

# *Mastering Complex Systems Safely*







***Promoting a new research field  
within ATM***



# ***Goals***



***Cross-fertilisation***

***State of the Art***

***Research challenges & Impact***

***Momentum***



***How?***



***Research Coordination***

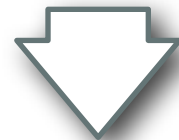
***Knowledge Dev***

***Research Network Dev***

***PhD Programme***



***Knowledge Dev***  
***Working Method Year 1***



***Direct input from members***  
***Working Groups***



# ***Working Groups***

Athens University of Economics & Business - Research Center (AUEB)

Chinese University of Hong Kong

Ecole Nationale de l'Aviation Civile (ENAC)

École Polytechnique / Institut des Systèmes Complexes de Paris-Île de France

ETH Zurich

Friedrich-Alexander University Erlangen Nurnberg

HCF - Human-Factors-Consult GmbH

Kiev National Aviation University

Linköping University

National Technical University of Athens (NTUA)

Polytechnical University of Madrid (UPM)

TU Braunschweig

TU of Catalonia

TU Darmstadt

TU Delft

TU Dresden

TU Harburg

Universidad Autónoma de Barcelona

University of Belgrade

University of Catania

University of Hannover

University of Helsinki

University of L'Aquila

University of Leicester

University of Melbourne

University of Milano-Bicocca

University of Naples- Parthenope

University of Porto, LIACC/NIADR, TAP Portugal

University of Salzburg

Uppsala University

University Rey Juan Carlos

Vilnius University

Vrije Universiteit Amsterdam



# ***Working Groups***

AERTEC

Airspace Management Strategies Inc.

ALG Indra

ASDA

Atos Origin

BluSky Services Group

Boeing

Capgemini Sud

CATEC

CIRA

CRIDA

CTAE

Deep Blue

DSE Consulting LTD

EASA

EATRADA

FAA

GMV Aerospace and Defence S.A.U

GMVIS Skysoft S.A.

Hafner Engineering, LLC

Helios

Honeywell

IDS Ingegneria Dei Sistemi S.p.A

Integrasys S.A.

ISI Foundation

ISDEFE

Jeppesen

Lufthansa Systems

NASA

NextGen AeroSciences, LLC

Onera

Research Executive Agency (REA)- European Commission

Roke Manor Research

SINTEF

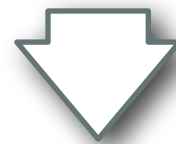
Slot Consulting

TCP

To70



# ***Working Groups Year 1 participants***



***Characterisation of disturbances***

***Resilience***

***Information Management***

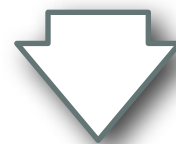
***Data Sources***



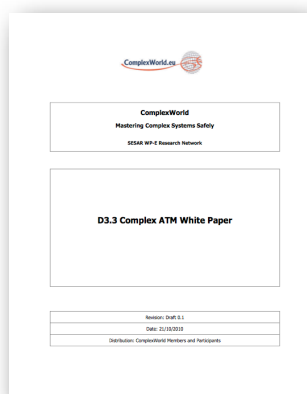
# ***Working Groups Year 1***



***Direct input from members  
Working Groups***

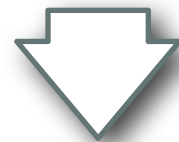


# ***Complex ATM Position Paper***





***Vision Nov.2011***

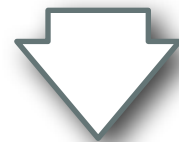


***Reference in Complexity Research in Air Transport  
Position Paper***

***The main Scientific Result of the Network  
The main Network Challenge***



***Vision Nov.2011***



***Reference in Complexity Research in Air Transport***

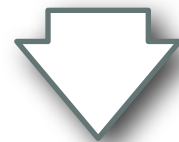
***Position Paper***

**+**

***Network Conference***



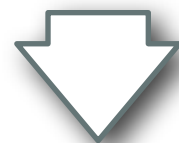
***Vision Nov.2011***



***Reference in Complexity Research in Air Transport***

***Position Paper***

***Network Conference***



***Working Method Year 2***



**2010**

***Issue 0.1***

**2011**

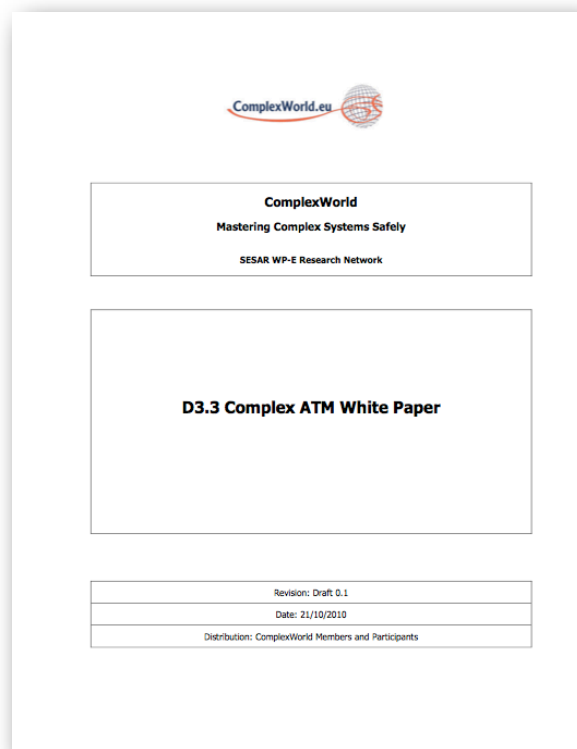
***Issue 1***

**2012**

***Issue 2***

**2013**

***Issue 3***



***WP.E Projects***

***PhDs***

***WP.E Projects***

***PhDs***



# ***Complex ATM Position Paper***



# ***Complex ATM Position Paper***



## ***Foundations***

# ***Foundations***



- 1 State of the art
  - Definition & Concepts
  - Tools and Techniques
  - Gaps, challenges, barriers
- 2 Research Threads



# *Foundations*



*Multiple Spatio-Temporal Scales*

*Non-determinism and Uncertainty*

*Emergent Behaviour*



# ***Complex ATM Position Paper***



## ***Foundations***

### ***Modelling and Managing Complexity***



# ***Complex ATM Position Paper***



## ***Foundations***

## ***Modelling and Managing Complexity***

## ***Improving ATM Performance***



*Improving ATM Performance*



*Open Questions*  
*Potential Applications*



# ***Complex ATM Position Paper***



***Foundations***

***Modelling and Managing Complexity***

***Improving ATM Performance***



***Thanks,***

***David - [dp@innaxis.org](mailto:dp@innaxis.org)  
ComplexWorld.eu***



# **ComplexWorld Network**

## **Mastering Complex Systems Safely**

**Damián Rivas, University of Seville**

SESAR Innovation Days  
ENAC, Toulouse, 29/11 – 1/12, 2011



# ComplexWorld Network (2)

## OUTLINE

- ComplexWorld Annual Conferences
- PhD Programme



# 1st COMPLEXWORLD ANNUAL CONFERENCE

Complexity and Air Traffic Management

6 - 7 July 2011

ETSI - Universidad de Sevilla  
Sevilla, Spain



# 1st ComplexWorld Annual Conference

Attendees:

50 people from 9 countries

(France, Germany, Italy, The Netherlands, Turkey, Spain, Sweden, UK, USA)

# 1st ComplexWorld Annual Conference

## PROGRAMME SUMMARY

- OPENING SESSION
- KEYNOTE PRESENTATIONS (Invited Speakers)
  - Sherry Borener, FAA
  - Stefano Boccaletti, UPM
- SESSIONS ON ATM / COMPLEXITY SCIENCE
  - 5 presentations
- SESSIONS ON WP-E PhDs
  - 5 presentations
- SESSION ON RESILIENCE
  - 3 presentations
- ASDA Presentation
- CLOSING SESSION

# 1st ComplexWorld Annual Conference

## Results from the survey

### Positives

- Conference Location
- Agenda
- Speakers
- Networking Opportunities
- Relevancy of Invited Speakers
- Overall Conference / Interest in next ComplexWorld event

### Drawbacks

- Lack of communication regarding transportation
- Preference over a more centralised location, such as Madrid.
- Quality of PhD presentations
- Need additional coverage on topics such as:
- Connection of ATM and Complexity Research
- Applications of complexity research for ATM challenges

# 2nd ComplexWorld Annual Conference

- 2nd ComplexWorld Annual Conference, June 2012? Seville, Madrid?  
(including Tutorial Sessions for PhD candidates)

# PhD Programme

7 PhDs funded by SESAR WP-E  
(6 have already started)

# Intelligent Modelling the Impact of Unpredictable Adverse Weather on ATM Performance

PhD candidate: **Manuela Sauer**

PhD supervisor: **Thomas Hauf**

**Leibniz University of Hannover**, Institute of Meteorology and Climatology

Development of an algorithm DIVMET which...

- simulates the CDM of pilot and ATC
- proposes a realistic route through a field of adverse weather e.g. thunderstorms
- extends existing air traffic models by the effect of adverse weather

Identify worst case weather scenarios

- Benefit of additional environmental weather knowledge?
- Optimum solution?

Evolving complexity with multi-aircraft safety related interactions

Guidance for ATC

# Uncertainty Models for Optimal and Robust ATM Schedules

PhD candidate: **Andreas Heidt**

PhD supervisor: **Prof. Dr. Alexander Martin**

Institution: **Friedrich-Alexander-University Erlangen-Nuremberg**

## Research Challenge:

The research will identify possible sources of uncertainty and non-determinism in ATM. A typical result would be a schedule that would be extremely robust to changes described by the uncertainty set and will support the building activity of a true performance-driven ATM system by allowing the development of a set of performance metrics that incorporate uncertainty and accuracy as part of their definition.



EDOM  
Economics · Discrete  
Optimization · Mathematics



# Data Mining Applied to Aviation Data

PhD Candidate: **David Estébanez Gallo**

PhD Supervisor: **Ernestina Menasalvas Ruiz**

Institution: Universidad Politécnica de Madrid

**Research Challenge:** Data mining of flight information related databases (ASRS, FOQA, ...) in order to obtain patterns and relationships that can help to improve aviation safety. To fulfill the goal, semantic enrichment of the available datasets, preprocessing and integration of different data sources will be required.

# Assessing Airport Performance through Complexity Science

PhD Candidate: **Soufiane Bouarfa**

PhD Supervisor: **Richard Curran**

Institution: Delft University of Technology

**Research Challenge:** Due to the limitation of airport performance assessment, for which many models have been developed to reflect augmented knowledge about specific performance criteria, decision-making has been very complex. This research explores a multi-disciplinary approach to model the airport emerging performance and make tradeoffs among multiple performance objectives.

# Analysis of air transportation using complex networks

PhD Candidate: **Pablo Fleurquin**

PhD Supervisor: **Jose Javier Ramasco & Maxi San Miguel**

Institution: Universitat Illes Balears, IFISC

**Research Challenge:** The objective is to extend the use of graph theory addressing problems such as the delay propagation in a single company or multi-company scheduling or the optimization of flux of passengers from origin to destination. The final aim is to propose a new theoretical framework based on network theory to model and optimize the organization of passenger fluxes and flight schedules.

# Interlevel Relations between Models within Air Traffic Management

PhD Candidate: **Nataliya Mogle**

PhD Supervisor: **Jan Treur**

Institution: VU Amsterdam

**Research Challenge:** The main objective is to establish interlevel relations between the different models described in the ATM literature. The project proposes to address this question from a computational modeling perspective, by defining explicit interlevel relations between computational models at different levels.

The end product of the project will be a library of models and interlevel relations describing the ATM system at different levels of abstraction, which can be used to identify the required skills and characteristics for human and software agents involved in ATM processes.

