PROJECT FINAL REPORT

Grant Agreement number: 255876

Project acronym: CARING

Project title: Contribution of Airlines for the Reduction of Industry Nuisances and Gases

Funding Scheme: Clean Sky

Date of latest version of Annex I against which the assessment will be made: NOV 2009

Type of report: **Final report**

Period covered: **from JAN 1st 2010** **to DEC 31st 2011**

Name, title and organisation of the scientific representative of the project's coordinator[1]:

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[1] Usually the contact person of the coordinator as specified in Art. 8.1. of the Grant Agreement .

[2] The home page of the website should contain the generic European flag and the FP7 logo which are available in electronic format at the Europa website (logo of the European flag: http://europa.eu/abc/symbols/emblem/index_en.htm logo of the 7th FP: http://ec.europa.eu/research/fp7/index_en.cfm?pg=logos). The area of activity of the project should also be mentioned.

Declaration by the scientific representative of the project coordinator

I, as scientific representative of the coordinator of this project and in line with the obligations as stated in Article II.2.3 of the Grant Agreement declare that:

- The attached periodic report represents an accurate description of the work carried out in this project for this reporting period;
- The project (tick as appropriate) [3]:

  ☒ has fully achieved its objectives and technical goals for the period;
  has achieved most of its objectives and technical goals for the period with relatively minor deviations.

  ☐ has failed to achieve critical objectives and/or is not at all on schedule.

- The public website, if applicable

  ☒is up to date

  ☐ is not up to date

- To my best knowledge, the financial statements which are being submitted as part of this report are in line with the actual work carried out and are consistent with the report on the resources used for the project (section 3.4) and if applicable with the certificate on financial statement.
- All beneficiaries, in particular non-profit public bodies, secondary and higher education establishments, research organisations and SMEs, have declared to have verified their legal status. Any changes have been reported under section 3.2.3 (Project Management) in accordance with Article II.3.f of the Grant Agreement.

Name of scientific representative of the Coordinator: Alexandre FERAY.....

Date: .....13.../ 7...../ ..2012.....

For most of the projects, the signature of this declaration could be done directly via the IT reporting tool through an adapted IT mechanism.

[3] If either of these boxes below is ticked, the report should reflect these and any remedial actions taken.

4.1 Final publishable summary report

Executive summary:

Project CARING (Contribution of Airlines for the Reduction of Industry Nuisances and Gases) is a two-year project (2010-2011) led by a consortium of 9 members including flight ops specialists, environmental specialists, air transport economists and airlines.

The goal of the project was:
- To better understand actual trajectories flown by airlines in real conditions, and to assess their impact on the environment
- To better understand environmental regulations for the air transport and their impact on the airlines
- To build an economic model of the airlines and the environment

The project studied FDR data from several thousand flights from 6 different airlines operating 9 different aircraft types. The analysis allowed to understand the differences between trajectories, the explaining variables and constraints for trajectory choices and how aircraft trajectories and standard operating procedures could be improved to reduce the environmental constraints while remaining compatible with the real-world environment of the flights (ATC, weather, operations).

After studying all environmental constraints (noise and emissions) worldwide and explaining their mechanism and financial impact on airline, the consortium surveyed 100s of airlines about the way they tend to adapt to these new constraints.
The consortium developed several scenarios for the evolution of the regulatory framework and economic conditions.

In addition to environmental costs, the consortium studied the other sources of costs of airlines (all direct operating costs) to put them in perspective and better understand how airlines would balance environmental costs with other costs.

Finally, these studies served as input to the development of a global economic model that shows how airlines react to environmental constraints (an in particular EU-ETS) in a monopoly, duopoly and pure competition environment.
These economic models were played against the above mentioned scenarios to project how a sample airline would benefit or not from the environmental constraints in a competitive environment depending on the fleet it operates and of its environmental efficiency.
The model showed that green aircraft give a competitive advantage to airlines while at the same time having a beneficial effect on the environment.

Project context and objectives:

Project CARING (Contribution of Airlines for the Reduction of Industry Nuisances and Gases) aims at better understanding how airlines deal with the environmental constraints, currently and in the future.
CARING pursues three main objectives in line with Clean Sky's Systems for Green Operations ITD:

- Gather trajectory data from actual flights. These trajectory data will be used in Clean Sky's simulator to evaluate their environmental impact and will be compared with future optimal trajectories permitted by the progress of the Clean Sky programme.
- Understand the current and future environmental constraints and the basis for taxations, emission permits, etc.
- Model how airlines deal with the environmental constraints, and how it affects their economics, their operations and their strategy.

To be comprehensive, the CARING study covers several models of airlines: regional, low-cost, charter and long-haul.
For trajectory data, environmental specialists will work with airlines to record FDR data on a variety of routes (congested airports, secondary airports, medium haul, long haul), aircrafts (turboprops, single aisles, long range) and approaches (regular, CDA) that are relevant for an environmental study. Trajectory data will then be analyzed and synthesized for use within the Clean Sky simulator.
For environmental constraints, the consortium will conduct a survey of existing and potential future international rules.
At last, an economic modelling will be developed based on the previous surveys and an analysis of the other costs within an airline (crew, delays, missed connections, etc.). This economic business model will help understand how the environmental constraints might affect future airline strategies, fleet and network decisions.
The consortium involves 9 airlines as well as airline environmental specialists, airline operations & costs specialists and air transport economists.

Description of the main S&T results/foregrounds:

WP3: Trajectory data

The selection of routes went quickly as schedule but the availability of data became an issue during the summer as it proved longer than expected to process the data within airlines (in particular due to the necessity to anonymize all date because of safety and union issues). Data became available at the end of the summer with a couple of months of delay.
Also, data from the regional airline (Airlinair) proved disappointing as the data recorded on the QAR for the ATR-42 and ATR-72 is poor and limited in terms of fuel flow information.

The IT development work to process efficiently this huge amount of data had been underestimated. It required heavy investment with consecutive delays so that we were able to process them full speed only at the beginning of Fall 2010. However, a very rich set of tool has been developed that allowed to interpret the data in many ways and to be very detailed in the interpretation of the phenomena.

The analysis of the date proved much longer than expected and WP3 will largely exceed the estimated workload, as more data analysis leads to more needs for investigations and explanations (It will span in 2011 and will probably more than double the expected manpower devoted to the task).

However, by the end of 2010, we managed to have a very thorough analysis of all the date we got, in all phases of flights.

In 2011, the flight trajectory analysis was completed with mainly:

- Detailed study of the fuel saving best practices (CDA, reduced acceleration altitude, flap usage, single engine taxi...).
- Comparison of actual flown trajectories and flight data with forecast from the OFP (Operational Flight Plan)
- Detailed interviews with the airlines: pilots, chief pilots, flight safety officers and flight ops personnel. This allowed better interpreting the flight data and understand the actual constraints met by the aircraft operator in a real commercial and ATC constrained environment. This showed that progress in the ATM field are necessary to fully optimize flight trajectory. As a consequence, the liaison with SESAR should probably be strengthened.
- Extension of data analysis to Swiss Intl airline, with thousand of new flights recorded. This allowed extending our FDR data set to new aircraft types, and in particular the Airbus single-aisle fleet (A319-320-321) and the Airbus A330 fleet (A330-200 and A330-300).
  This also extended our study to a new airline business model: the one of a major network airline with hub and spoke operations.
- Generation of sample data files representative of different types of flight. These sample flights were generated in raw and neutral engineering format so as to be reused in future Clean Sky research and act as a benchmark for trajectory optimization.

In addition the software tooling to interpret flight data was improved with the new studies and new data source imports.

At the end, this task was highly successful scientifically with very interesting and detailed foregrounds that include:

- A report on aircraft trajectory dispersion on all phases of flights on various models of airlines, flights and aircraft
- A report on the application of fuel an environment preservation best practices in actual flight conditions (commercial exploitation of the aircraft, pilots in condition, ATM and weather constrained environment)
- A selection of representative sample flights with all their parameters. These flights will be used to develop new FMS systems with advanced trajectory management.
- A set of software code to analyze FDR data for environmental purposes.

WP4: Current and future environmental constraints

WP4 went smoothly and as expected due to the good knowledge of partners in charge of this workpackage.
The most uncertain part of this work (forecasting future tendencies) was addressed by interviewing many stakeholders (ICAO, FNAM, ...) and monitoring CAEP works, and by building synthetic scenarios of possible futures (positive/negative economic environment, weak/strong political commitment).

At the end of this work package, the following foregrounds have been developed:

- Survey all existing emissions environmental constraints worldwide and describe their mechanism and financial impact on airlines
- Survey all existing noise environmental constraints worldwide and describe their mechanism and financial impact on airlines
- Survey tendencies on environmental constraints for emissions and forecast scenario of constraints evolutions for the next 20 years

- Survey tendencies on environmental constraints for noise and forecast scenario of constraints evolutions for the next 20 years

WP5: Airlines operations and costs

WP5 addressed two objectives: understand non-environmental as well as environmental costs of airlines and their strategies to adapt.

Concerning non environmental costs, an important work was carried to process public data from the US DOT, with statistical analysis and business intelligence. This led to a clear understanding of airline costs and their evolution but somehow tinted with a US point of view. The report attempted to give a wider view when possible (for example on crew costs, and differences between business models), but with some limitations due to the lack of public data on the other regions of the world.

Concerning environmental costs, the study was split into two parts: a desk-study with legislation analysis and simulation of economic impact on airlines based on the regulations mechanism, market data (e.g. CO_2 market) and airline data (airline schedules, operating aircraft types, OAG and SSIM data). This allowed drawing interesting and objective conclusion.
In complement to this work, an ambitious survey was sent to more than 100 airlines and followed by heavy work calling airlines to get as much responses as possible. This led to about ~30 airlines responding which is a fair number considering the complexity of the survey and the natural tendency of airlines not to participate to these kinds of research, by lack of time or reluctance to release information.

In general, WP5 results were in line with what was expected, except maybe in the feeding of numerical data that could be easily used to tune the economic model of WP6.

At the end of this work package, the following foregrounds have been developed:
- Survey non-environmental costs of airlines, understand their importance, variation and differences between various types of airlines (regional, low-cost, charter and network), and between geographical zones.
- Survey environmental costs of airlines, their impact on airline economics and strategies, and their practices to mitigate them.

WP6: Economic modelling

In 2010, WP6 work focused on the delivery on a first basic economic model that would show the impact of environmental constraints on airline economics in a non competitive environment (to be completed by a model of a competitive environment in 2011).
After preliminary analysis permitted by the results of WP4 an WP5, it was decided that the economic model should focus primarily on emissions regulation (in particular ETS) as it is the only one that has a clear and important impact on economics.

This model was built and allowed to perceive that the influence of the regulation could be positive or negative to an airline, based precisely on its environmental performance, and especially on the technology of its fleet.
This is an interesting conclusion as it builds a case for a sound environmental regulation as well as for technical progress allowed by projects like Clean Sky.

In 2011, WP6 continued the work started in WP11 on the economic model. In particular, advanced economic models were developed that put into equation the behaviour of airline economics in reaction to changes in the environmental regulatory context and to changes in airline greenness efficiency.
The advanced economic models address the case of airline monopoly, duopoly and pure competition. The models were calibrated against real data. This was a complicated part as little data was available. This is probably to date the weakest part of the research.
The models were used against the scenarios described in WP4.2 of possible evolution of the environmental regulatory framework or of the air transport economic conditions up to the 2020 scope.
The application of the models on the scenario show how an aircraft's positioning in term of environmental friendliness can give a competitive advantage to an airline compared to a competitor operating less environmental friendly aircraft types.
This justify the European investment in aircraft environmental research (such as Clean Sky) and will allow the aircraft and equipment manufacturers to build a business case that shows to their customers that the new "green" functions also have an economic value.

At the end of this work package, the following foregrounds have been developed:

- Advanced economic models that put into equation the behaviour of airline economics in reaction to changes in the environmental regulatory context and to changes in airline greenness efficiency.
  The different models model airline reactions to environmental regulations (in particular EU-ETS) in a monopoly environment, duopoly environment and pure competition environment.
- Simulations that illustrate the impact of environmental regulations on sample airlines in the different scenarios described in WP4.2 on the possible evolution of the regulatory framework and international economic conditions.

Description of potential impact:

WP3: Trajectory data

The dispersion analysis and sample flights will be used by other Clean Sky projects within the SGO-ITD's MTM (Management of Trajectory Mission). The dispersion analysis allows understanding which trajectories are actually flyable in a real ATC and weather constrained environment and how airlines and pilots proceed with their choices. This will be taken into account in the development of future FMS systems with green functions.

The chosen sample flights will be used as benchmarks for the development of the new trajectory optimization algorithms.
The development of more environmental friendly trajectory optimization algorithms and their implementation in future FMS should improve the fuel consumption and CO_2 footprints of flights of several % in the take-off, climb, descent and final approach phases, whilst at the same time reducing the noise footprint on the ground. In the cruise phase, more limited impacts are expected.
The first demonstrator for this new trajectory optimization is expected in the 2014 timeframe.

The FDR analysis work led to software components and data mining algorithms development. This research work will be leveraged by OpenAirlines to develop and commercialize a Fuel Preservation Software solution. This solution is expected to be ready in 2013 and should allow airlines to save an

average of 2% on their fuel consumption and CO_2 footprint. This solution is expected to develop the business of OpenAirlines and its number of employees.

In the very short term, the results of the flight trajectory analysis have been shared with the participating airlines which have discovered fuel saving potential that could be put in practice quickly. The participating airlines expect to reduce their fuel consumption and environmental footprint by 2% just by modifying their operational procedures.

WP4: Current and future environmental constraints

The reports developed in this work package will have an indirect impact by their contribution to work package 6.
They will also define the environmental benefits that lead to airline cost reductions and that must be implemented in priority to the new generation FMS built after WP3.

WP5: Airlines operations and costs

The reports developed in this work package will have an indirect impact by their contribution to work package 6.
They will also define the environmental benefits that lead to airline cost reductions and that must be implemented in priority to the new generation FMS built after WP3.

WP6: Economic modelling

The economic model developed by ENAC can have the following applications:

- Build the business case for environmental friendly features of new aircraft and avionics. This business case will show to airlines that their best interest, from a sheer economics point of view, is to adopt green aircraft in their fleet. This will facilitate the adoption of green technology and thus will allow attaining the ecological benefits (in CO_2, other green house gases emissions and noise reductions) without preventing the development of the air travel industry with all its economical, social and cultural benefits.
- Help the legislator assess beforehand the efficiency of their regulations, as this model can simulate how airlines will adopt their operations and thus how the emissions and their environmental efficiency will be improved.

Public website address:

www.caring.aero

4.2 Use of dissemination and foreground

4.2.1 Section A: Public

TEMPLATE A1 - LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES

No.	DOI	Title	Main author	Title of the periodical or the series	Place of publication	Date of publication
No.1		Inclusion of the aviation sector into the Emission Trading Scheme: an economic analysis	Estelle Malavolti, Marion Podesta	EARIE (European Association for Research in Industrial Economics)	Stockholm, Sweden	01/09/2011
No.2		Strategic reactions of airlines to the ETS	Estelle Malavolti, Julien Jenvrin	Word Conference on Transport Research	Lisbon, Portugal	11/07/2010

TEMPLATE A2 - LIST OF DISSEMINATION ACTIVITIES

Nº	Type of activities	Main leader	Title	Date	Place	Type of audience	Size of audience	Countries addressed
1	Publication	Ecole Nationale de l'Aviation Civile (ENAC)	Strategic reaction of airlines to the ETS	11/07/2010	Lisbon Portugal	Scientific community (higher education, Research)		All (conference in Portugal)
2	Publication	Ecole Nationale de l'Aviation Civile (ENAC)	Inclusion of the aviation sector into the Emission Trading Scheme: an economic analysis	01/09/2011	Stockholm, Sweden	Scientific community (higher education, Research)		All (Conference in Sweden)
3	Web sites/Applications	TRANSAVIA FRANCE	CARING general public website	01/07/2011	Paris, France	Scientific community (higher education, Research) - Industry - Civil society - Medias		All
4	Media briefings	TRANSAVIA FRANCE	2011 Annual Environmental Report	01/09/2011	Paris, France	Industry - Civil society - Medias		France, Holland
5	Videos	TRANSAVIA FRANCE	Green flying practices	01/07/2011	Paris, France	Civil society - Medias		France
6	Conference	Nextops	CARING CleanSky presentation	07/11/2011	Barcelona, Spain	Scientific community (higher education, Research) - Industry	100	All (conference in Spain)
7	Conference	Nextops	CARING Clean Sky Presentation	29/11/2011	London	Scientific community (higher education, Research) - Industry	150	All (Conference in UK)
8	Publication	Nextops	Cleansky CARING presentation	13/12/2010	Amsterdam (Netherlands)	Scientific community (higher education, Research) - Industry	200	All (Conference in Netherlands)
9	Conference	Nextops	CleanSky CARING presentation	17/06/2010	Amsterdam, Netherlands	Scientific community (higher education, Research) - Industry	100	All (Conference in Netherlands)
10	Exhibitions	Nextops	Clean Sky CARING Flyers	16/09/2010	Geneva, Switzerland	Industry - Civil society - Policy makers	300	All

4.3 Report on societal implication

Section B: Ethics

The project did undergo an Ethics review whose results are summarized in the following Table.

ETHICAL ISSUES TABLE

	YES	NO
Informed Consent		✓
Does the proposal involve children?		✓
Does the proposal involve patients or persons not able to give consent?		✓
Does the proposal involve adult healthy volunteers?		✓
Does the proposal involve Human Genetic Material?		✓
Does the proposal involve Human biological samples?		✓
Does the proposal involve Human data collection		✓
Research on Human embryo/foetus		✓
Does the proposal involve Human Embryos?		✓
Does the proposal involve Human Foetal Tissue / Cells?		✓
Does the proposal involve Human Embryonic Stem Cells?		✓
Privacy		✓
Does the proposal involve processing of genetic information or personal data (e.g. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?		✓
Does the proposal involve tracking the location or observation of people?		✓
Research on Animals		✓
Does the proposal involve research on animals?		✓
Are those animals transgenic small laboratory animals?		✓
Are those animals transgenic farm animals?		✓
Are those animals cloned farm animals?		✓
Are those animals nonhuman primates?		✓
Research Involving Developing Countries		✓
Use of local resources (genetic, animal, plant etc)		✓
Benefit to local community (capacity building i.e. access to healthcare, education etc)		✓
Dual Use		✓
Research having direct military application		✓
Research having the potential for terrorist abuse		✓

Section C: Workforce statistics

Workforce statistics:

Type of position	Number of women	Number of men
Scientific coordinator		1
Work package leader	1	4

Experience researchers (e.g. PhD holders)	3	1
PhD students	0	0
Other	2	14

Recruitment:

4 people were recruited specifically for this project (2 women and 2 men), at OpenAirlines (2) and ENAC (2).

Section D: Gender aspects

We did not carry gender equality actions in this project.
There was no gender dimension associated with the research content.

Section E: Synergies with science education

The project led to several classes at ENAC University and the Toulouse Business School on the impact of the environment on air transport and airline economics.

The project developed a general public website with educational scientific content in the form of videos and flash animations which explain the benefits of fuel saving best practices in different phases of a flight.

Section F: Interdisciplinarity

The disciplines involved in the project were:
- Aeronautics engineering science
- Economics
- Environmental sciences
- Mathematics and computer science

Section G: Engaging with Civil society and policymakers

The project disseminated to ICAO and the CAEP (Committee on Aviation Environmental Protection). The results of the project could be used by governmental bodies to assess the efficiency of environmental regulations.
It could be used by policy makers in the following fields, at the international level or European level:
- Environment
- Research and innovation
- Taxation
- Transport

Section H: Use and dissemination

Three research articles were published/accepted for publication in peer-review journals, all written by ENAC University on the economic model of Air transport and the economics.

The project will have a positive impact on the employment. OpenAirlines intends to expand its workforce by 5 people by 2013 to exploit the result of this research.

Section I: Media and communication to the general public

Thanks to the presence of airlines and their contact with the general public, the project did a good work communicating its results to the general public.
Using Transavia's communication agency (Agence H), the results of the project were communicated through:

- A general public website (www.caring.aero)
- Press releases
- TV footage
- Environmental reports (Transavia, TUI)

The results of the project were communicated mostly in English, but also in French and German.