TEAM_Play

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between air transport, environment and society]

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V0.2	15/04/2013	Second draft version incl. additional inputs from D3.8 and D4.7
V1.0	17/05/2013	Final draft after editing by Paul Brok, Chris Eyers and Nicolas Duchêne

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1 Introduction

Modelling of aviation's sustainability has become more complex and requires broader assessments, including environmental and socio-economic impacts, in order to provide adequate decision support. The US-developed Aviation Environmental Tool Suite (including AEDT, APMT and EDS) reflects this trend by combining different models into a tool suite to allow integrated assessments.

The TEAM_Play project (Tool Suite for Environmental and Economic Aviation Modelling for Policy Analysis) is a collaborative project co-funded by the FP7 Research Programme of the European Union which addresses the same requirement. It ran from December 2010 to March 2013 and included 18 partners: DLR, NLR, ENVISA, FOI, MMU, AEA, ANOTEC, Janicke Consulting, CERC, COMOTI, Snecma, Airbus, Rolls-Royce, University of Cambridge, ENAC, TAKS, National Aviation University, and LimitedSkies.

Prior to TEAM_Play, numerous individual models existed in Europe, addressing different aspects of air transport and related impact modelling (noise, local / greenhouse gases emissions, but also climate change and economic impacts). Hence, the main focus of TEAM_Play was on creating a modelling framework in which existing European modelling capabilities could be combined in order to support and strengthen the European perspective in the international policy arena.

The TEAM_Play tool suite also broadens the scope of potential impact assessments in order to improve awareness of additional effects which are crucial for the aviation development but which were not yet fully addressed in earlier modelling systems. Examples are impact monetisation, third party risk, airport capacity constraints, extended forecast horizon, alignment of local, regional and global assessments.

This paper summarises the main project achievements:

- In Work Package (WP) 1, a data warehouse and data exchange platform were established, allowing for consistent provision of data and for structured transmission of input and output data between models. The development and provision of Data and Format Guidelines for the European aviation modelling community were another major output of WP1.
- In WP2, the actual TEAM_Play tool suite was established by designing the necessary model interfaces. The tool suite consists of two modelling systems and different air transport forecast, technology response and environmental impact models. Activities also included an update of the AERO-MS model and the development of policy decision support tools, including a macroeconomic impact model and an Energy Module which sets air transport's and global energy consumption in perspective.
- In WP3, model runs for selected baseline, business as usual and policy scenarios were carried out to test the functioning of the tool suite. Significant work was also performed to harmonise and update default databases which are used by many impact assessment tools (such as aircraft table, engine

emissions table, etc). Scenario-specific traffic files for local and global modelling studies were also prepared and provided to modellers via the data warehouse and the data exchange platform.

- The focus of WP4 was on the scientific coordination, IPR issues and durable implementation of the project. In this WP, a roadmap for a European Aviation Modelling Strategy was developed, which also includes other activities and projects such as X-NOISE and other available European modelling toolsets such as the ones used in Clean Sky and SESAR work programmes.
- WP5 and WP6 were the dissemination and management work packages.

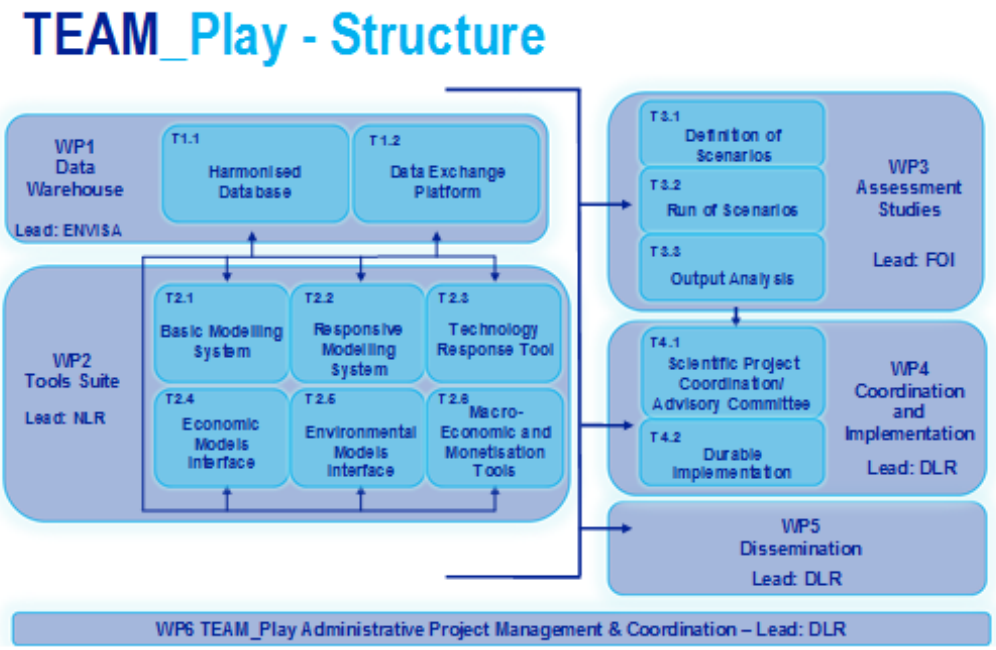


Figure 1: TEAM_Play Structure

2 TEAM_Play Tool Suite, Data Warehouse and Data Exchange Platform

The project's main achievement is the establishment of connections between existing European models and tools (air transport forecast, noise, local and greenhouse gas emissions, economic and environmental impacts) in a common environment and approach, including standardised access to common data sources (and output datasets resulting from the TEAM_Play model runs) collected in a data warehouse.

The tool suite consists of a **Basic Modelling System** (BMS) working in high granularity, and a **Responsive Modelling System** (RMS) allowing for feedback loops; the RMS has been setup around the AERO modelling system which in an earlier version was one of the first modelling tools endorsed for CAEP use.

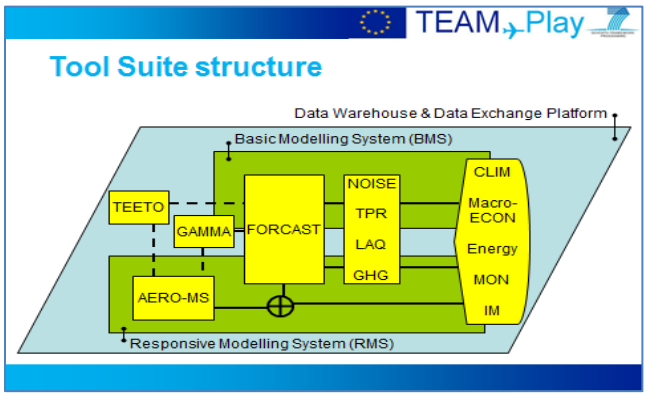


Figure 2: Tool Suite Structure

Models involved include:

- Fleet generator/rollover models GAMMA and FORCAST;
- Technology Response Tool TEETO;
- Local emissions models and dispersion calculators ADMS-Airport, ALAQS, LASPORT and PolEmiCa;
- Noise (contour) models IsoBell'a, SONDEO and STAPES;
- Greenhouse gas emissions model FAST, AEM and AERO-2k;
- Climate response models AirClim and LinClim;
- Third Party Risk model 3PRisk;
- Policy decision support tools: a macroeconomic impact model (gross value added; employment), a monetisation model for environmental impacts, sustainability indicators and an Energy Module.

Main achievements in WP1 and WP2 include the following:

- Set-up of a working Data Warehouse (DW) and Data Exchange Platform (DEP) based on Alfresco open source software;
- Definition, collection and processing of data into common formats;
- Release of Data Formatting Guidelines which will be of use for the European aviation modelling community;
- Model enhancements, including introduction and necessary calibration of an enhanced AERO-MS, and development of proper interfaces that could be linked to the DEP/DW;
- Development/enhancements of the policy decision support tools.

3 Scenario Runs

The overall objectives of WP3 were to demonstrate the applicability of the tool suite (BMS and RMS) to multiple realistic air traffic scenarios and policy use cases and to highlight any data availability gaps that limit the scope of scenarios that can be studied using TEAM_Play. Chosen traffic scenarios remained as close as possible to scenarios envisaged within ICAO-CAEP or ECAC-ANCAT so that any improvements and shortcomings of the TEAM_Play modeling systems could clearly be assessed.

All TEAM_Play tools and models were applied in at least one scenario run and modelling system. Table 1 provides an overview of the scenarios and policies chosen, and of the applied models. Both modelling systems were tested with a baseline 2006 and a 2026/2050 "business as usual" ("BaU") scenario, for which we applied the CONSAVE "unlimited skies" ("ULS") scenario. These reference scenarios were then compared to the results of 2026/2050 BaU scenarios in which additional environmental policies/measures were applied. The basic modelling system (BMS) was also tested with a 2006/2026 CAEP dataset. The following environmental policies/measures were included:

- BMS: 2026 CO2 standard (implemented in 2020), 2050 Open Rotor
- RMS: Ticket tax, Long term ETS, Bio-fuel, Eco-routing

These scenarios reflect TEAM_Play's (cap)ability to assess the economic and environmental impact of potential policy measures for civil aviation.

Modelling System	**BMS studies (Basic Modelling System)**	**RMS studies (Responsive Modelling System)**
Scenarios	Baseline 2006 2026/2050 BaU (ULS) 2026/2050 CAEP 2026/2050 BaU with policies (see below)	Baseline 2006 2026/2050 BaU (ULS) 2026/2050 BaU with policies (see below)
Measures / Policies (2026/2050)	2026 CO2 standard (implemented in 2020) 2050 Open Rotor	Ticket tax Long term ETS Bio-fuel Eco-routing
Models included	• predictive air traffic at global level worldwide (FORCAST) • global emissions worldwide (AEM, FAST) • climate change (AirClim, LinClim) • aircraft noise (based on airport(s) case study) (SONDEO, IsoBella) • local air quality (based on airport(s) case study) (ADMS-Airport, ALAQS,	• global air traffic demand and socio-economic impact (AERO-MS) • predictive air traffic at global level worldwide (FORCAST) • global emissions worldwide (AEM, FAST) • climate change using either AERO-MS or global models' output (AirClim, LinClim) • airport local modelling (aircraft noise, local air quality, third party

	LASPORT, PolEmiCa) • third party risk (based on airport(s) case study) (3PR)	risk) • energy module • macro-economic impact module • monetisation module

Table 1: Definition of Scenario Runs and Models applied

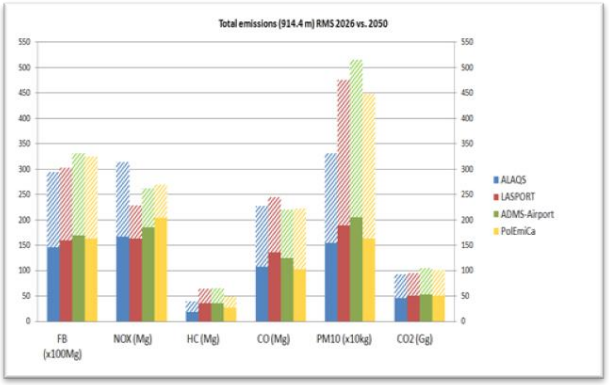
Due to the significant number of models included in the TEAM_Play scenario runs, considerable work was performed in order to define a common data structure which encompasses all requirements from all models. This work resulted in the development of a "Data and Format Guideline (DFG)" document. This document specifies guidelines for the expected format and content of the input data tables uploaded on the TEAM_Play Data Warehouse (TPDW) in preparation of a scenario run. All the TPDW data required to conduct global or local aircraft environmental impact assessment is governed by the DFG: air traffic predictions (overall or airport-specific movement journal containing runway / stand assignments), aircraft default parameters, fuel flow and emissions, noise performances, worldwide airport and countries, airports databases, as well as airport specific parameters (coordinates of runways, taxiways, gates, meteorology. Moreover, a common output of models is also specified in the DFG which was extremely helpful to allow easy comparison of results from various models, but which was also critical for 'downstream models' e.g. the climate models which required three dimensional gridded information in specific format from global aviation emissions models.

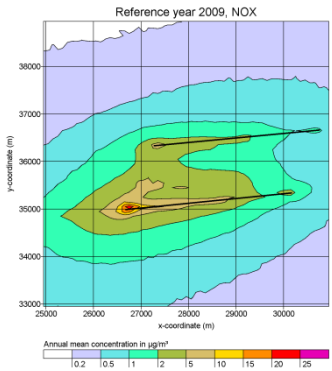
Every modeller involved in TEAM_Play was able to access data on the TPDW using its own credentials since the platform was developed in conformity with the requirements associated with data confidentiality as it's often the case in the aeronautics domain.

In the following section, we compile some selected results to demonstrate the broad capability of the TEAM_Play modelling systems.

It should be noted that the scenario modeling activities in TEAM_Play WP3 were aimed at demonstrating the capabilities developed during the project and thus they were sometimes based on simplified assumptions. Consequently, results from the scenario runs should not be used for actual policy decision-making.

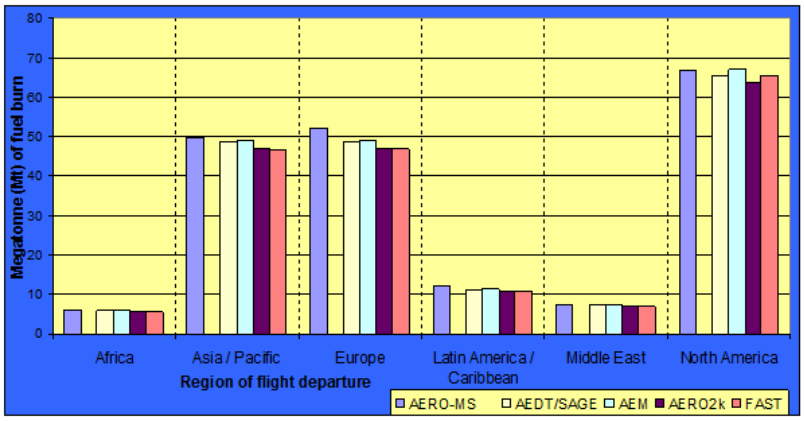
- **Emissions Modelling (BMS results):** Local emissions at the Case Study airport: 2026 vs. 2050 (left) and NOx annual mean concentration near ground in µg/m³ at Case Study airport in 2009 (right)





Source: LASPORT model

- **Fuel Burn and Employment (RMS results):** Following the calibration of AERO-MS, it was possible to run downstream RMS models. Among others, the following total fuel burn and employment results were obtained for the baseline year 2006.



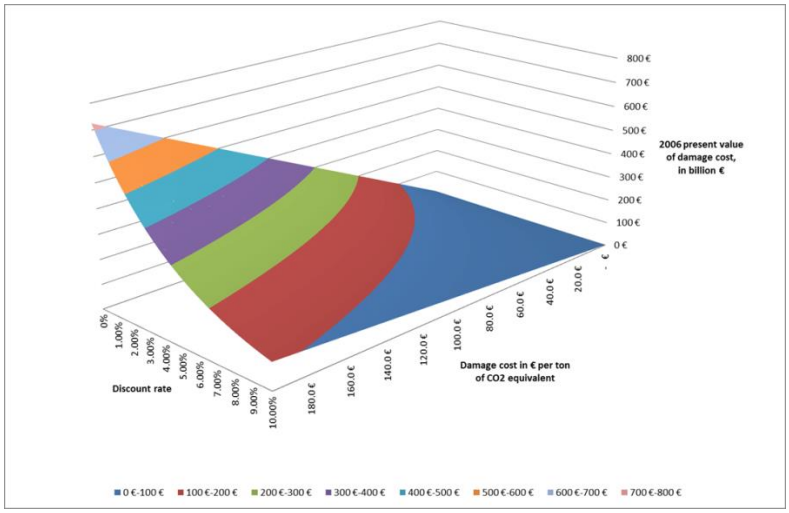
Airlines ('000 employees)		
direct	indirect	sum
2,139.37	2,314.37	4,453.74

Aircraft ('000 employees)		
direct	indirect	sum
1,742.24	2,230.21	3,972.45

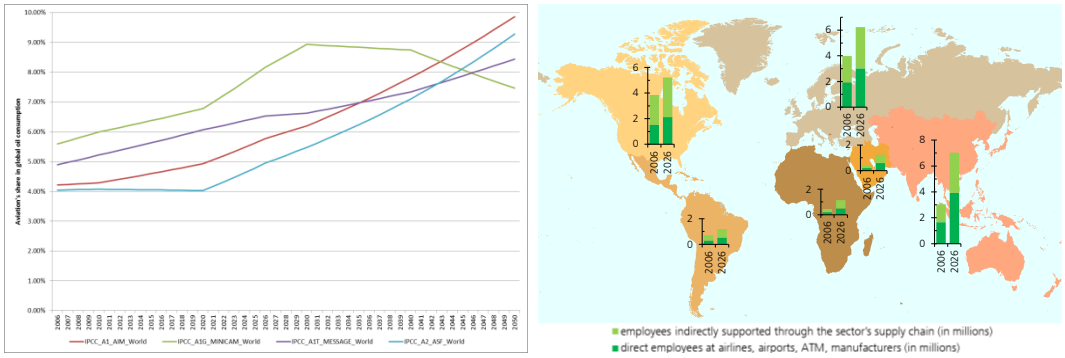
airports & ANSP ('000 employees)		
direct	indirect	sum
1,940.77	2,060.95	4,001.72

air transport system (sum) ('000 employees)		
direct	indirect	sum
5,822.38	6,605.53	12,427.91

- **Monetisation of Climate Impact (based on RMS output):** This is the 2006 base case climate change cost of aviation, depending on marginal CO2 damage cost (range 1-200 €) and discount rate (0-10%)



- **Energy Module:** Aviation's share in global oil consumption 2006-2050 (left) and **Macroeconomic Effects:** Worldwide Employment in Aviation (2006/2026) (right)



- **Visualization for Interdependency Analyses:** Radar plots are applied to visualize many parameters from various modeling areas and to identify trade-offs.

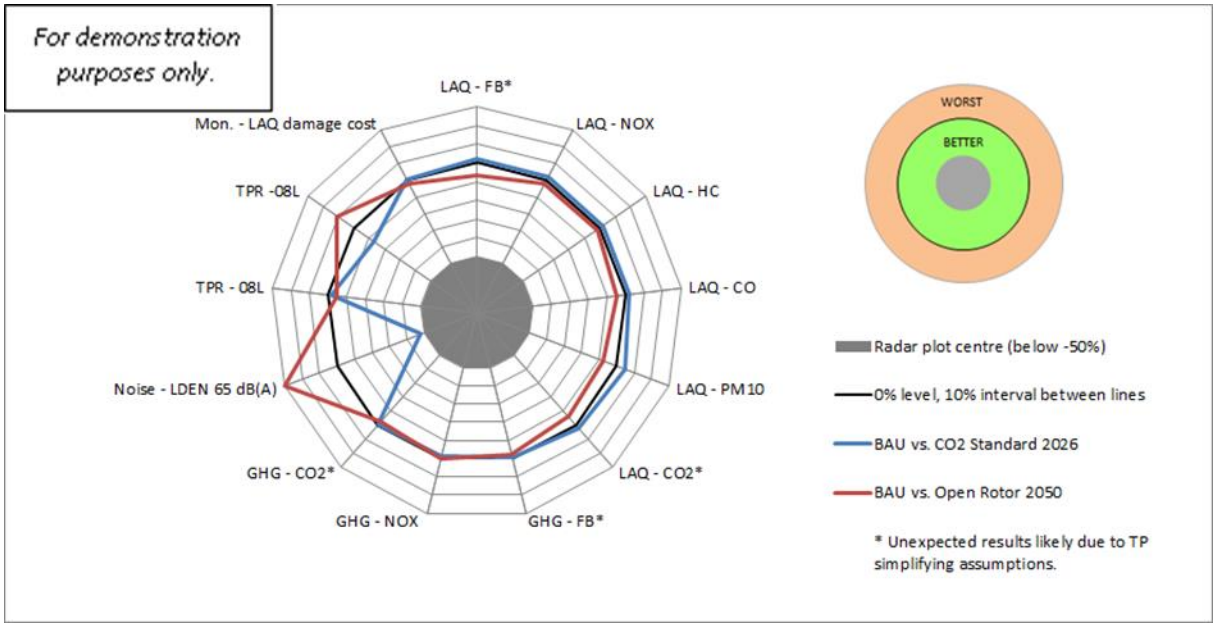


Figure 3: TEAM_Play example results - evolution of indicators between (BaU vs policy scenario) for the BMS.

4 Durable Implementation

With regard to the future use of the Tool Suite, a concept for the durable implementation of the TEAM_Play tool suite in the context of a European Modelling Strategy has been developed. This concept was presented to the ANCAT Modelling Interdependencies Task Group (MITG) meeting in Zürich (CH) and the ECAC-ANCAT meeting in Vienna (AT), both in April 2013.

The proposal is based on the need for further activities at European level on aviation environmental modelling in support of policy analysis and policymaking, primarily to address CAEP but also national and regional environmental modelling needs. These environmental modelling activities need to be established on a long-term basis.,In particular, they should guarantee the availability (now and in the future) of a joint and permanent facility for European aviation environmental modelling, which is tailor-made and up-to-date. This will ensure a strong(er) European position in the ICAO CAEP process.

To meet this need, a roadmap for a durable organisational structure for aviation environmental modelling in Europe was developed. This organisational structure would primarily be driven by a European environmental modelling strategy. The roadmap proposes that MITG is responsible for the development of this strategy and that it in particular will consider the results from EU FP7 projects TEAM_Play and X-NOISE and other available European modelling toolsets such as the ones used in Clean Sky and SESAR work programmes. The roadmap also presents an initial set of ideas about the potential structure of this organisation, for example it suggests the setup of a research & modelling community association, and/or a European modelling partnership, and in this connection the setup of a joint and permanent facility.

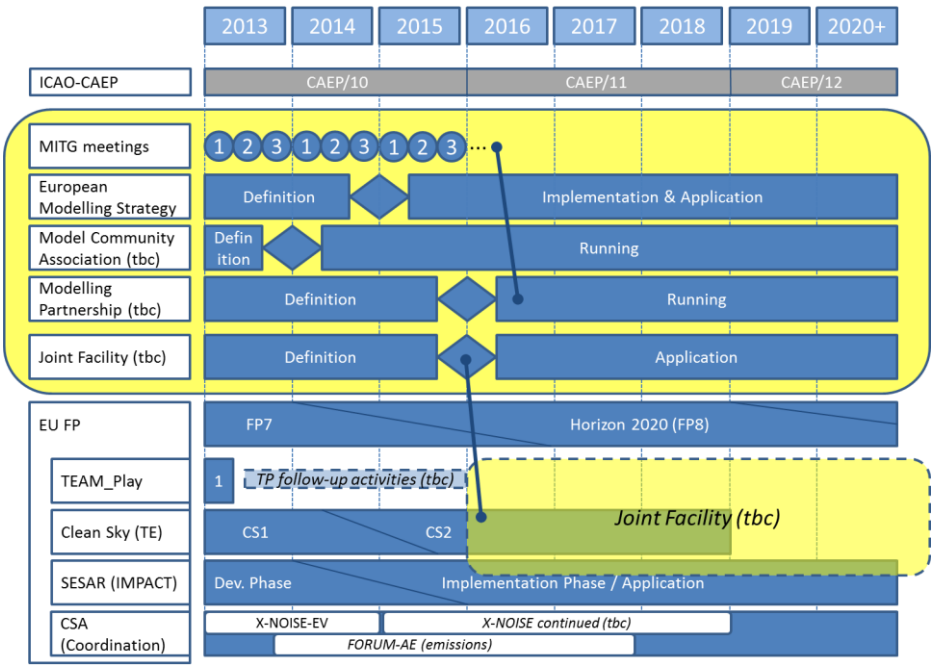


Figure 4: European Modelling Strategy Roadmap

5 Conclusions

Public awareness of impacts of the growing air transport sector on climate change, local air quality and noise has risen and is expected to continue to rise. Numerous policy measures to tackle these challenges are under consideration or have been implemented. At the same time, there are substantial economic and social benefits of air transport for all societies in a world operating a globalised economy.

The actual effects of regulatory action are often hard to estimate and can result in trade-offs, for example between economic benefits and environmental impacts and between the individual environmental benefits themselves. Hence, the EU FP7 project TEAM_Play (Tool Suite for Environmental and Economic Aviation Modelling for Policy Analysis) was a milestone towards a European facility for the measurement of the economics and impacts of the air transport system and its related policies. Various state-of-the-art tools were combined in a tool suite, linked to a common data warehouse and then tested for selected scenarios. This combined set of tools now offers a broad range of useful modelling capabilities, all in one tool suite, which did not exist in Europe prior to this project. The use of the same input data for all modelling activities is an enabler for accurate trade-off studies as it is ensured that results from various models remain comparable (important as well is the documentation of all assumptions from all models – see the WP3 reports for examples). Moreover, comparing results from various models is a way to increase the robustness of the final numbers which would be used for evaluation policy options.

The tool suite flexibility allows for assessments to be undertaken with different approaches, methodologies and resolutions and for the results to be related to a wide range of sustainability indicators. Additionally, the potential for comparison of trends from various models within the same domain brings significantly more robustness to the results of any study.

The management of work flow and data exchanges has been setup, so it now only needs further and broader use, and most of all, actual/real applications. The TEAM_Play Data Warehouse has been proven to be very useful and easy to use for scenario data storage distributing and sharing model input and output data amongst the modelling teams. Hence, it is now possible to model new scenarios quickly if input data is provided according to the TEAM_Play data formatting guidelines (DFG). This provides a good foundation for future work.

In summary, beside connecting the individual tools and providing tested work flows for assessments, the current capabilities of the TEAM_Play tool suite are:

a) Quantification of current and future aviation impacts (considering ecology, economy, trends, technologies, policies)
b) Goal assessment (ACARE/Flightpath 2050, SESAR, IATA etc.) quantifying success level based on user-defined scenarios
c) Normative modelling (identifying requirements to reach the goals)
d) Quantified Scenarios on long term developments, providing know-how depending on various aviation internal and external trends

e) Analysis from global and European level down to local airport level
f) Data Warehouse Platform with EUROCONTROL information on European airports, allowing local assessments

Within a European Air Transport Modelling Strategy, TEAM_Play should be regarded as a nucleus for a durable European Policy and Impact Assessment Facility whose five main pillars are:

- Integration of European aviation stakeholders to identify needs for environmental and socio-economic impact assessments
- Improvement of tools and integration of new models to meet challenges emerging from new policy instruments
- Conducting individual impact and interdependencies assessment studies for current or planned aviation policies
- Implementation of durable management structures and business plans for the TEAM_Play tool suite
- Networking with other European funded projects, and collaboration with US research initiatives on interdependency modelling which are highly advanced in developing aviation policy assessment tools.