COTTON

WORKSHOP #1

31/05/2018

Meeting: **COTTON Workshop #1**

Date / Time: **31/05/2018 9:00 -16:45**

Location: **UPM**

Chairman: **Eva Puntero (Project Coordinator)**

Fernando Gómez Comendador (Project Member)

Participants:

1	Russel Garnham	EUROCONTROL
3	Vilmar Mollwitz	DLR
4	Predrag Terzioski	EUROCONTROL
5	Damián Rivas	University of Sevilla
6	Patricia López de Frutos	CRIDA
7	Manuel Soler	UC3M
8	Francisco Sáez	Cranfield University
9	Raphaël Jungers	UCL
10	Ignacio Morán	ENAIRE
11	Fernando Ruiz-Artaza	ENAIRE
12	Fernando Gómez Comendador	UPM
13	Rosa Arnaldo	UPM
14	Javier Rosendo	UPM
15	Sabela Iglesias	UPM
16	Julen Elortegi	UPM
17	Eva Puntero	CRIDA

18	Marta Sánchez	CRIDA
19	Danlin Zheng	CRIDA
20	Andrija Vidosavljevic	ENAC
21	Daniel Delahaye	ENAC
22	Leila Zerrouki	EUROCONTROL
23	Clark Borst	TU Delft
24	Tobias Finck	DLR

#1 Welcome and Presentation of the Agenda

In the first place, the progress made in the WP2 was presented [1.][2.];how the work had been structured so far and the considerations taken for the following steps. The team discussions structure to be followed during the day was also presented [3.]. Two activities were carried out:

- Session 0: The activity consisted of individually selecting the most appropriate complexity generators for each time horizon in each of the two analysed SESAR solutions (Dynamic Airspace Configuration, DAC and Flight Centric ATC, FCA). For this, an initial list was presented from which they could select, eliminate, redefine or suggest new ones.
- Session 1: In this activity, the individual conclusions reached in Session 0 were shared and sorted it out in levels of uncertainty.

The invited experts were divided into two groups, also integrating the project members. Each group would carry out the same activities but one group focused on DAC and the other one on FCA.

The main questions that arose during this explanation had to do with the definition of complexity to be used and what the time horizons should be in each case. Some suggest following the time horizons of the ATM Master Plan in a common way for both solutions, while others consider that the time horizons of DAC and FCA should be assumed. Also, the level of implementation of DAC/ FCA should be tackled. Some comments point to a timeframe for the outcomes of the project quite in the future, to be considered when defining the scenarios (for example the existence of airways) and levels of implementation.

It is discussed the concept of "complexity in the service", that is, there is an intrinsic complexity (given by the traffic), and later a global complexity linked to the service in a scenario (i.e. the way traffic is managed). This global complexity must be considered for the allocation of responsibilities in traffic management. COTTON will analyse the impact of the intrinsic complexity on ATC service and what is needed to support it.

Questions about the expected benefits of DAC and FCA as isolated and combined concepts arose. Although the demonstration of DAC and FCA viability is out of the scope of COTTON, the project shall consider them and be clear on how it will contribute to reinforce these benefits. Main contribution from COTTON to FCA will be supporting the decision making on when and where to implement FCA and DAC; the transition between the two areas and the trajectory allocation through complexity.

The list of complexity generators used as a reference was the one shown in the following table.

CATEGORY	COMPLEXITY GENERATOR	COLOUR CODE
Airspace	Number of airways within the airspace of responsibility	
	Number of crossing points within the airspace of responsibility	
	Presence/proximity of restricted airspace	
	Distribution of crossing points and their proximity to airspace boundaries	

CATEGORY	COMPLEXITY GENERATOR	COLOUR CODE
	Airspace geometry	
	Difference between upper and lower FL	
	Airspace volume	
Conflicts	Angle of convergence in conflict situation	
	Number of conflicts predicted	
	Number of opposite heading	
	Degrees of freedom of the controller in the resolution strategy of the conflict (e.g. procedural or supporting tools limitations)	
	Minimum vertical/ horizontal (the lower of the two) distance between flights at conflict point	
	Proximity of potential conflicts to sector boundary	
Flow organisation	Altitude AC distribution	
	Speed AC distribution	
	Percentage of fligths out of standard flows	
	Flows and Routes distribution: Number, geometry (orientation relative to sector shape, merges, crossings…)	
	Vectoring restrictions	
Operational Procedures	Number of actors acting per procedure	
	Frequency congestion	
	Handover procedures	
	Separation standards	
	Risk of operational errors	
	Coordination procedures	
Traffic	Number aircraft entering	
	Number aircraft exiting	
	Number of aircraft changing altitude	
	Distribution of flight time per aircraft under ATCO responsibility in the given timeframe	
	Ratio of standard deviation and mean of ground speed	
	Average sector flight time	
	Fraction of aircraft climbing	
	Fraction of aircraft in cruise	
	Fraction of aircraft descending	
	Aircraft per unit volume	
	Average instantaneous count	

CATEGORY	COMPLEXITY GENERATOR	COLOUR CODE
	Total number of flights in the timeframe	
	Flight level difference between crossing flights	
	Time difference at crossing points	
	Vertical convergence (diverging, constant or converging)	
	Concurrence of crossing points with ATCO pre-identified "crossing points"	
	Distribution/dispersion of traffic in volume	
Traffic mix	Aircraft type mix (performance)	
	Operation category mix	
	Proportion of arrivals, departures and overflights	
Others	Risk of technical failures	
	Level of aircraft intent knowledge	
	Weather conditions	

Table 1: Complexity Generators

The information contained in the table shows the analysis resulting from the complexity metrics analysed by the project so that the colors identify 4 degrees of use. The complexity generators that have a green mark are those used in most metrics, while those that have a red mark are barely used.

For the teamwork sessions, the complexity generators must be sorted in the Table template below. They are categorized in three time horizons (indicating their availability at each TH) and in 3 levels of impact on complexity:

- High impact
- Medium impact
- Low impact

Then, for each complexity generator sorted, it is analysed the degree of uncertainty associated with that generator in the selected horizon:

- High uncertainty
- Medium uncertainty
- Low uncertainty

COMPLEXITY GENERATION/ INFLUENCE	LONG TERM	MEDIUM TERM	SHORT TERM
HIGH			
MEDIUM			
LOW			

Table 2: Table template

#2 DAC group

First, before beginning to select the complexity generators, the group defined the time horizons and associated the type of information available in each of the phases. The result of the selected phases is presented in the following figure.

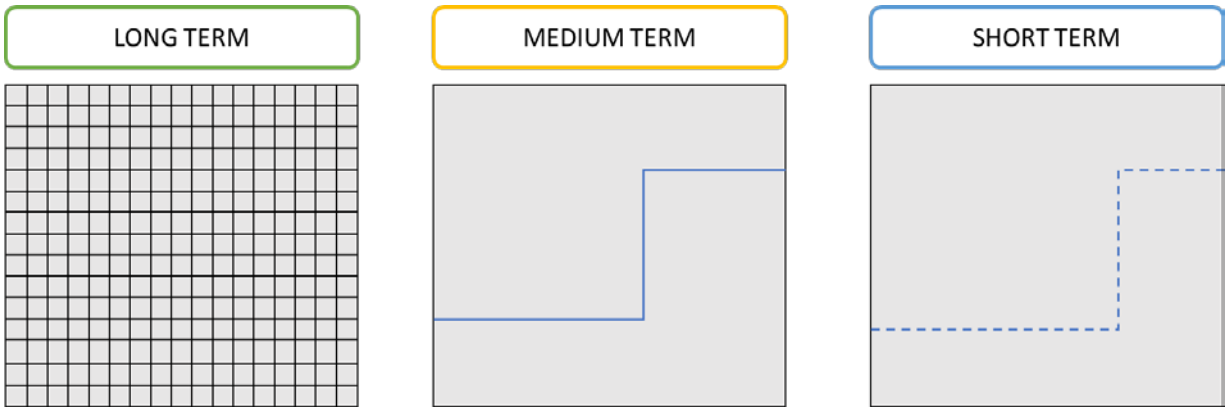

Figure 1: DAC Phases

In the long-term phase, the definition of small volumes (Sector Building Blocks) takes place. The traffic demand and known airspace conditions are the input for the definition of the size and shape of these airspace bricks. The next step (medium term) will be to define operational volumes taking into account operational procedures and the expected taskload. Finally, in the short-term phase, small modifications are made to the structure defined in the previous step, already with more precise

information of the previous conditions and taking into account human factors (workload). The short-term phase includes execution, when airspace configuration changes also take place.

The possibility of modifying these horizons is discussed according to the European zone in which DAC is being applied, because there may be overflight zones and others with large airports that will have different needs. Some suggest that the initial blocks should be fixed from 1 year earlier.

Among the issues raised in the debate was the question of defining the size of the initial blocks of a larger or smaller size according to the traffic conditions that exist at that moment, therefore the size of the blocks will be related to the uncertainty.

It is assumed that there will be no free flight and therefore there will be some fixed points in the airspace.

As a result of proposing the configuration of sectors, the hotspots will begin to appear, therefore they are not predefined only by the traffic conditions.

Participating members in other SESAR projects such as COPTRA (http://coptra.eu/) raise the need to develop tools that combine and relate probable trajectories.

The need to take into account the transition times when changing the configurations of sectors with respect to the anticipated situation is also valued. The duration of the configurations is a factor of complexity impacting mainly in the short-term time horizon. The day before of operation is when the transition of configurations is considered a complexity generator, so configurations are adapted accordingly.

Regarding the weather conditions, it is clear that we will only take them into account in the final stages of the process but they will have a great impact on the final decisions. They can be used in two ways:

- Proactively (24 hours before).
- Reactively (at the time of the operation).

During the discussion there was an open point regarding the variation in occupancy. Some defended that the variation of peaks and valleys of complexity would suppose an increase to the own complexity. Also this increase would not exist in a situation of constant conditions. For others, this situation would not suppose an extra complexity, besides defending the impossibility of measuring this increase.

With all this discussion present, the results of this session are summarized in the following table.

COMPLEXITY GENERATION/ INFLUENCE	LONG TERM	MEDIUM TERM	SHORT TERM
HIGH	• Crossing Trajectories/Flows • Military Areas • Entry Counts • Occupancy • Traffic in Evolution	• Military Areas • Crossing points proximity to Airspace Boundaries • Entry Counts • Occupancy • Traffic in Evolution • Airspace Geometry	• DMA • Aircraft per Unit Volume • Entry Counts • Occupancy • Traffic in Evolution • Airspace Geometry
MEDIUM	• Vertical Convergence • Flows Angle of Convergence • Proximity of crossing flows to boundaries	• Weather Forecast • Aircraft per Unit Volume	• Weather Nowcast • Proximity to Boundary • Angle of Convergence • Number of Conflicts • Number of opposite headings • Minimum V/A distance
LOW			

Table 3: DAC Session 1 Results

This is the final classification of complexity generators that was established for the DAC. Those found in green indicate that the level of uncertainty is low, those with a yellow colour are associated with an average uncertainty and those in red with a high uncertainty. On the other hand, for those that are in black their level of uncertainty was not established.

For lack of time not all were analysed in detail. The parameters they had selected in Session 0 have been revised later to complete the information.

#3 FCA group

First, it is defined the 3 time horizons for which the generators will be selected.

- Long Term reaches up to 48 hours before the operation (entry to the FCA).
- Medium Term would go from 48 hours before the operation (entry to the FCA) until 4 hours before. It is considered that the weather predictions of 6 hours before the operation will be useful to estimate complexity.
- Short Term will be few hours before the execution, between 1 and 3 hours before the entry into the FCA.

It is agreed to limit the scope of the assessment to en-Route operation in a free route environment

Below are some of the ideas that emerged during the discussion.

The uncertainty in medium term does not allow speaking of conflict by itself, there could be no complexity between two aircraft but even so the ATCo will have to monitor it, which affects the crossing trajectories.

The conflicts are more relevant in short term horizon because of its accuracy in time evolution. The severity must be taken into account when taking a conflict resolution manoeuvre, since this will be reflected in the impact it has on the rest of the traffic.

The complexity metrics resulting from the workshop would be integrated into the flight allocation procedure since it is already stated that one principal criteria for allocation is the workload and secondly the potential conflicts within FCA.

Regarding the coordination between the ATCOs in FCA, if there is a conflict between two aircraft allocated to different flight centric ECs, then it is necessary their coordination for the conflict resolution; on detriment of the reduction of flight transfers between sector boundaries. One important aspect to be taken into account is that within FCA, the ATCos have less situational awareness since the flights are allocated to different controllers and the information of the flights are not totally shared between them.

Regarding the meteorological conditions, the importance of thunderstorms is introduced, since it generates a great impact without relevant information of its evolution and the affection to traffic. The effects of the uncertainty could be measured in the Medium and Short Terms, but it will be probabilistic information (only 1 hour before, the information of the storms would be accurate enough for its use, which is very limiting)

A more dedication to flight in evolution than those in cruise is stated.

Regarding the airspace, it is understood that there will be hotspots but that they will be separated by all airspace.

As for the workload, it is mainly summarized in 2 issues that will depend essentially on the one hand the functions of the ATCo and on the other the (probabilistic) number of aircraft in FCA.

In a future TBO environment, the uncertainty of the trajectories would be significantly reduced thanks to the new operating methods centred to airspace user's preferences.

The greater difficulty in measuring vertical convergence (EPP) than the horizontal one arises. Because it is mentioned that for vertical convergence the prediction is very difficult and in many cases the controllers use their personal experience on it.

Taking into account all these ideas discussed, the generators that will affect each one of the temporal horizons are considered, with the results that are offered in the following table. For the completion of the table, two iterations were done, firstly a selection of the complexity generators contribution to complexity and known in each timeframe where identified. Secondly the three most important in each phase were identified and its level of uncertainty discussed.

COMPLEXITY GENERATION/ INFLUENCE	LONG TERM	MEDIUM TERM	SHORT TERM
HIGH	• Degree of freedom of the controller in the resolution strategy of the conflict • Number & Structure of Traffic Flows • A/C type mix • Coordination Procedures	• Fraction of A/C climbing and in cruise and descending • Probabilistic A/C entering • Probabilistic Potential Interactions • Change of altitude • Restricted Airspace (more flexible in the future) • Number of Actors acting per procedures • Flight object (all traffic info)	• Thunder Storms • Vertical Convergence • Number of potential conflicts predicted • Level of A/C intent knowledge • Proximity of potential conflicto to FCA boundary • Flights Interactions • Conflict Detection & Resolution Support and Monitoring System • Number of A/C entering • Coordination BTW ATCos
MEDIUM	• Use of Datalink	• Weather Influence on Trajectory • Distribution of flight time per A/C per ATCo • Flow Organisation • Flight level difference between crossing flights • Probabilistic Inf. Weather	• Flight level difference between crossing flights • Horizontal Convergence • Ratio of Standard Deviation and mean of Ground Speed
LOW	• Airspace Geometry	• Airspace Volume	

Table 4: FCA Session 1 Results

This is the final classification of complexity generators that was established for the FCA. Those found in green indicate that the level of uncertainty is low, those with a yellow colour are associated with an average uncertainty and those in red with a high uncertainty. On the other hand, for those that are in black their level of uncertainty was not established (they were not among the three more important per phase).

A note for the difference between Airspace geometry and volume is stated. The geometry defines the volume and the volume assesses the complexity within the volume.

Only the uncertainty of the complexity generators that were considered most important was categorized.

#4 Results

Finally, after compiling the results of each of the group sessions and the tables that each of the participants filled in individually (Session 0), the information has been compiled in the following table.

The objective of the analysis process has been to define four categories for the set of complexity generatos identified in the project:

- Elements of the list that are considered important in the definition of complexity metrics, or with slight changes.

- Elements of the list that can be considered included in other elements already selected.
- Elements that can be discarded from the list because they are not important for the complexity metric.
- Identification of new elements that should be considered as additional complexity generators in the final selection of the project

The following table shows these results from the workshop information, to obtain a unified set of complexity generators:

CATEGORY	COMPLEXITY GENERATOR	COMPLEXITY GENERATOR Review
Airspace	Number of airways within the airspace of responsibility	Number of main flows
	Number of crossing points within the airspace of responsibility	Number of interaction points
	Presence/proximity of restricted airspace	Presence/proximity of restricted airspace
	Distribution of crossing points and their proximity to airspace boundaries	Distribution of crossing points and their proximity to airspace boundaries
	Airspace geometry	Airspace Geometry
	Difference between upper and lower FL	Related with airspace volume
	Airspace volume	Airspace Volume
Conflicts	Angle of convergence in conflict situation	Related with "Vertical and horizontal convergence"
	Number of conflicts predicted	Number of conflicts predicted
	Number of opposite heading	Related with "Vertical and horizontal convergence"
	Degrees of freedom of the controller in the resolution strategy of the conflict (e.g. procedural or supporting tools limitations)	Degrees of freedom of the controller in the resolution strategy of the conflict (e.g. procedural or supporting tools limitations)
	Minimum vertical/ horizontal (the lower of the two) distance between flights at conflict point	Related with "Vertical and horizontal convergence"
	Proximity of potential conflicts to sector boundary	Distribution of crossing points and their proximity to airspace boundaries
Flow organisation	Altitude AC distribution	Altitude AC distribution
	Speed AC distribution	Speed AC distribution
	Percentage of flights out of standard flows	Not considered

	Flows and Routes distribution: Number, geometry (orientation relative to sector shape, merges, crossings…)	Flows distribution
	Vectoring restrictions	Vectoring and operational restrictions
Operational Procedures	Number of actors acting per procedure	Related with coordination procedures
	Frequency congestion	Not considered
	Handover procedures	Related with "vectoring and operational restrictions"
	Separation standards	Not considered
	Risk of operational errors	Not considered
	Coordination procedures	Coordination procedures
Traffic	Number aircraft entering	Traffic entry
	Number aircraft exiting	Related with "traffic entry"
	Number of aircraft changing altitude	Altitude AC changes
	Distribution of flight time per aircraft under ATCO responsibility in the given timeframe	Distribution of flight time per aircraft under ATCO responsibility in the given timeframe
	Ratio of standard deviation and mean of ground speed	Related with "speed AC distribution"
	Average sector flight time	Related with "distribution of flight time per aircraft under ATCO responsibility in the given timeframe"
	Fraction of aircraft climbing	Related with "altitude AC changes"
	Fraction of aircraft in cruise	Related with "altitude AC changes"
	Fraction of aircraft descending	Related with "altitude AC changes"
	Aircraft per unit volume	Related with "occupancy", "traffic entry" and "airspace volume"
	Average instantaneous count	Related with "occupancy"
	Total number of flights in the timeframe	Related with "occupancy"
	Flight level difference between crossing flights	Related with "Vertical and horizontal convergence"
	Time difference at crossing points	Time difference at crossing points
	Vertical convergence (diverging, constant or converging)	Related with "Vertical and horizontal convergence"
	Concurrence of crossing points with ATCO pre-identified "crossing points"	Not considered
	Distribution/dispersion of traffic in volume	Not considered
Traffic mix	Aircraft type mix (performance)	Related with "speed AC distribution"
	Operation category mix	Not considered

	Proportion of arrivals, departures and overflights	Not considered
Others	Risk of technical failures	System failure
	level of aircraft intent knowledge	Not considered
	Weather conditions	Weather conditions

New Proposals	Airspace uses	To include different uses for airspace
	Occupancy	The best option to take into account traffic density
	Transition and changes in configuration	It will be very important issue for DAC and FCA application
	Vectoring and operational restrictions	To include all operational requirement
	Vertical and horizontal convergence (diverging, constant or converging)	It reflects better angles and conditions in conflict points
	Time difference at crossing points	Best option to assess conditions at the point of conflict
	CDR Support and monitoring System	It is important to take into account technical means
	Coordination support tools	It is important to take into account technical means especially in FCA application

Table 5: Complexity Generators Workshop Results

The colour code of the Complexity Generators Review column is as follows:

- The yellow boxes indicate that this parameter was not selected by any of the participants;
- The blue boxes imply that this parameter is considered within another element
- The green boxes are those selected parameters although they may have a new denomination.

Apart from the results related to the identification of the complexity generators more relevant in DAC and FCA environments and their uncertainty, some general recommendations were extracted from the workshop discussions to be taken into account in COTTON activities:

- COTTON shall clearly identify the complexity definition used in its research and the types of complexity considered (intrinsic complexity, cognitive complexity, etc…)
- The project shall consider FCA and DAC benefits and be clear on how it will contribute to reinforce them.
- Research shall be based on future scenarios whose relevant assumptions shall be clearly stated in COTTON deliverables, e.g. presence or not of free route operations

Finally, it can be concluded that a high participation in the Workshop was achieved, a large amount of useful feedback was collected for the development of the WP2 and a concrete proposal was reached about the Complexity Generators as it was intended.

#5 Annex: Results Photos

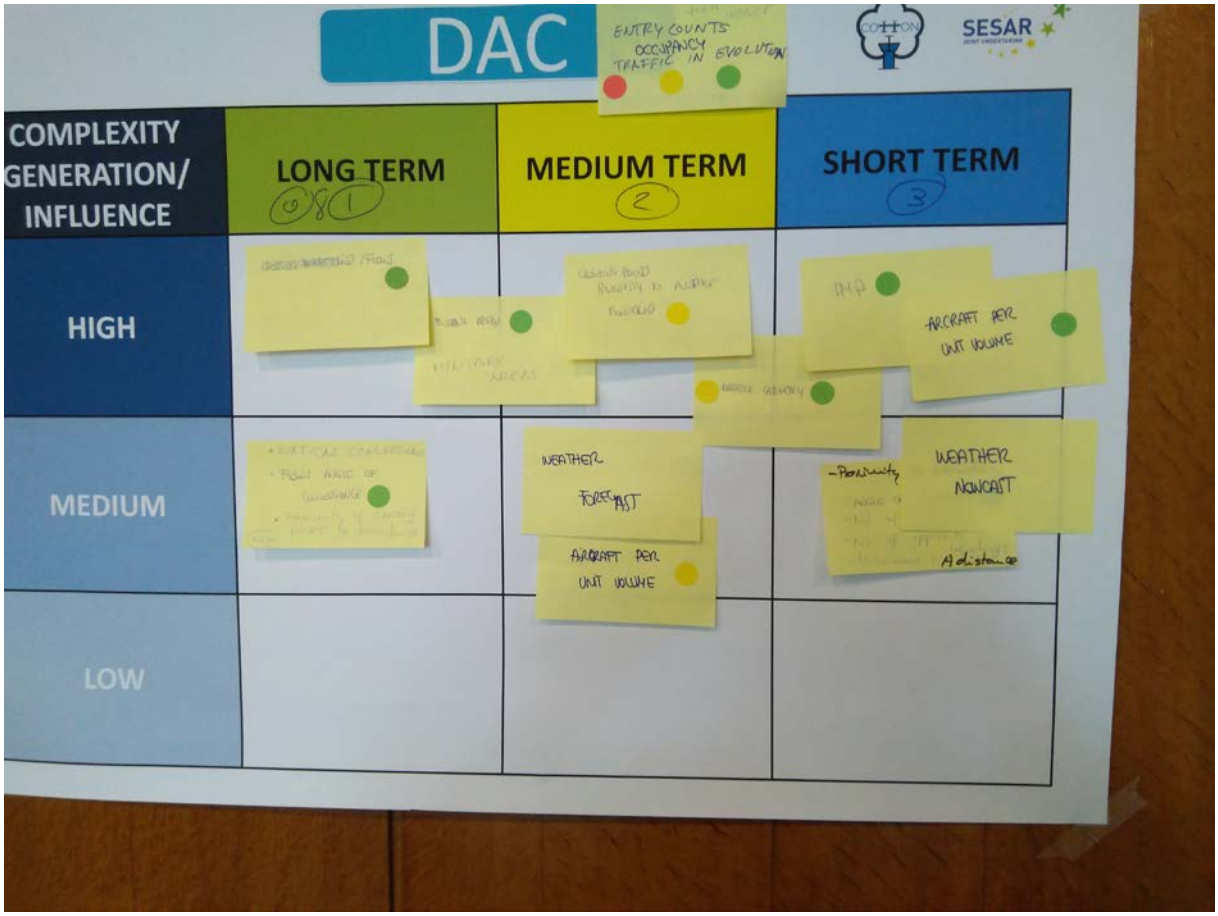

Figure 2: DAC Results

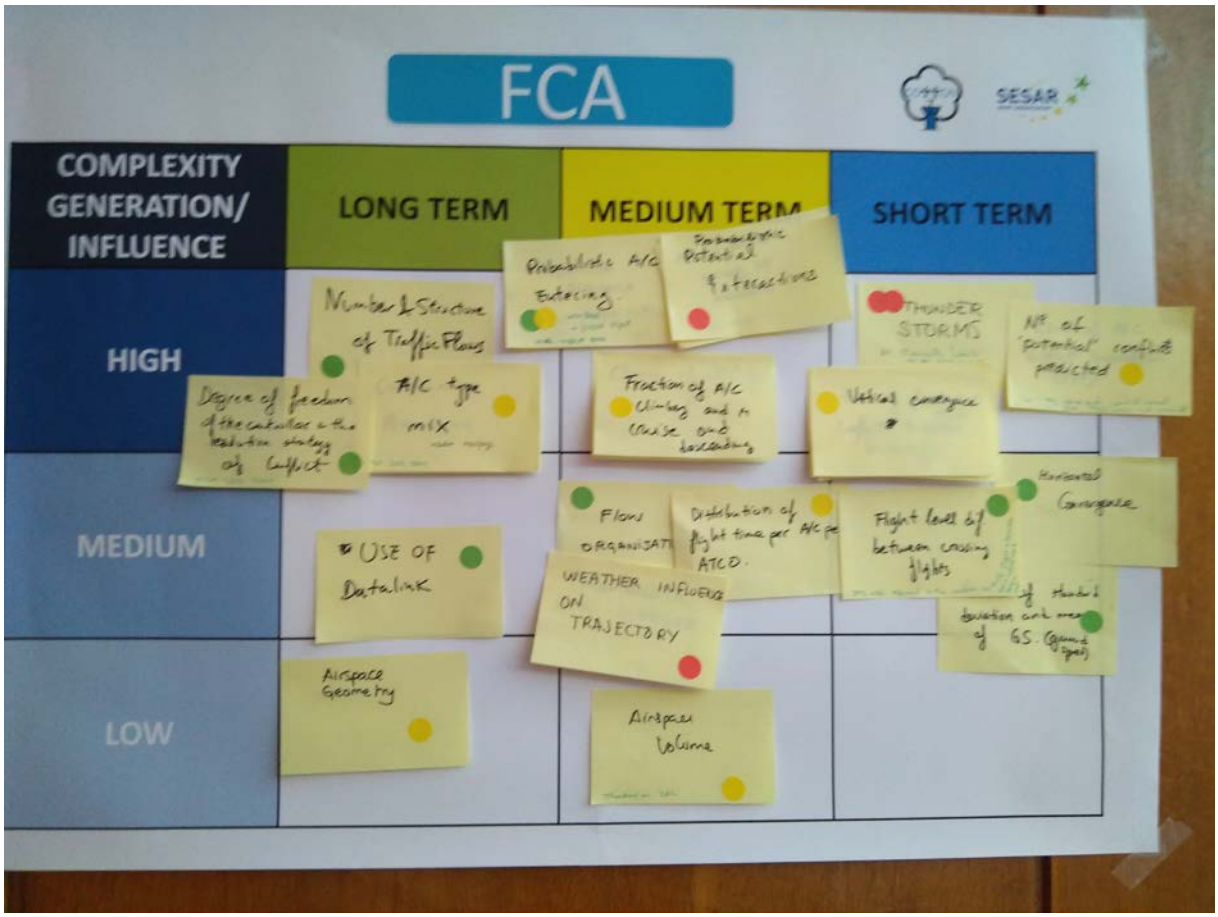

Figure 3: FCA Results

[1.] COTTON, COTTON_First Workshop Project Presentation_v00.01.00, 10/05/2018
[2.] COTTON, COTTON_First Workshop_Introduction_v00.01.00, 10/05/2018
[3.] COTTON, COTTON_First Workshop - Teamwork Sessions 1&2_00.01.00, 10/05/2018