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WP8 –A^3 ConOps Refinement

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EC DG-TREN iFLY Project

Brussels, Sep 29, 2009

Agenda

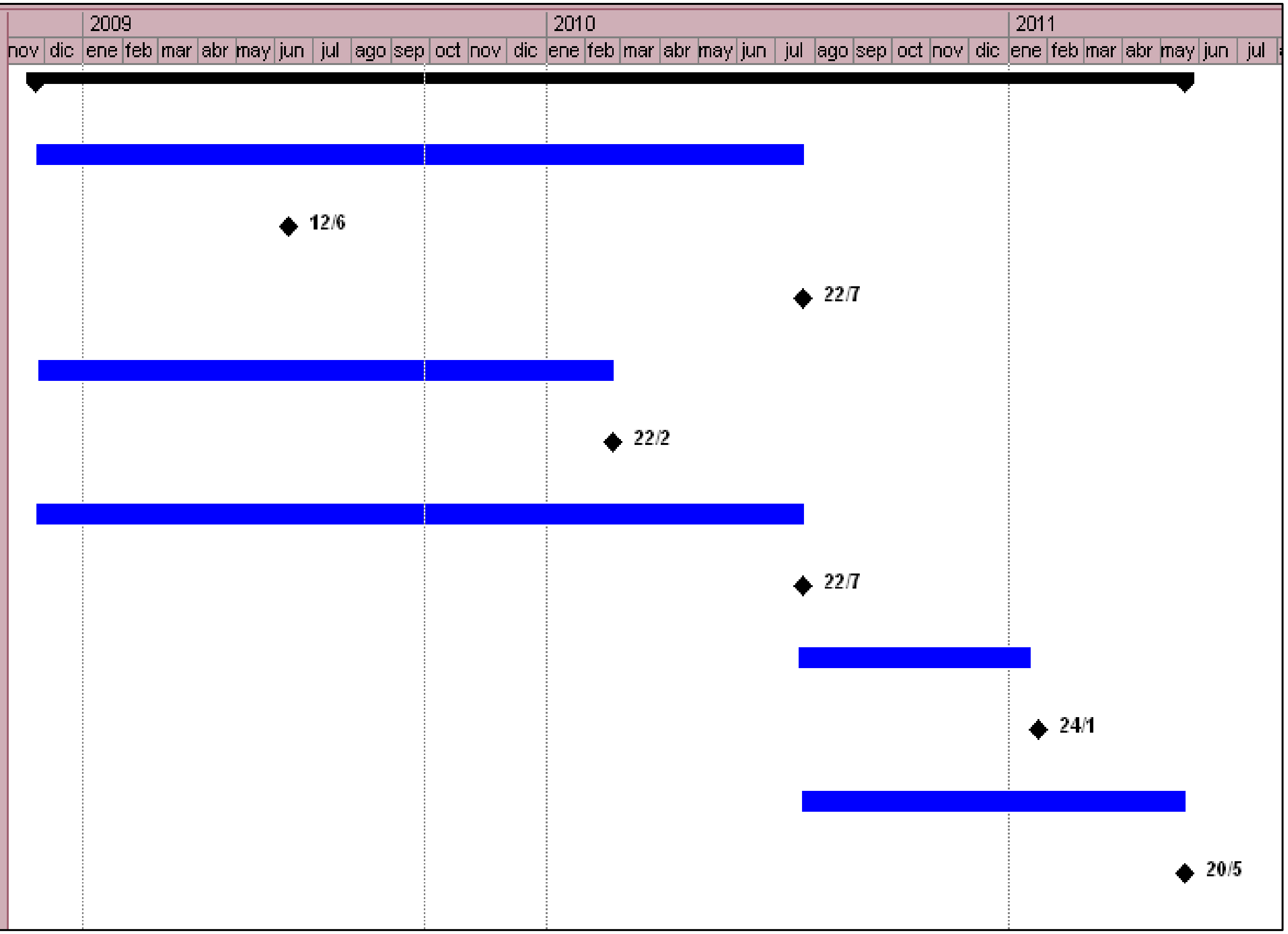
- Outlook on Work Package 8 Activities
- D8.1i Intermediate A^3 Concept of Operations

WP8

WP8.1: Integration of mathematical results	**Isdefe**
WP8.2: Distributed Air Traffic Flow Management Concept	**NLR**
WP8.3: A^3 equipped aircraft within the SESAR	**Isdefe**
WP8.4: Non-airborne Requirements in support of A^3 equipped aircraft.	**Isdefe**
WP8.5: Potential mitigating measures of bottlenecks.	**Isdefe**

WP8 Gantt

Work Package	Beginning	Deadline
WP8 A3 ConOps refinement	mar 25/11/08	vie 20/5/11
WP8.1 Integration of mathematical results	mar 25/11/08	jue 22/7/10
D8.1.i Intermediate report of A3 ConOps refinement	vie 12/6/09	vie 12/6/09
D8.1 A3 ConOps refinement report	jue 22/7/10	jue 22/7/10
WP8.2 Distributed Air Traffic Flow Management	mié 26/11/08	lun 22/2/10
D8.2 Distributed Air Traffic Flow Management Concept	lun 22/2/10	lun 22/2/10
WP8.3 A3 equipped aircraft within SESAR	mar 25/11/08	jue 22/7/10
D8.3 A3 and SESAR report	jue 22/7/10	jue 22/7/10
WP8.4 Non-airborne Requirements in support of	lun 19/7/10	lun 17/1/11
D8.4 Non-airborne requirements for A3	lun 24/1/11	lun 24/1/11
WP8.5 Potential mitigating measures of bottlenecks	jue 22/7/10	vie 20/5/11
D8.5 Potential mitigating measures of bottlenecks	vie 20/5/11	vie 20/5/11



ongoing Sub-WP

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- WP8.1: Integration of mathematical results.

  This WP develops a updated version of the A^3 ConOps considering the outcomes of the WP3, WP4 and WP5, as well as feedback from WP2 and WP9.

- WP8.2 Distributed Air Traffic Flow Management Concept

  This WP describes an air traffic flow management concept which builds upon the philosophy behind autonomous aircraft operations and breaks away from the centralised doctrine of current flow management.

- WP8.3: Vision of A^3 equipped aircraft within the SESAR settings.

  WP8.3 develops a vision how the gradual increase of A3 equipped aircraft within SESAR setting should fit best

WP8.1 Tasks

- WP8.1: Integration of mathematical results.

Task – WP8.1.1 Integration of results WP3
“Prediction of complex traffic conditions”

Task – WP8.1.2 Integration of results WP4
“Multi-agent Situation Awarness consistency analysis”

Task – WP8.1.3 Integration of results WP5
“Pushing the limits of conflict resolution algorithms”

D8.1i.Intermediate Report of A^3 ConOps refinement.

Task – WP8.1.4 Integration the results

D8.1.A^3 ConOps Refinement

WP8.2 Tasks

- WP8.2: Distributed Air Traffic Flow Management Concept.

Task – WP8.2.1.Description of A3 ATM environment for ATFM.

Task – WP8.2.2.Indentification of problem areas of ATFM and possible solutions in A3 environment.

Task – WP8.2.3.Develpment of ATFM concept building on advantageous of A3 operations.

D8.2.Distributed Air Traffic Flow Management Concept

WP8.3 Tasks

- WP8.3: Vision of A3 equipped aircraft within the SESAR settings.

Task WP8.3.1 Analysis of A^3 ConOps impact on strategic ATM.

Work Document: Analysis of A^3 ConOps impact on strategic ATM

Task WP8.3.2 Vision of A^3 equipped aircraft within the SESAR setting

D8.3. A^3 equipped aircraft within SESAR

Status of WP8

WP8.1: Analysis of A3 ConOps impact on strategic ATM.	
D8.1i. Intermediate Report of A^3 ConOps refinement.	Submitted end of July
D8.1. A^3 ConOps Refinement	Final Report: July/2010
WP8.2: Distributed Air Traffic Flow Management Concept.	
D8.2 Distributed Air Traffic Management Concept	February/2010
WP8.3: Vision of A3 equipped aircraft within the SESAR settings.	
D8.3 Work Document: A^3 equipped Aircraft within SESAR	October/2009
D8.3. A^3 equipped Aircraft within SESAR	Final Report: July/2010

Next steps

- WP8.1.
  - WP8.1 Internal meeting
  - Results integration
  - Development of the D8.1
- WP8.2.
  - Identification of possible solutions in A^3 environment for identified problem areas of ATFM
  - Developement of ATFM concept
  - Development of D8.2
- WP8.3.
  - Revision Process of the D8.3.Work Document
  - Considering Results of WP8.2 : Integrating ATFM
  - Description of A3 equipped aircraft within SESAR

Layout D8.1i

- **Section 1. Introduction.**
- **Section 2. A3 ConOps in D.1.3.** This section resumes the results obtained in the D.1.3
- **Section 3. Complexity metrics for autonomous aircraft.** This section summarizes the results that have been obtained in the deliverables 3.1 and 3.2i.
- **Section 4. Multi-agent situation awareness.** This section explains the work that has done in the WP4.1. Further investigations will provide results for the refinement of the A^3 ConOps in the WP8.
- **Section 5. Conflict resolution.** This section resumes the results obtained in the deliverables 5.1, 5.2 and 5.3i.
- **Section 6**. **Concluding remarks.** This section summarizes the objective of this report and the follow-on work on refining the A^3 ConOps within the WP8.
- **Section 7. References.** This section provides a list of references.
- **Section 8. Appendices.** This section provides an acronyms list.

Section 3: Complexity metrics for autonomous aircraft

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The concept of air traffic complexity can be particularly useful in the iFly A^3 ConOps to assess and predict traffic conditions that may be over-demanding to the autonomous aircraft design

D3.1. Report on complexity metrics applicable to autonomous aircraft.

Existing approaches to air traffic complexity evaluation and prediction are reviewed and critically analyzed in terms of their capabilities and limitations from a general advanced autonomous aircraft perspective (see the tabular classification).

Section 3: Complexity metrics for autonomous aircraft

metric	required data	output type	time horizon	control-dependent	sector-based	dependent on air traffic organization	computational load
aircraft density	number of aircraft in the sector	aggregate indicator (time dependent)	short term (extendable with trajectory prediction)	yes (through the threshold on the number of aircraft)	yes	no	small
dynamic density	number of aircraft and other aggregate indicators of traffic distribution and aircraft changing geometries, sampled over 1 minute	aggregate indicator (time dependent)	short term (extendable with trajectory prediction)	yes (the relative weights of the complexity factors are workload dependent)	yes (through the complexity factors and their relative weights)	partially	significant when defining the relative weights, small in the on-line usage
interval complexity	number of aircraft and other aggregate indicators of traffic distribution, sampled over 20–90 minutes	aggregate indicator (time dependent)	medium/long term	yes (the relative weights of the complexity factors are workload dependent)	yes (through the complexity factors and their relative weights)	slightly	significant when defining the relative weights, medium in on-line usage (trajectory prediction is needed)
fractal dimension	aircraft trajectories	aggregate indicator	long term	no	no	yes	significant
input-output model	aircraft trajectories	complexity map, representing the control effort to accommodate a new aircraft as a function of its initial conditions	short/medium term	yes	no	yes, indirectly	high
intrinsic metric based on Lyapunov exponents	aircraft trajectories	complexity map representing the largest Lyapunov exponent as a function of space	short/medium/long term	no	no	yes	high

Classification of the approaches to air traffic complexity

D3.2i. Intermediate report on timely prediction of complex conditions for en-route aircraft.

Long term complexity metrics are based on the aircraft RBTs, with the understanding that each aircraft should generally conform to its current RBT. They will be useful for trajectory management purposes.

Mid term complexity metrics are based on the aircraft state and intent information. They will support the mid term conflict detection (CD) and conflict resolution (CR) functions.

Section 4: Multi-agent situation awarness

D4.1. Report on hybrid models and critical observer synthesis for multi-agent situation awareness.

D4.2i. Intermediate report on compositionality properties of critical observability.

Section 5: Conflict resolution

- Long term CR:
  - Traffic Flow Management Algorithms: Use existing TFM methods and replace metrics such as sector capacity with A^3 relevant complexity metrics
  - Trajectory Management: Extend the use of Mid Term CR algorithms to longer horizons, solving online congestions, instead of conflicts.

- Mid term CR: Use of Decentralized Model Predictive Control (MPC)

- Short term CR: Use Navigation Functions. Combined with mid-term MPC to provide preview, ensuring manoeuvre feasibility and improved performance. The short-term CD&R should be able to suggest one or more simple maneuvers, for the crew to select

Section 5: Conflict resolution

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Feature	ConOps Requirement D1.3	Robust decentralized MPC
Look-ahead time	15–20 minutes	Requirement met
Coordination	Not required	Not required
Principle of use	Intent	Requirement met
Priority rules	Yes	Only used in case of communications failure
Secondary conflict creation	Do not	None created
2-minute state vector conflict	Avoid	Not addressed yet No problem in principle
Type of resolution algorithm	Intent-based	Intent-based
Alternative resolutions	Should provide	Not provided yet

Comparison of ConOps requirements and properties of the robust decentralized MPC algorithm for mid-term conflict resolution

Section 5: Conflict resolution

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Feature	ConOps Requirement D1.3	MPC&NF
Look-ahead time	12 – 20 minutes	15 – 20 minutes
Coordination	Not required	None
Priority rules	Yes	Yes
Secondary conflict creation	Do not	Avoided
Type of resolution algorithm	Intent-based	Intent-based
Alternative resolutions	Should provide	Can provide

Comparison of ConOps requirements and properties of the combined MPC&NF algorithm for mid-term conflict resolution

THANKS FOR YOUR ATTENTION