheme.

- As regards the sectoral scope, the indicators to be analysed do not relate to long-term results which would determine the protracted characteristics of the sector (pyramid structuring; long R &Dcycles). In addition, the beneficiaries of the scheme belong to a variety of sectors. Thus, there are no obstacles to the extension of the monitoring group to other sectors.

- However, shocks over the period could affect the beneficiary group and the control group separately. In this case, it will be necessary to:
  - Introduce control variables and/or;
  - Restrict both groups to sectors where the impacts of major shocks that occurred during the period are similar (COVID-19, Recovery Plan) before matching;
  - Alternatively, it would be possible not to restrict the sectoral scope of the assessment. In this case, the indicators of interest will have to be related to the turnover of the undertaking.

Control variables and identification of potential challenges

Other factors or shocks could affect the group of beneficiaries and the comparator group differently, outside the scheme. They will need to be discussed and taken into account in the analysis. This includes:

– Other aid to the sector;

– Other R &Dand innovation aid;
– Under the previous regime.

This review and the first methodological choices made will be adjusted according to the availability of the data, the updating of the databases and the new elements that will be brought to our attention by the time of the implementation of the analysis.

General conclusion

The evaluation of the scheme SA.59366 on aid for research and development for the decarbonisation, competitiveness and safety of air transport for the period 2020-2023 raises a number of challenges related to the definition and implementation of the evaluation methodology.

This interim report identifies and analyses the methodologies that can be implemented in coherence with the evaluation plan validated by the European Commission. The report thus provides an initial assessment of the potential for applying these methodologies, presenting both the relevance and the limitations associated with them. These include:

- on the one hand, difficulties linked to the implementation of conventional evaluation methodologies in a context where the organisation of the aviation industry is specific, but also, as presented in Chapter 1, to the implementation of the support plan targeted by the scheme;
- on the other hand, the challenges, in particular econometric challenges, which were identified in the report, including the question of the time needed to implement a counterfactual method, but also the selection of the monitoring group and the other potential challenges identified and developed in the report.

As regards econometrics, the methodological choices made will be adjusted according to the availability of data, the updating of the databases and the new elements that will be brought to our attention by the time the analysis is implemented.

The *ad hoc* methodology presented in the report also makes it possible, despite the challenges of data collection, to complement the econometric analysis, based in particular on the theory of change and the data collection solutions presented in the report.

The purpose of combining these two methodologies is to carry out the fullest possible evaluation of the aid scheme, in line with the objectives set out in the evaluation plan, in accordance with the methodological framework set by the European Commission.

Appendices

Annex 1. Case study No 1: Research collaborations between industrial and academic actors under the Aeronautical Aid Scheme

The purpose of this case study is twofold: understand the effect of the aid scheme on private public cooperation, on the one hand, and the impact of such cooperation on innovation, on the other.

Section 1.1 provides a summary of the literature and defines the theoretical framework. Empirical, statistical and qualitative analyses are presented in Sections 1.2 and 1.3. Section 1.4 cross-analyses the challenges of cooperation through a cross-analysis of 3 projects.

1.1. Summary literature review on research relations between industrial and academic actors

1.1.1. An approach identifying a dual impact at the same time

The literature includes much work on research relationships between industrial and academic actors (see Plantec, 2021 for a review). The dominant perspective considers a "dual impact". Collaboration within the same project should lead to virtuous interactions between academic research activities and the development activities of industrial actors. This implies that scientific research activities have a positive impact on the ability to generate inventions, and vice versa, that activities to develop products, processes or services have a positive impact on the ability to generate scientific publications.

This approach is widely used in theoretical and empirical work and has served as a framework for many empirical work aimed at better understanding the mechanisms of collaboration (in terms of degree and type) but also the effects of this collaboration on the quality of innovation. Two dimensions concerning the quality of innovation are mainly analysed:

- the economic value of the invention, often measured on the basis of the diffusion power of innovation in a given ecosystem, and
- the novelty or radicality of innovation, i.e. the disruptive capacity of the invention compared to the existing one.

1.1.2. Causal effects of scientific research activities on the quality of new products

As a first step, the literature document the extent to which scientific research by academic actors can contribute to the development of new products, processes or services of industrial actors (Soning, 2001; And Sorenson, 2004).

From a theoretical point of view, scientific knowledge is developed on a regular basis by academic actors enabling them to be located at the border of knowledge. In an industry such as aeronautics, where innovation relies on (and increasingly relies on) scientific knowledge, this can play a key role in innovation performance and the competitiveness of actors. Once developed, this new scientific knowledge is either combined with other knowledge to enable an invention to be designed, or is used to promote other combinations of knowledge (Ahuja & Lampert, 2001; —Ing, 2001; The latter's activities, 2004; Yayavaram & Ahuja, 2008). This is typically the phase of confrontation between the problem of industry and the scientific expertise of academics, which will lead to the creation of a new solution. Literature also shows that the dynamics are virtuous: using scientific knowledge promotes quality inventions (originality, novelty, value).

However, the literature indicates that the link between new scientific knowledge and inventions is not mechanical and that scientific knowledge takes a long time before being integrated into inventions. Industrial players face difficulties in integrating, assimilating and using new scientific knowledge in their inventive processes. The causes of this difficulty are of several kinds. There is some inertia in companies due to routines, necessary for the innovation and industrial process, which limits the ability to integrate and use new knowledge. Moreover, innovation processes are increasingly complex and require an increasing amount of knowledge of different kinds.

This problem seems to be accentuated in the event that there is no collaboration between the two entities in the research phase. This comes in particular from institutional barriers that make it difficult to establish a common working framework (Arora & al., 2018; Zahra & al., 2018; Noteboom & al., 2007; Cabanes & al., 2020). Industrialists and academics have different approaches to research and also tend to work on different types of research projects. If practices such as secrecy or patenting are well suited to the effective commercialisation of research results, such practices may constitute obstacles to the exploitation of academic research. Thus, such practices may constitute barriers to collaboration between industrial and industrial actors.

The development of collaborations with academic stakeholders may have several effects on the participating companies in this respect:

- Accelerating the acquisition and exploitation of scientific knowledge within companies
- Access to state-of-the-art expertise to solve particular technical difficulties
- Access to specific equipment and testing, simulation capacity
- Reduction of internal research efforts by abandoning the development of certain upstream technological bricks103

These effects will be tested during the interviews.

1.1.3. Causal effects of new product development activities on the quality of science

Secondly, the literature highlights the extent to which activities to develop new products, processes or services could contribute to scientific research activities (Perkmann & al., 2013; 2021).

It highlights different effects of product, process or service development activities:

- Or they appear to interfere with the proper conduct of scientific activities (secrecy practices, limitation of the circulation of knowledge, orientation towards application and limit of serendipity),
- Or they appear to lead to positive hybridisation between industrial needs and science, where researchers are called upon to carry out basic work while maintaining usability orientation.

This requires the presence of special conditions in order to switch collaboration from a potentially harmful system to a virtuous system (Blumenthal & al., 1996; Czarnitzki & al., 2015; Gibbons & al., 1994; Etkowitz & Leydesdorff, 2000; Stokes, 1997). These conditions are often specific to each research project, often with a focal point on the issue of intellectual property, and need to be discussed when it is

103This, on the one hand, reduces the risks for the company and, on the other hand, increases the diversification of exploitation possibilities, including for future research.

launched.

Furthermore, the literature shows that researchers who collaborate with industry and therefore are exposed to, or are themselves producers of, the development of new products, processes or services, have higher research productivity than their peers. However, the identification of the origin of this higher (causative) productivity is not obvious because multiple factors interfere ("Matthew effect", peer influence, higher past performance, reputational effects) (Guldbrandsen &Smeby, 2005; Tijssen, 2018; Bikard & al., 2019).

In addition, scientific performance can be enhanced by access to new ideas, testing capacity, diversity of teams fostering creativity, etc. (Van Looy &al., 2006; Callaert & al., 2015; Narayanamurti & Odumosu, 2016; Goldstein & Narayanamurti, 2018).

In this respect, the development of collaboration with industrial actors may have several effects for participating laboratories:

- Obtaining a better understanding of industrial needs and ensuring greater value for money
- Stimulating creativity and the acquisition of new ideas
- Obtaining feedback/information from industry to improve the quality of research
- Test spaces or equipment that would not be accessible without collaborations
- Increased research efforts with the funding obtained

These effects will be tested during the interviews.

- The literature highlights the "dual impact" of collaboration between academic and industrial actors. However, this requires special conditions for the relationship to be virtuous both during the research project and for this to be expressed in higher performance at the end of the project compared to a project without an industrial-academic collaborative component.

1.2. Summary overview of the challenges of cooperation and structuring of the aviation sector in France

Aeronautics is a highly innovative industry. According to figures from the Ministry of Research (2019), aeronautics and space manufacturing accounts for EUR 3,7 billion of R &Dexpenditure, making it the second largest sector of R &Dafter automotive. The sector benefited from a positive momentum (expenditure growth of 4.7 % between 2018 and 2019), which, however, was strongly affected by the crisis (12 % decrease in R &Dexpenditure between 2019 and 2020). To support innovation, the sector needs cooperation between public and industrial laboratories.

Collaborations are marked by the organisation of the sector, which is very pyramid, structured around the integrators, who are the main donors. Public research is structured around a major player: ONERA. Centres for basic and applied research, working closely with the main French aeronautical donors. The research ecosystem also brings together academic research laboratories and/or research laboratories attached to the CNRS working on subjects at an earlier stage.

- The proximity of ONERA to industry and its positioning encourages cooperation between public and private actors.

The research agenda of the sector is largely coordinated within CORAC, which allows exchanges between industrial players, academic laboratories and the DGAC. Not all actors are present or have access to the roadmap for reasons of confidentiality of research agendas. However, ONERA can act as a relay to academic actors who do not have access to this roadmap. Information can also pass directly between industry, stakeholders and academic actors where there are pre-existing relationships.

- ♈ This coordination of research agendas allows for a better link between industrial needs and the work carried out in the academic laboratories, thus ensuring better chances of building a cooperative project and, more generally, of enhancing the value of research work. On the other hand, it promotes the replication of relations between the players, particularly with regard to the arrival of new academic players in the networks.

1.3. Statistical analysis of collaborative projects under the Aeronautical Aid Scheme

The statistical analysis aims to better understand and quantify the collaborative dimension of the aeronautical programme among the 204 projects supported by the DGAC.

1.4. laboratories and academic actors are beneficiaries of the Aeronautics Support Programme, representing 15.2 % of the total beneficiaries. In terms of volume, this is the least represented category of beneficiaries behind the Major Groups, mid-caps (18.3 %) and SMEs (25.4 %). The bulk of (monetary) support is provided to the large groups, followed by ETI (4 %). Academic actors account for only 3.9 % of the total amount of support, placing them just ahead of SMEs (2.6 %).

In detail, 49 projects have at least one beneficiary laboratory or academic actor, i.e. 24 % of projects involving an industrial-academic partnership. In detail, 69.4 % of these projects have only one academic beneficiary, 20.4 % have 2 laboratories or academic actors, 8.5 % have 3 laboratories or academic actors and only 4.3 % of projects have more than 3 laboratories or academic actors.

Thus, the weight of academic players is low digitally compared to a programme such as H2020. This points to a fundamental difference in ambition, as the aeronautical aid scheme has an industrial purpose, despite its pre-competitive position, and not upstream research.

- ♈ Although almost a third of projects have a collaborative component, this represents little in terms of volume of support. This may raise the question of the degree of involvement of academic actors in research activities and the effect of such collaborations on the creation of new scientific and innovation knowledge, both in volume and in radicality. ONERA is the most represented academic actor in the programme, being involved in 71.4 % of collaborative projects. It receives 73.9 % of the support for laboratories and academic actors. The rest of the aid is distributed fairly evenly among the other 34 academic beneficiaries. The second most strongly supported public actor is the CEA 104 with 4 % of support for laboratories and academic actors. In terms of participation in projects, CETIM ranks second with 6 projects (17 % of total projects involving at least one academic laboratory).

They are also mainly projects involving only one academic beneficiary. Among these collaborative projects, ONERA is overrepresented. This is of course due to the fact that ONERA is the main French research centre in the aeronautics, space and defence sector covering all disciplines and technologies in the field.

- ♈ Collaboration between several academic actors within the same project can have a greater beneficial effect not only for these academic players but also for industrial players. The combination of academic knowledge within the same project has a greater effect than the juxtaposition of knowledge through silos interactions.

The104 Commission for Atomic Energy and Alternative Energy

These results are in line with the objectives of the Aeronautical Aid Scheme, which is more an industrial programme than a public-private collaborative programme. The qualitative analysis presented in the following section should provide a more nuanced insight into the impact of collaboration on research activities.

1.4. Cross-analysis of projects targeted by the case study

1.4.1. Presentation of the analysis and methodology chosen

Understanding the impact of the scheme on the development of private public cooperation and ultimately on the quality of research and its impact requires a qualitative deepening of projects that have been financed.

To achieve this, 3 projects were selected (see below). In addition, as part of the development of the evaluation methodology, a questionnaire was distributed to 12 stakeholders (83 % response rate), the results of which fed into the case study on certain points.

Presentation of the projects selected for the case study

In this case, 3 projects were selected in connection with the DGAC for this deepening: MAMBO, LAMA, ARISE. These projects, described below, have specific characteristics allowing for an in-depth view of the different dimensions, including the role of academic actors (leading partner, key partners).

As this analysis is based on 3 case studies, the conclusions serve an illustrative purpose and are not representative of all projects involving an academic actor.

	Number of partners	Number of academic partners	Budget total (amount of support)	Share of the budget allocated to the academic actors
MAMBO	22	13	EUR 7 310 500	51 %
LAMA	4	2	EUR 5 306 500	56 %
ARISE	5	2	EUR 3 112 500	67 %

MAMBO

The objective of the MAMBO project is to adapt the methods and tools for prediction and experimental characterisation of noise sources of aircraft components and of the complete aeroplane to the specificities of the new powertrain and aeroplane configurations. As a result of this work, a significant improvement in the accuracy of digital prediction and measurement chains is expected (source: DGAC technical file).

Led by Airbus Operations, MAMBO is particularly interesting for this case study as it is the project with the strongest collaborative dimension. It brings together 22 partners with a total budget of more than EUR 7 million, including 13 laboratories and academic stakeholders. It groups the following in descending order of the amount of support: Lyon Central School, ONERA, Sorbonne University, University of Mans, CNRS Centre Poitou-Charentes, ISAE, ENSAM, INRIA, INSA Lyon, Gustave Eiffel University, Grenoble Alpes University, ATTM and CEREMA.

LAMA

The LAMA project is part of a broader approach to create a new digital tool for the mechanics of CODA fluids. This process, which started in 2018, includes 3 key partners, Airbus, ONERA and the German Centre for Aeronautics and Aeronautics (DLR). These 3 partners correspond to CODA's development team, which does not exclude the participation of other actors, as is the case in LAMA. CODA partners are also funded by institutional actors from other countries, such as in Germany where LUFO finances DLR and Airbus Germany for their part of the work. At French level, this approach was supported over the period 2018-2020 through the OMEGA3 project, and from 2021 by LAMA. It should be noted that these projects correspond in practice to the French version of the CODA approach. Therefore, the case study will frequently refer to CODA rather than LAMA.

Led by Airbus Operations, LAMA is a small project involving 4 partners, including 2 laboratories, with a budget of over EUR 5 million. The LAMA project contributes to the enrichment of a fluid mechanics simulation system by integrating new digital methods and models. The project aims in particular at improving the design of architectures.

aerodynamics of future ultrasobic aircraft that the current simulation systems do not know to address, e.g. the very elongated wing. The second objective allows for a significant reduction in development cycles through the deployment of automated simulations.

ARISE

The objective of the ARISE project is focused on the development of new methods for modelling materials, focusing on the problems and challenges faced by R &T in the field of aeronautics. This objective is reflected in the realisation of various software components, the relevance and effectiveness of which is demonstrated in business cases and scientific challenges.

ARISE, led by the ONERA laboratory, is a smaller project: this is the deepening of a past research project. It brings together 5 partners, including 2 laboratories and academic stakeholders, with a budget of over EUR 3 million.

The following section focuses on cross-analysis of results across several angles:

- **Project design and operation**: organisation and quality of the relationship between industrial and academic actors
- Importance of academic/industry collaboration for the project

To carry out this analysis, a series of semi-directional interviews were conducted with the technical and research officers of the MAMBO, LAMA and ARISE projects. For each project, the confrontation of the industrial and academic vision has made it possible to identify the main hallmarks and challenges of collaboration. In this preliminary version of the case study, the choice was made to analyse projects with different and unique collaboration characteristics. In fact, ONERA has often been requested. An extension of the results to other beneficiary academic actors is foreseen in the second version of the case study.

Table 22. List of interviews carried out

Draft	Beneficiary	Persons interviewed	Function	Legal classification

MAMBO	Airbus Operations	Maud Lavieille Olivier Brassier	Acoustic department R &Tpropulsion	GE
	Lyon Central School	Marc Jacob	Professor of fluid mechanics and acoustics	LABO
	ONERA	Franck Clero	Head of Aerodynamic and Acoustic Aeroelasticity Department	LABO
LAMA	Airbus Operations	Jean-Yves Chiaramonte	Business Manager R &T	GE
	ONERA	Vincent Couaillier	Head of Unit, Aerodynamic Department,	LABO
			aero-elasticity, acoustics	
ARISE	ONERA	Jean-Didier Garaud		LABO
	Safran	Vincent PATOZ Benoît GUILLIONo	DG AC project manager in charge of partnerships	GE

Source: G.A.C.

1.4.2. Cross-analysis

1.4.2.1. Project design and operation

For the 2 industry-led projects (LAMA and MAMBO), the development of the research project and the establishment of the consortium took place in two stages.

- A first stage of internal discussion with the various interlocutors on the subjects envisaged made it possible to define the strategic lines of the project.
- A second step, in which several academic partners were contacted to provide expertise on one aspect of the project. Conversely, as part of the MAMBO project, some academic players have also contacted industrialists directly, such as Airbus Operations, in order to integrate the project.

These partnerships are mainly based on **historical relationships** between industrial and academic actors, or even for one of them (LAMA), are directly part of a more comprehensive and long-standing partnership. From a technical point of view, French academic players with the necessary expertise in aeronautics research activities are few and are often known for a long time by industry in the field. In addition, the DGAC's expectations in terms of the size and results of the projects have encouraged the players to work with historical partners with the same working culture and experience in setting up this type of project.

Iterative discussions took place with the different partners to identify the most relevant technical proposals and to refine research activities. Depending on the size of the projects, discussions on the research programme took place either bilaterally between the leader and the academic partners, or in a much more collaborative way, with the interests of each other being pooled.

With regard to the ARISE project led by ONERA, the logic is different as it involves deepening a past research project. However, as before, the consortium is based on a close and long-standing partnership. The consortium had a long-standing knowledge, with the exception of Safran Engines Aircraft, which joined the ARISE project in order, inter alia, to provide an additional case of application on the helicopter.

In**conclusion**, it appears that the importance of the issues at stake, the need for specific skills and the overall structuring of the sector tend to favour old partnerships in order to set up these projects. As this conclusion is based on a limited number of projects, it needs to be taken with caution, but seems to be in line with the partnership strategy of a group such as Safran, which is based on a narrow circle (around 30) of strategic partners among academic actors.

1.4.2.1. Importance of academic/industry collaboration for the project

The importance of collaboration between laboratories and academic and industrial research stakeholders is assessed in four main areas: the financing of upstream research, the development of new scientific knowledge, the support and development of relations between the two players, and the dissemination of academic knowledge and the exploitation of research.

<u>Upstream research funding</u>

The share of the total budget allocated to academic stakeholders is 3.8 % of total support, i.e. more than EUR 49 million out of a total of EUR 1,3 billion. This share is relatively small and reflects the industrial dominance of the programme. Additional funding linked to the programme may also benefit laboratories through sub-contracted services. Although the proportion of this funding is a minority, the academic and industrial players have stressed the importance of the programme in supporting upstream research activities.

The DGAC projects have made it possible to support real technological risk taking for both academic and industrial players, although their size has remained limited.

- For academic stakeholders, the level of requirements laid down in the tender specifications and the amount of support made it possible to integrate very exploratory research into the projects, setting the bar very high.
- For ONERA, in particular, whose task is to respond to industrial problems, DGAC projects have made it possible to reprioritise upstream research.
- In addition, the academic stakeholders surveyed consider that the DGAC projects have enabled them to develop targeted research axes for several years (5-6 years).
- In addition, the format of the DGAC programme makes it possible to create a special working environment between industrial and academic players, often bilaterally or 2-3 players. This framework is particularly conducive to the development of upstream research activities enabling regular iterations, for example for the ARISE project, between methodological development, software editing and use-case testing to refine the method.

<u>Development of new academic scientific knowledge</u>

Academic players, who are very well enrolled in the aeronautical research community in France and in Europe, such as ONERA, bring scientific excellence by specialising in very specific areas that industrialists cannot take on at this level.

The collaborative format of DGAC projects has had a real impact on the scientific knowledge produced in several respects.

- By working on cases of usage, academic players are better able to understand industrial issues and therefore to be part of a technological research perspective. They thus ensure greater use of scientific work. The projects allow them to have access to confidential technical specifications and to test modelling on the basis of confidential real data. For example, the MAMBO project provided an unprecedented framework for discussion and transmission over the past decade of Airbus Operations' flight information to ONERA. Field feedback improves the quality of academic research. More generally, the confrontation of knowledge and ways of working in a highly marked field of research, notably through the CORAC Roadmap, is a vehicle for stimulating creativity and co-creation of new ideas.

- For industrialists, easy access to advanced aeronautical research equipment such as test beds or characterisation devices is a major lever for knowledge creation. The challenge is both to be able to test solutions, but also to have a mastery of methodologies to analyse results.

In conclusion, the collaborative format has had a significant impact on the production of new knowledge, both by allowing for more substantive topics and by balancing a variety of research topics. In terms of results, based on the feedback from the questionnaire, 2/3 of the collaborative projects studied could lead to new patents being filed. More specifically, respondents postponed 1 patent applications in 2022 and 1 in 2023.

<u>Support and development of relations between industrial and academic actors</u>

Industrial and academic stakeholders stress the importance of nurturing these collaborative research relationships.

Industrial players enable academic actors to take into account all the constraints on the ground, in some cases to test large-scale innovations, and are indispensable partners in scale-up and bringing innovations to the market through their production tools.

In addition, academic actors provide new solutions to meet the needs of industry, both in terms of developing new scientific knowledge, providing methodology and analysis, and also in terms of state-of-the-art testing facilities.

However, these relationships require a possibility of funding, without which they end up tarnishing. However, the scheme provided for under the aid scheme is unique in the various types of funding available.

- The DGAC also finances other projects, which strictly benefit academic players and do not include these collaborative dynamics.
- The National Research Agency (Agence Nationale de la Recherche) provides little funding for collaborative arrangements with industrialists and has a position on issues which are very upstream, which do not have close industrial purposes.
- The structural projects of competitiveness clusters also provide an opportunity for funding collaborative projects, but the volumes remain limited and are not particularly geared towards aeronautics and do not represent a sufficient size to support ambitious technological developments in a strategic sector.
- Regional projects are more aimed at encouraging local economic development through the development or establishment of industrial sites or the local business fabric.
- European projects (such as Horizon 2020, Horizon Europe or CleanSky) facilitate a wider working space where each partner brings specific expertise around a challenge in the aviation sector. This funding is used more, where there are European partners.
- The Institute for Technological Research is the closest mechanism to support these collaborations between public and private actors. However, it concerns only certain types of upstream work which may be suitable for pooling between actors and cannot replace the work supported by the DGAC.

Moreover, the partnership risk is very different, which is a major decision-making factor for players in the aviation industry. National aeronautics projects led by the DGAC and/or CORAC are screened by a demanding evaluation grid with regard to the issues of confidentiality, technological and industrial sovereignty and intellectual property (IP) sharing. On the other hand, European projects bring together a larger number of partners of any nationality. Thus, the pooling of aeronautical research may be more risky than under national projects.

The aid scheme for aeronautics thus represents a privileged space for collaboration between public and private actors. To that end:

- 80 % of respondents to the questionnaire in the pilot phase (which includes 10 respondents) stated that the project has **strengthened existing partnerships**. Only 20 % of respondents said that the project allowed them to work with new partners. This confirms the point discussed below on the importance of existing partnerships in the context of DGAC projects. Moreover, this also shows that projects can feed into a renewal of this partnership base.
- 40 % of respondents said that the project enabled them to be better identified/recognised in the ecosystem.

Dissemination of academic knowledge and promotion of research

In the context of the knowledge economy and global competition for knowledge in aeronautics, particularly in connection with the challenges of the energy transition, the question of promoting research is becoming increasingly strategic. Moreover, obtaining funding, particularly public funding, is now often dependent on the ability of researchers to generate knowledge that can be mobilised by society or to irrigate it with useful knowledge. Valorisation makes it possible to give academic stakeholders and discipline some legitimacy to their various partners.

In order to be able to value the search for collaborative projects, a number of conditions must be met, the most important being intellectual property.

The strategy chosen in the DGAC projects studied is that of partnership. This method of collaboration is a major vehicle for harnessing the knowledge produced. There are two challenges:

- The 1st is the sufficient knowledge of both parties to capitalise on later projects based on the technologies developed.
- 2nd is the sharing of intellectual property. The consortium agreement signed at the beginning of the project helps to protect everyone's interests and to find a common ground. For the industry, the aim is to ensure the confidentiality of their technologies, which is a major issue in aeronautics, and the ability to exploit the results of the work in their fields. For academics, the IP issue is also central in order to be able to freely continue the work or even have the possibility to adapt it in other collaborations, subject to constraints under the consortium agreement (usually the results cannot be used with competitors of the industry involved in the project).

Academic actors are also important actors in promoting the dissemination of knowledge in the form of publications or disseminating knowledge produced in seminars. The latter may lead to conflicts in relation to intellectual property (need to wait for patents) or because of the risks associated with the dissemination of information. However, the collaborative aspect of these projects does not determine how to exploit the results of the projects. The knowledge and tools developed by academic stakeholders are the subject of independent use by industrial partners or other industrial players. In the course of the interviews carried out, the obstacles identified to the production of academic publications by researchers did not appear to be significant, and at least similar to those in other sectors, despite the particularly significant competitive risks in the field of aeronautics (adjustment of content to critical elements which do not call into question the publication itself). Thus, a number of publications are either actual or planned in the context of the projects. According to the results of the questionnaire, 1 publication of the projects in peer-reviewed journals is planned each year between 2020 and 2022. In 2023, 9 co-publications from projects and 5 project publications in peer-reviewed journals are planned.

More generally, academic actors benefit from the network of other consortium partners and may thus reach wider audiences than usual. The challenge is to get its work recognised within its scientific community, but also among industrial stakeholders who are partners or future partners. This was, for example, the case for the Lyon School after its participation in the MAMBO project, which could be better identified by its peers, in particular ONERA.

Finally, the DGAC projects have made it possible to finance a number of CIFRE (industrial research training conventions). This format of thesis favoured in the projects studied makes it possible to strengthen exchanges between public research laboratories and industrial stakeholders. In practice, the doctoral candidate is an employee of the company but remains supervised by an academic researcher and works on a research topic. These arguments ultimately contribute to the innovation process of the industrialists receiving support from the DGAC, and are also an interesting lever for the valorisation of research, as the doctoral candidate is often recruited at the end of his thesis. Respondents pointed out that 5 CIFRE theses were launched in 2022 and a further 3 will be launched in 2023, of which 2 will be launched on DGAC projects.

In**conclusion**, despite the competition issues specific to the aviation sector, the DGAC projects have indeed made it possible to promote the dissemination and capitalisation of knowledge through:

- Carrying out work to enrich the various participants
- Management of intellectual property and dissemination policy to safeguard the interests of academic stakeholders
- Human capital development through CIFRE
- Raising the profile of stakeholders, particularly academic players, enabling them to develop new collaborations at national or European level;

1.5. Conclusion

Overall, it appears that, despite a limited volume of funding, the aid scheme plays a particular role in the development of private public partnerships and the valorisation of public research. These research partnerships require funding to support collaborative R &D.Lack of alternative funding solutions are available in the field of aeronautics and none of the volumes similar to the ambitions of the scheme.

Analysis of the replies, however, calls for this conclusion to be qualified because of the particular role played by ONERA in the context of the French academic research landscape on aeronautics.

- Thus, in the context of the MAMBO project, although ONERA indicated that it could have financed the works from own funds because it was an important topic for them for 5/6 years, the sizing would have been significantly lower, which would have resulted in a tripling of the time needed to carry out the works. As regards the Lyon Central School, in the absence of support from the DGAC, the overall ambition would have been severely affected. Similarly, Airbus Operation considers that the project would at least have been postponed or even abandoned with a potential postponement to a future R &D.
- As regards the ARISE project, in the same way, ONERA envisaged an investment from equity, but on a scale of 5 times smaller over 3 years. The aid scheme has thus made it possible to resise and, above all, to ensure that the same work is carried out at the same time by the partners, allowing for synchronisation of progress and greater efficiency.
- Finally, as regards LAMA, ONERA stated that, in the absence of DGAC funding, it would not have been able to participate in the consortium (or would have had a minimum participation). This

would have reduced their positioning in the consortium and their access to the associated intellectual property and thus to work on future developments. Beyond this aspect, this would have resulted in a significant reduction in financial resources, and the two CIFRE thesis financed by Airbus would have been called into question. Finally, this would have had an impact on relations with the various partners.

Annex 2. Interview grid used (excluding case study) and questionnaire

The proposed questionnaire for collecting information from beneficiaries is available in a separate file, in Excel format and the applicable interview grid for interviews with project leaders in Word format.

Annex 3. Evaluation matrix

The evaluation matrix is available in a separate file in Excel format.

Annex 4. Literature review on econometric evaluation method

In its methodological guide for the evaluation of state aid, the European Commission sets out the main possible methods for identifying the causal impact of aid schemes.105 These are so-called "counterfactual" methods, which consist of comparing a result obtained with the aid concerned with the result that would have been achieved in its absence. Since the result obtained by the aid is by definition observed only in the case of the undertakings in receipt of the aid, it is necessary to construct a 'counterfactual' scenario, most often on the basis of a so-called 'control group'. This group must be composed of undertakings which have not benefited from the aid and which are as similar as possible to the undertakings receiving the aid.

In practice, the most commonly used approaches are quasi-experimental methods, namely: the double differences method, the regression by discontinuity and the instrumental variables. Random experiments and the estimation of structural models may also be considered depending on the nature and characteristics of the aid scheme to be assessed, as well as the availability of data.

This annex presents a literature review focusing on the dual differences method associated with matching methods. This is the empirical approach identified by the French authorities as the most relevant in view of the characteristics of the aid scheme and the data available. It also addresses other methods potentially applicable to the present case.

4.1. Classical approach to double differences

The double differences method is a causal evaluation method which compares the performance gap between the beneficiaries of an aid plan and a control group before and after the aid is granted. The trend observed in the performance gap is then attributed to State aid. This method is based on several assumptions:

- A hypothesis called SUTVA (Stable Unit Treatment Value Assumption) which implies that there is no interference or variation in the treatment106. That is to say that the potential outcome of an individual does not vary with the treatment assigned to another individual and that for each individual there are no different forms or versions of treatment;
- An assumption of exogeneity which implies that control variables are not influenced by treatment;
- An assumption of parallel trends which implies that the differences between beneficiaries and the control group are stable over time and that both groups are equally affected by common shocks during the analysis period.

When panel data are available107, the double differences method is often implemented using a two-way Fixed Effects (TWFE) regression, using the following equation:

$$V_{it} \quad “_I + y_t + \text{P}^{™FE} D_{it} + 8^{x}{}_{it} + £_{it}$$

105See: European Commission (2014), Commission Staff Working Document, Common Methodology for State Aid Evaluation, SWD (2014) and Annex 1.

In106 the context of counterfactual methods, the variable of treatment (or treatment) is called the variable whose effect is to be measured. In the context of the evaluation of an aid scheme, it therefore corresponds to the aid scheme itself.

Panel107 data are data that have both an individual and a temporal dimension, i.e. they include several observations over time for the same statistical individual.

Where:

- V_{it} is the result variable (Interest Performance Indicator) for an enterprise *i* observed in period *t*;
- ^ʌ is an individual fixed effect. These are indicator variables identifying each enterprise in the database;

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- $_t$ is a fixed temporal effect. These are indicator variables identifying the time units (e.g. years);
- D_{it} is the treatment variable. This is a variable of interaction between two variables indicators, each identifying the aid beneficiaries and the aid period, respectively;
- X_{it} is a set of control variables;
- $£_{it}$ is the term 'error', the distribution of which follows a normal zero average law.

The main interest factor is $P_{TW}^{F^}$ which measures the average change of V_{i} in the case of undertakings benefiting from an aid plan compared with undertakings which did not receive aid. Note that the estimator $P_{TW}^{F^}$ is valid if the characteristics omitted in $£_{it}$ are invariant over time (or invariant between groups, as specified above). If doubts remain about this invariance, one solution is to introduce delayed values of the explained variable among the explanatory variables:

$$V_{it} = 0\ V_{IT-1} + `_i + y_t + P_{TW}^{FE} D_{it} + 8X_{it} + £_{it}$$

As suggested by Angrist and Pischke (2009), delayed values V_{IT-2} can then be used. as an instrument of V_{IT-1}—

4.2. Recent developments

The double differences method is a technique commonly used by economists because it is technically easy to put into practice and allows the determinants of V, *which* are unobservable and fixed over time, to be 'gummy'. As mentioned above, the estimator $P_{TW}^{F^}$ allows an average effect to be identified for all the companies treated.

In some situations, the estimation of an average effect is not entirely satisfactory. For example, a recent trend in econometric literature has shown that this method is biased when the effects of treatment are heterogeneous. In the case of an aid plan, this would mean that the effect of the aid is different depending on the beneficiaries. De Chaisemartin and D'Haultfœuille (2020 and WP 2022) show that, under the classical assumption of a parallel trend, when the effect of treatment is heterogeneous, the estimator $P_{TW}^{F^}$ may be biased. Several authors propose robust double differences estimators with heterogeneous treatment effects.

Firstly, Chaisemartin and D'Haultfœuille (2020) offer an estimator in binary treatment and use DID_M estimator, which is a t-weighted average *of* two types of double differences:

- A twofold difference comparing the evolution of the results $t - 1$ and t of the groups moving from non-treated to treated between these two periods with the evolution of the results of the non-treated groups to the two periods;

- A twofold difference comparing the evolution of results $t - 1$ and t of the treated groups on both dates with the evolution of the results of the groups moving from treaties to non-treated between these two periods.

Subsequently, de Chaisemartin et al. (2022) show that DID_M estimator can be extended to continuous treatments. Their estimator is presented in the case of two periods. They assume that between the first and the second period the treatment of certain units changes while that of the other units does not change. Their estimator then compares the evolution of the results of those who change treatment and those who do not. With continuous treatment, such comparisons can be made either by reweighting those who do not change treatment by propensity score or by adjusting the change of result of those who change treatment using a non-parametric regression of the change of result on the treatment of the first period among those who do not change treatment. Under assumptions of parallel trends in all potential outcomes, the corresponding estimates identify a weighted average of the effect (for all those who change treatment) of the change in treatment, standardised by the difference between the first value of the treatment and the second. This effect can be interpreted as the average effect of an increase in the treatment of a unit on the result.

Another important issue is dynamic effects. New contributions have made it possible to take them into account, and to consider that a group of treaties may also be affected by past treatments.

First, several authors propose estimators considering binary treatment with a staggered design, i.e. different groups can only switch from untreated to treatment and can do so at different times. In this context, Callaway and Sant'Anna (2021) and Sun and Abraham (2021) propose to replace the hypothesis of parallel trends to the untreated outcome with an assumption of parallel trends to the outcome of the observations that have never been addressed.

Callaway and Sant'Anna (2021) consider that in binary and staggered treatment, groups can be aggregated into cohorts that start to receive treatment at the same time. They then seek to measure the average effect of treatment at period *c* +, *for* a cohort that started to receive treatment in period *c*. To estimate this effect, they propose to compare, by means of a double difference, the evolution of the result of each cohort between period *c* – 1 and period *c* +) *with* the evolution of the result of groups that are never treated. The authors also propose an estimator similar to the one presented above but which uses as a control group individuals not yet treated rather than those who are never treated. This latter estimator can be very useful when there is no group that is never treated. Callaway and Sant'Anna (2021) also propose estimators based on an assumption of conditional parallel trends: in this case, only groups with similar characteristics have a similar evolution of their result without treatment.

Sun and Abraham (2021) offer an estimator similar to that of Callaway and Sant'Anna (2021) which also measures the effect of treatment for a cohort composed of groups starting to receive treatment at the same time. Their estimator uses groups that are never treated as a control group or groups treated last if there is no group that is never treated.

Borusyak et al. (2021) propose an estimator that is fairly close to that of Callaway and Sant'Anna (2021) and Sun and Abraham (2021), but which is more precise because, rather than comparing the evolution of results between period *c* – 1 and *c* + +, they propose to compare the evolution of the average results between the period 1 and the period *c* – 1 with the period *c* + la. However, that estimator may be more biased than that of the previous authors in the event that the assumption of parallel trends does not sufficiently hold.

Other authors offer estimators in a dynamic context with non-binary processing or non-staggered design.

In particular, Chaisemartin and D'Haultfœuille (2021) offer robust estimators with heterogeneous and dynamic treatments where groups can be aggregated into cohorts depending on when they are first treated. The authors then seek to estimate the average effect for a cohort of having been treated for the first time there are periods compared to having never been treated. They show that, under the assumption of parallel trends, this average effect can be estimated by a double difference comparing the evolution of results between periods *c – 1 and c* + – of cohort groups that were first treated in period *c* and non-treated groups in the period 1 to *c* +. In this 'non-staggered' design, this effect is difficult to interpret as it can combine several different effects. For example, some groups may be treated for the first time in period *c* and among these groups, some may remain treated in period *c* + 1 while others may no longer be treated. The measured effect will aggregate both the effect of being treated for two periods and the effect of having been treated for a period of one period. The authors therefore propose to aggregate these effects on the basis of a cost-benefit ratio which is estimated by calculating a weighted sum on *c* and the effects of the treatment in each period, which amounts to calculating a weighted sum of several double differences. This ratio can be interpreted as an average of the effect of one treatment unit increase.

Apart from the choice of modelling resulting from the design of the treatment, one of the key issues in the implementation of the double differences method is to have a control group sufficiently similar to the treatment group to ensure that the effect measured is that of the aid scheme.

4.3. The choice of control group

In the context of the double differences method, as in the case of the more general counterfactual methods, the quality of the monitoring group is a fundamental condition for the validity of the assessment, even more than the assessment method itself. As the European Commission recalls in its methodological guide: " *It is the quality of this monitoring group that will determine the validity of the assessment*" 108.

There are several statistical methods available to form a control group. The following sub-sections present an approach that is particularly appropriate to the case at hand: matching methods. In the alternative, the method of synthetic control is also presented.

4.3.1. Matching methods

Matching methods use statistical techniques to produce an artificial control group by looking for another untreated individual (or group of untreated individuals) for each treated individual with the closest observable characteristics possible.

Two assumptions are required for the validity of matching methods:

- A common medium (individuals with similar characteristics in the treatment and control group), thus each observation treated may be associated with at least one untreated observation in the control group;
- The absence of selection bias due to unobservable characteristics: the X variables must contain all the information necessary to characterise the potential results.

In order to ensure that matching is as fair as possible, it is important to include in the matching procedure all variables known to be related to both the assignment of the treatment and the result. On the other hand, variables that may have been affected by the treatment should not be included. One way of ensuring this latter condition is to use delayed variables, hence the importance of having information on the characteristics of individuals before treatment.

The matching procedure is chosen in two stages: the first is to define the distance between two individuals, i.e. the measurement of the similarity between two individuals, and the second is to choose the matching method.

European108 Commission (2014), Commission Staff Working Document, Common Methodology for State Aid Assessment, SWD (2014), p. 7.

There are three main ways of calculating the distance between two individuals:

- The first is the exact distance which considers that two individuals are similar only if the values of all their observable pre-treatment variables are the same. Although the exact matching is ideal, the main challenge is that it does not work very well when the number of covariables is large. Requiring accurate matches often leads to many individuals not being matched, which can lead to a greater bias than if the matches had been inaccurate but more individuals were included in the analysis. One way of addressing this problem is to achieve a Coarsened Exact Matching (CEM) which consists of exactly matching over ranges of values rather than a single value.
- The second distance that can be used for matching is the distance from Mahalanobis which defines the distance between two individuals *i* and *j* as follows: $D_{tj} = ({}^{X}i - {}^{X}j)'^{-1}(\wedge\wedge - \wedge j)$. If the effect you want to measure is ATT (Average Treatment Effect of the Treated), it *is* the variance-covariance matrix of X in the full control group; if one looks rather at the ATE (Average Treatment Effect for these acronyms), it is the variance-covariance matrix of X in the treatment and full control groups. If X contains category variables, they need to be converted into a set of binary indicators, although the distance works better with continuous variables. The distance from Mahalanobis can work fairly well when there are relatively few covariables, but it does not work as well when the covariables are numerous or do not follow normal distributions. This is probably due to the fact that Mahalanobis's matching metric considers all interactions between X elements equally important. With more co-variables, Mahalanobis's matching is therefore trying to match more and more of these multivoic interactions.
- The third distance that can be used for matching is the distance between propensity scores, the propensity score being the probability of an individual being treated. Propensity score matching consists of matching individuals who, regardless of whether they have been treated or not, have a close probability of being treated given the covariables observed. The balancing property of the propensity score ensures that treated and untreated units with the same propensity score have distributions of similar observable characteristics. However, this property is verified only for the real score that is not observed and must therefore be estimated. The quality of the estimation of the average effect of treatment therefore depends closely on that of the propensity score (S. Quantin, 2018). Any model linking a binary variable to a set of predictors may be used to estimate the propensity score. The most commonly used is logistic regression, although non-parametric methods such as boosted CART or generalised boosted models (GBMs) often perform very well.

It is possible to combine the different distance measurements presented above. For example, it is possible to use accurate matching on some covariables and the propensity score for others, or to combine Mahalanobis distance matching and propensity score.

Once the choice of distance to compare individuals has been made, this distance must be used for matching. There are several types of matching.

The first possible type of matching is *the nearest neighbour matching* which corresponds in its simplest form to a matching 1 to 1. It consists of selecting for each treated individual *the* individual in the control group with the smallest distance from him or her. A limit to the simple matching of the nearest neighbour is that the order in which treated individuals are matched may change the quality of the matching. *Optimal matching* avoids this problem by taking into account all connections when selecting individual connections, minimising an overall distance measurement.

Where there are a large number of individuals in the control group, it is sometimes possible to obtain several good matches for each individual treated, then this is referred to as the ' *ratio matching*'. The number of neighbours to be retained is then based on a classic biais-variance compromise. Increasing the number of neighbours makes it possible to reduce variance by increasing the size of the matched sample, but may lead to a bias in the estimate, since the 2th, 3th etc. selected individuals may in fact be more and more distant from the individual being treated.

Another key issue is whether it is appropriate to use the same individual in the control group for different individuals in the treated group. Surrogate matching improves the quality of matching if an individual in the control group resembles several individuals in the treatment group and may be necessary in case the control group contains a relatively small number of individuals. However, inference becomes more complex in matching with remittances, as matched controls are no longer independent as some are part of the matched sample more than once and this has to be taken into account in the analysis of the results, for example by using frequency weights.

The second type of matching is *stratification matching* that forms groups of individuals that are similar for example, as defined by the quantiles of the distribution of propensity scores. The validity of this method is based on respect for the balancing property within each stratum. The setting of the number of strata and their intervals should therefore be guided by this objective. In practice, strata are often defined according to the quantification of the propensity score, leading to the construction of five strata of the same size. *Full matching* methods are an extension of the stratification method where the number of strata is determined empirically.

The**third possible type of matching is *the weighting matching*** which consists of applying a weight to each individual so that the distribution of the relevant characteristics is the same in the control group and in the treatment group once those weights are applied. A first possible weighting is to weigh each individual by the inverse of their propensity score.

TI 1 1-Ti

This weighting makes it possible to measure the ATE. Formally, the weights are as follows: *W[* = ^ + ^ -

j; where $\hat{e}_k$ is the estimated propensity score of individual *k*.

To measure ATT, it is possible to weight the odds and the weights are as follows:
Wi = *Ti* + (1 – *Tj)* - ^ -. This weighting gives a weight of 1 to treated individuals and one L-E;
weight of untreated individuals. Kernel matching is

1-ei

a weighting method that calculates an average over several individuals in the control group for each individual treated, with weights defined by their distance. One of the drawbacks of weighting is that variance can be very high if the weights are extreme, for example if the estimated propensity scores are close to 0 or 1.

Finally, irrespective of the method chosen, the good quality of the matching carried out must be verified. This includes comparing the co-variable distributions in the sample of treated individuals and in the control sample by using for example a test of differences in averages or a difference in standardised averages to verify that matching has significantly reduced differences between groups of treated and untreated individuals.

4.3.2. The synthetic control method

The synthetic control method is a causal inference method developed by Abadie and Gardeazabal (2003) which, unlike counterfactual assessment methods, which aim to assess the average effect of a treatment, makes it possible to assess the individual effect of a treatment.

In practice, when setting up the monitoring group, it is often difficult to find an untreated individual with characteristics that are sufficiently close to the individual being treated. The idea behind the synthetic control approach is that a combination of individuals often provides a better comparison for the treated individual than any untreated individual alone. Thus, the purpose of this method is to construct a valid counterfactual for each individual treated with a weighted linear combination of untreated individuals who reproduce thepre-treatment characteristics of the treated individual.

The principle of constructing the counterfactual is to select untreated individuals so that their pre-treatment characteristics are as close as possible to those of the treated individual. To this end, all untreated individuals are considered to belong to a set of potential counterfeiters called “donor pool”, and each potential counterfactual will contribute with some weight to the reconstruction of the values of the pre-treatment variables of the treated individual. The optimum weights are calculated in two steps. The first step is to find a combination of untreated individuals within the ‘donor pool’ so that the difference between the values of the predictive variables of the treated individual and the controlling individuals is as small as possible. The second step is to find the optimal weights of predictive variables as the co-variables are weighted according to the importance of their predictive power on the result variable. Once the weights of each individual in the control group are calculated, the counterfactual result of the treated individual shall be estimated by the weighted linear combination of the observed results of the control group individuals. Finally, the impact of the treatment on the treated individual is measured by comparing the observed result of the treated individual with his/her estimated counterfactual result, which is the result he would have obtained in the absence of treatment.

This method is generally used to estimate the impact of public policies at aggregate levels, for example at State or regional level. However, as explained autant-Bernard et al. (2020), this method can also be used to estimate the impact of public policies on large companies, for which it is often difficult to find companies with similar characteristics.

Abadie (2021) presented a comprehensive review of the methodological advantages and difficulties associated with this methodology. It also shows that recent developments make it possible to extend the approach to cases with multiple units handled. Robbins, Saunders, and Kilmer (2017) propose, inter alia, the construction of a single synthetic control showing the aggregate values of the covariables of the group of treated units.

Annex 5. Boards

Table 23. Breakdown of aid by sector

NAF	Description:	Amount of aid (MEUR)	Share of aid (%)	Share in number of beneficiaries (%)
3030Z	Aircraft and spacecraft	755,4	55.65 %	14.49 %
2651A	Manufacture of navigational aid apparatus	226,8	16.71 %	2.34 %
7219Z	Other research and experimental development on natural sciences and engineering	65,2	4.80 %	8.41 %
3316Z	Repair and maintenance of aircraft and spacecraft	54,5	4.01 %	0.47 %
2790Z	Manufacture of other electrical equipment	47,1	3.47 %	1.40 %
7010Z	Activities of head offices	45,5	3.36 %	2.34 %
2229A	Manufacture of plastic based technical parts	34,9	2.57 %	1.87 %
7112B	Engineering, technical consultancy	29,7	2.19 %	14.95 %
2711Z	Manufacture of electric motors, generators and transformers	10,5	0.77 %	0.47 %
6202A	It systems and software consultancy	9,1	0.67 %	3.27 %
2651B	Manufacture of scientific and technical instruments	7,8	0.57 %	2.34 %
8542Z	Tertiary	7,6	0.56 %	10.28 %
2562B	Industrial mechanics	7,4	0.54 %	3.74 %
2899B	Manufacture of other specialised machinery	7,2	0.53 %	0.93 %
2573B	Manufacture of other tools	5,7	0.42 %	0.93 %
2733Z	Manufacture of wiring devices	4,0	0.29 %	1.40 %
4669B	Wholesale (business-to-business) of miscellaneous industrial supplies and equipment	3,8	0.28 %	0.93 %
2825Z	Manufacture of non-domestic cooling and ventilation equipment	3,7	0.27 %	0.93 %
2732Z	Manufacture of other electronic and electric wires and cables	3,6	0.27 %	0.93 %
2630Z	Manufacture of communication equipment	3,4	0.25 %	0.47 %
2815Z	Manufacture of bearings, gears, gearing and driving elements	3,4	0.25 %	0.93 %
2219Z	Manufacture of other rubber products	2,8	0.21 %	2.80 %
6201Z	Computer programming	2,6	0.19 %	2.34 %
7490B	Various professional, scientific and technical activities	2,1	0.15 %	2.80 %
7120B	Technical analyses, tests and inspections	2,0	0.14 %	1.40 %
2720Z	Manufacture of electric batteries and accumulators	1,1	0.08 %	0.93 %
2561Z	Treatment and coating of metals	1,1	0.08 %	0.47 %
2041Z	Manufacture of soap and detergents, cleaning and polishing preparations	1,0	0.07 %	0.47 %
5829C	Editing of application software	0,8	0.06 %	1.40 %
7022Z	Business and other management consultancy activities	0,6	0.05 %	0.47 %

2896Z	Manufacture of rubber and plastics working machinery	0,6	0.04 %	0.47 %
1320Z	Weaving,	0,6	0.04 %	0.47 %
4652Z	Wholesale (business-to-business) of electronic and telecommunications components and equipment	0,6	0.04 %	0.47 %
2932Z	Manufacture of other parts and accessories for motor vehicles	0,6	0.04 %	0.47 %
2594Z	Manufacture of fasteners and screw machine products	0,5	0.04 %	0.47 %
7220Z	Research and experimental development on social science and humanities	0,5	0.04 %	0.93 %
5829B	Editing of software development and language tools	0,5	0.03 %	0.93 %
2014Z	Manufacture of other organic basic chemicals	0,4	0.03 %	0.47 %
2849Z	Manufacture of other machine tools	0,4	0.03 %	0.93 %
2611Z	Manufacture of electronic components	0,4	0.03 %	0.93 %
2550A	Forging, stamping, mastering; powder metallurgy	0,4	0.03 %	0.47 %
6311Z	Data processing, hosting and related activities	0,3	0.02 %	0.47 %
2511Z	Manufacture of metal structures and parts of structures	0,2	0.01 %	0.93 %
2573A	Manufacture of moulds and models	0,2	0.01 %	0.47 %
2841Z	Manufacture of metal forming machinery	0,2	0.01 %	0.47 %
3320D	Installation of electrical, electronic, optical or other equipment	0,2	0.01 %	0.47 %
6110Z	Wired telecommunications activities	0,2	0.01 %	0.47 %
4675Z	Wholesale (business-to-business) of chemicals	0,1	0.01 %	0.47 %
2030Z	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	0,1	0.01 %	0.47 %
2814Z	Manufacture of other taps and valves	0,1	0.01 %	0.47 %
6420Z	Activities of holding companies	0,1	0.00 %	0.47 %
5110Z	Passenger air transport	0,0	0.00 %	0.47 %
8413Z	Regulation of and contribution to more efficient operation of businesses	0,0	0.00 %	0.47 %

Source: DGAC and Diane + data, Deloitte Finance analysis

Table 24. List of matching and control variables

Nature of the characteristics	Variables	Databases	Role
R &Dcharacteristics	Expenditure on R &D@@	R & D survey, GECIR database, CIS investigation, DIANE (non-beneficiaries)	Matching
Employment characteristics	Number of workers	DADS base – BTS items, DPAE base	Matching
	Number of employees in R &D@@	DADS- BTS posts database, BMO survey, R &Dresearch	Matching

Nature of the characteristics	Variables	Databases	Role
Financial characteristics and accounting officers	Income statement variables such as: - Turnover - EBE — — Profits/losses - Debt - Tax	FARE, Tax liabilities and Diane (turnover)	Matching
	Financial variables used for the selection of beneficiaries of the scheme: - Share capital - Debt/equity ratio - Interest Cover Ratio (EBE/interest)	FARE, Tax liabilities	Matching
Other characteristics of the enterprise	Membership of a group (indicator)	LIFI, DIANE	Apparіation/ Control
	Sector of activity (NAF code)	FARE, DIANE	Control
	Membership of a competitiveness pole	Pole_competitivit_2	Control
COVID impacts	Impact of COVID-19 on companies in terms of employment and activity	ACEMO-COVID	Appariation/ Control
COVID aid	Partial activity	SINAPSE109	Control
	Carryovers of employee contributions	Rep_Covid RG	Control
Other R &Dand innovation	CIR	GECIR base	Control
	Amount of exemptions for JEI	JEI base	Control
	Other public research funding	R &DSurvey	Control
	Funding from the EU Framework Programmes for Research and Innovation	CORDIS	Control

Source: Deloitte Finance analysis

The control variables from the following databases may not be available at the time of the evaluation (we recall in brackets the availability of each source):

- SINAPSE (2019);
- GECIR base (2008-2020);

109The SINAPSE database provides information on requests for partial activity, on applications accepted and refused and on the establishment or company in which the application was made. This database is not specific to COVID-19 and the last update of this database dates back to 2019. It can therefore only be used if it is updated by the time the evaluation is carried out.

— JEI base (2004-2020);

— R &DSurvey (1980-2019)

Table 25. List of aid to the aviation sector

Objective of the aid	Help	Type of aid	Period	Funding body	Amount
Support to the Treasury	Loans guaranteed by the State (PGE)	Cross-cutting response to the crisis	May 2020 – April 2021	Bpifrance	EUR 694 MILLION (1,5) EUR 1 billion
	Repayable advances and soft loans SME/mid-caps	Cross-cutting response to the crisis	— —	CODEFI/DGFIP	— —
	Carry-overs of charges	Cross-cutting response to the crisis	March 2020 — March 2021	DGFIP/URSSAF	EUR 46 MILLION
	PGE Aero	Measure targeted at the sector	September 2020 – June 2021	Bpifrance	EUR 26,4 MILLION
	Speeding up payment of invoices	Measure targeted at the sector	March to December 2020	DGA	Less than 10 EUR MILLION
	Support to the Safran Treasury	Measure targeted at the sector	May 2020 to May 2027	EPA	EUR 115 billion
Support to maintain employment and the activity	Partial activity	Cross-cutting response to the crisis	2020-2021	DGEFP	EUR 428 MILLION
	Solidarity Fund	Cross-cutting response to the crisis	March 2020 — March 2021	DGFIP	EUR 2,2 MILLION
	Reduction in production taxes	Cross-cutting response to the crisis	Perennial	DGFIP	EUR 250 MILLION
	Training arrangements (FNE- training)	Cross-cutting response to the crisis	March 2020 – August 2021	DGEFP	EUR 10,4 MILLION
	Aid for the recruitment of young people and alternators	Measure targeted at the sector	— —	DGEFP	EUR 2,6 MILLION
Support for outlets	Debate holiday (moratorium on the repayment of export credits)	Measure targeted at the sector	March 2020 — April 2021	Bpifrance/DG Treasury	EUR 0,8 billion
	Favourable conditions for export	Measure targeted at the sector	2020-2021	Bpifrance/DG Treasury	EUR 3,6 billion

Objective of the aid	Help	Type of aid	Period	Funding body	Amount
	Early and flush public procurement (military)	Measure targeted at the sector	2020-2022	DGA	EUR 0,8 billion
Consolidation and transformation of the sector	Fonds Ace No SME/mid-cap partners	Measure targeted at the sector	2020-2030	APE/Bpifrance/DGE	EUR 1 billion (including EUR 200 million in public funds)
	Fund for the modernisation, diversification and greening of the sector's processes	Measure targeted at the sector	2020-2022	BPA/DGE	EUR 0,3 billion
	Financing of the R &D(assessed scheme)	Measure targeted at the sector	2020-2022	CORAC/DGAC	EUR 1,5 billion

Source: Court of Auditors – Public Support to the Aeronautical Sector, February 2022

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