COTTON

Capacity Optimisation for TrajecTory-based OperatioNs

FINAL WORKSHOP

02/12/2019

Meeting: **COTTON FINAL Workshop**

Date / Time: **02/12/2019 10:00 -16:00**

Location: **National Centre of Scientific Research (NCSR) "Demokritos"**
Athens, Greece

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

Participants:

ID	NAME	COMPANY	ROLE
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14	Xavier Fron	EUROCONTROL	GUEST
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16	Zsombor Óreg	Cranfield University	GUEST
17	Ede Schuller	HUNGAROCONTROL	GUEST
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19	Arife Aycan Mutlu	DHMI ATCO	GUEST
20	Panagiotis Kyriezis	Hellenic Civil Aviation Authority	GUEST
21	Peter Tormasi	HUNGAROCONTROL	GUEST
22	Fulya Aybek Cetek	Eskisehir Technical University	GUEST
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24	Elke Groeneveld	DFS	GUEST
25	Gerald Regniaud	DSNA	GUEST
26	Thimjo Koca	UAB	GUEST
27	Kiranraj Pushparaj	Nanyang Technological University	GUEST
28	Daniel Turcu	Heathrow Airport	GUEST
29	Nicolás Suárez Tetzlaff	CRIDA	GUEST
30	Patrick Schuster	Airbus	GUEST
31	Bruno Antulov Fantulih	University of Zagreb	GUEST
32	Petar Andrasi	University of Zagreb	GUEST
33	Igor Kuren	EUROCONTROL	GUEST
34	Fedja Netjasov	University of Belgrade	GUEST

#1 Introduction and Presentation of the Agenda

COTTON builds an integrated view of future Capacity Management (CM) processes by exploring how complexity assessment can help Dynamic Airspace Configuration (DAC) and Flight Centric ATC (FCA) and their integration, taking advantage of the trajectory information that is available in a Trajectory Based Operations (TBO) environment.

To achieve its objective, COTTON has assessed the suitability of the available complexity metrics to support DAC, FCA, and integrated DAC/FCA CM process. From the result of this assessment, COTTON has selected three candidate complexity metrics, namely Solution Space, Cognitive Complexity and Geometrical Complexity. It has evolved their mathematical formulation; and developed complexity–based methods to assess capacity in DAC and FCA.

COTTON proposes a complementary use of these three enhanced complexity metrics to build COTTON Complexity Assessment, which is flexible enough to support each CM sub–process; with the due granularity to address the specificities of DAC and FCA airspaces; and effective at each planning phase.

The development and integration of COTTON Complexity Assessment within the CM processes constitutes COTTON Enhanced Capacity Management, whose potential benefits are assessed in COTTON validation. The validation encompasses three exercises using fast time simulations for the evaluation of the COTTON solutions performance in the areas of: Feasibility, Capacity, Cost–efficiency, Safety and Human Performance.

Workshop Objectives

- Assess COTTON results ensuring the fulfilment of stakeholders needs.
- Identify further research and exploitation routes of COTTON outputs in Industrial Research projects.

Specifically, the following project outcomes were analysed:

- COTTON Enhanced Complexity Metrics, which better support DAC and FCA processes.
- COTTON Probabilistic Complexity for Capacity Management in ATM.
- Integration of Demand Uncertainty within Capacity Management.
- Enhanced COTTON Complexity Management to support integrated DAC/ FCA processes.

Agenda

Time	Item	Topic	
10:00 – 10:10	**0**	**Welcome and Introduction**	CRIDA
10:10 – 10:30	**1**	**COTTON as a whole**	CRIDA
10:30 – 11:00	**2**	**Enhanced Complexity Metrics to support Future Capacity Management**	ENAC/UPM
Coffee break			
11:20 – 11:50	**3**	**Enhanced Capacity Management Processes in DAC/FCA supported by Probabilistic Complexity**	ECTL/DLR
11:50 – 12:20	**4**	**Project Results and Activities Introduction**	CRIDA
Lunch break			
13:20 – 14:10	**5**	**COTTON Complexity Assessment in DAC**	
	5.1	**Activity A –** Selection DAC optimal configuration. In the short term based on Cognitive Complexity	CRIDA
	5.2	**Activity B –** Selection DAC optimal configuration in the medium term based on Geometric Complexity	ECTL
Break			
14:20 – 15:10	**6**	**COTTON Complexity Assessment in FCA**	
	6.1	**Activity C –** FCA traffic allocation in the short term based on Geometric Complexity	DLR
	6.2	**Activity D –Solution Space Demo**	TUD
15:10 – 15:35	**7**	**COTTON Complexity Assessment in integrated DAC/FCA**	
		Activity E – DAC FCA delineation based on COTTON complexity	ECTL
15:35 – 16:00		**Wrap–up**	UPM/CRIDA
End of Workshop			

#2 Questions and Answers

This section describes the questions arose during the workshop, all workshop presentations can be found in the attached .zip file.

1. COTTON as a whole

Project objectives, methodology, activities and deliverables were presented.

2. Enhanced Complexity Metrics to support Future Capacity Management

COTTON Enhanced Complexity Metrics were presented. Below, the main answers to the questions asked by workshop attendees are presented, for further detail, please check COTTON Deliverables D2.1 and/or D2.2.

- ***How do the NASA TLX/ISA values correlate with the statistical data of the complexity values of COTTON?***

  COTTON validation exercises were done with Fast Time Simulations. This means that no real-time workload values could be captured to be compared with the complexity values.

  The Cognitive Complexity metric is scaling the magnitude of its values between 1 to 5 to be easily comparable with ISA values, which have previously been calibrated (and correlated with) in Real Time Simulations in SESAR exercises. Therefore, this metric is already intrinsically taking into account the workload rating of the ATCOs.

  Within the framework of COTTON activities, a first attempt has been made to link Solution Space metric to expected workload levels. The assessment has been conducted by a Subject Matter Expert (SME) trial, where one air traffic controller was asked to rate the expected workload levels at regular time intervals during the playback of several traffic scenarios.

  Every 2 minutes in the playback of the scenarios, the controller had to rate his/her own expected workload level on a scale from 0 to 100. After the data had been gathered, a correlation analysis was done between the metric responses and the ISA ratings. Having the ISA workload ratings and the corresponding (averaged) metric values, linear Pearson correlation coefficients have been determined.

- ***How do you evaluate how much capacity (traffic) controllers can handle without affecting the safety?***

  In the validation exercises, the occurrence and severity of conflicts have been estimated, concluding in no negative impact on the safety KPA, which means that the number and severity of the conflicts are at least maintained or even reduced. This is a key aspect

linked to the threshold set up of each complexity metric. We have to find an optimal threshold for the proposed metrics in different operational environments, which is a continuous task to be done in future steps (Real Time Simulation techniques have to be used to get the human performance involved).

- ***Do we have to consider different complexity metrics for DAC and FCA solutions?***

  Indeed COTTON Solution proposes different complexity metrics for different operational environments and even for different time horizons within the same operational environment. We tried to assign the most suitable metric to each use case at each time horizon of each operational concept based on the requirements (including most important/influencing complexity generators and uncertainty implications) that each capacity management solution needs. The table below, presents the selection of COTTON Enhanced Complexity Metrics more suitable (in green) for each Capacity Management Solution and Time Horizon.

SELECTED METRIC	Long Term	Medium Term	Short Term
Dynamic Airspace Configuration	GEOMETRICAL APPR. COGNITIVE COMPLEXITY	COGNITIVE COMPLEXITY GEOMETRICAL APPR. SOLUTION SPACE	SOLUTION SPACE COGNITIVE COMPLEXITY GEOMETRICAL APPR.
Flight Centric ATC	GEOMETRICAL APPR. COGNITIVE COMPLEXITY	COGNITIVE COMPLEXITY GEOMETRICAL APPR. SOLUTION SPACE	SOLUTION SPACE COGNITIVE COMPLEXITY GEOMETRICAL APPR.

- ***In case a conflict is managed by two FCA controllers, there is an impact on complexity. Does COTTON consider it?***

  COTTON is aware from the beginning of the need to afford complexity assessment adapted to the concept (i.e. DAC, FCA specificities) and the consideration of these kind of complexity requirements is the motivation for COTTON to exist. At the first stage of the project, we identified this (together with other) requirements to support the development of complexity metrics to ensure that the actually support capacity management. Nevertheless, due to the mathematical difficulty to implement this, this improvement was not one of the improvements implemented in COTTON metrics algorithms. Being this one of the key aspects to be considered in future research.

3. Enhanced Capacity Management Processes in DAC/FCA supported by Probabilistic Complexity

COTTON Enhanced Capacity Management were presented. Below, the main answers to the questions asked by workshop attendees are described, for further detail, please check COTTON Deliverables D3.1.

- ***How much additional capacity and cost efficiency is achieved with integrated DAC/FCA solution?***

  The number of overloads is reduced without increment of the ATCO control hours compared with a pure DAC solution. This means that with the same number of controllers, they can handle the same traffic without declaring any hotspot, which also means that they would have been able to handle more traffic.

- ***Currently there is also a problem of 'unused' capacity due to the implementation of Capacity Buffers. Does COTTON address this problem?***

  The consideration of uncertainty as well as the use of more suitable complexity metrics are expected to allow for a more reliable complexity metric, thus better estimating capacity. COTTON validation exercises proves in fact a better prediction of overloads. This should allow the reduction of capacity buffers.

  On the other hand, a better identification of underload would enable a better use of capacity. Nevertheless, the main focus of the project was on the avoidance of the overloads. In any case, the underloads are measured in the validation exercises to be captured for future improvements of the enhanced capacity management processes.

- ***How have the capacity/complexity thresholds been set?***

  For the Cognitive complexity metric, the threshold was set over the 1 to 5 scale of the metric magnitude. This is easily done because this metrics is intrinsic to ISA values and the threshold is set to approximately a 70% of the maximum value by definition of the workload ranges of the ISA values.

  Geometric Complexity used a second approach to estimate reference value of the capacity based on historical traffic and sectorization data. The approach is based on the hypothesis that computed complexity of realized traffic situation in the active sector should be considered as acceptable, since controllers were able to control it. Using this approach, it is possible to compute historical 'acceptable' traffic complexity values and based on them identify referent value for the capacity. Moreover, it assumes that actual sector regulation happened since Flow Manager found a situation difficult-complex to manage by the controller.

- ***How do you consider military airspace in FCA allocation?***

Military Airspace has not been considered neither simulated in COTTON activities.

4. Project Results and Activities Introduction

Main project results were introduced. Below, the main answers to the questions asked by workshop attendees are presented, for further detail, please check COTTON Deliverables D4.2 and/or D5.3.

- ***Why does COTTON use different approaches to evaluate complexity in DAC short term and medium term exercises?***

  COTTON identifies the complexity metrics that, according to their granularity and capability to account for certain complexity generators, are more suitable to support each capacity management process at each planning phase. Even though COTTON recognises the value of using the same complexity metric at every timeframe, it has opt for scoping exercise validation focusing on the application of the most promising complexity metrics per timeframe in order validate COTTON hypothesis with the optimal use of resources and time.

5. COTTON Complexity Assessment in DAC

5.1 Short Term. Cognitive Complexity

An example of COTTON solution application to support DAC Short term processes as validated in COTTON exercise was presented. For further detail, please check COTTON Deliverable D4.1 and D4.2.

- ***Why are not we predicting the overload at the same time horizon but with a time lag?***

  COTTON does not use integrates all types of uncertainty but time uncertainty. This decision was made based on the maturity of the available demand models which, in the majority of the cases was not sufficient to be integrated within the complexity calculation algorithms. Future research should integrate more sophisticated demand uncertainty models to ensure that all types of uncertainty are considered.

5.2 Medium Term. Geometric Complexity

COTTON solution application to support DAC medium to short term processes using RNEST tool was presented. For further detail, please check COTTON Deliverable D4.1 and D4.2.

6. COTTON Complexity Assessment in FCA

6.1 Short Term. Geometric Complexity

- ***Does this new concept require changes in airborne equipment?***

  This concept matter has not been explicitly analysed by COTTON, nevertheless we can say that SESAR PJ10 seems not to have identified this requirement.

- ***How have trajectory allocation been performed in COTTON validation exercise?***

  Geometric Complexity Metric has been developed to support allocation purposes. This algorithm was inserted in DLR's simulation platform. FTS of one-hour traffic scenarios were conducted to assess the current workload of each (simulated) ATCO in intervals of one minute, which of course depended on the traffic that had been allocated to each (simulated) controller by the allocation algorithms. Allocation always took place 10

minutes before an aircraft entered the airspace and for workload prediction, the algorithms used the traffic situation as known at the time of allocation.

6.2 Solution Space DEMO

- ***Does this metric consider vertical profile and time uncertainty?***

  Currently, these parameters are not taken into account, only the lateral solution space is calculated. TU Delft is working on the inclusion of wind and uncertainty to improve the metric suitability for the allocation of flights inside FCA solution.

7. COTTON Complexity Assessment in integrated DAC/FCA

- ***What are the next steps of this new concept?***

  ATFCM short-term planning should be integrated with the ATC planning in the frame of INAP both for DAC and combined DAC / FCA.

  Procedures and more sophisticated tools for manpower (ATCO) planning and rostering should be put in place to enable full benefit of Complexity prediction based DAC and combined DAC and FCA.

  RTS should be performed in order to validate further thresholds and the buffers used for decision making.

  Allocation and Re-allocation process used in FCA should be fully integrated with the DAC processes in order to explore the potential benefits.