

Model Based Architecting for evolutionary design of Systems of Systems (SoS)

SoS Research activities at Airbus Group Innovations

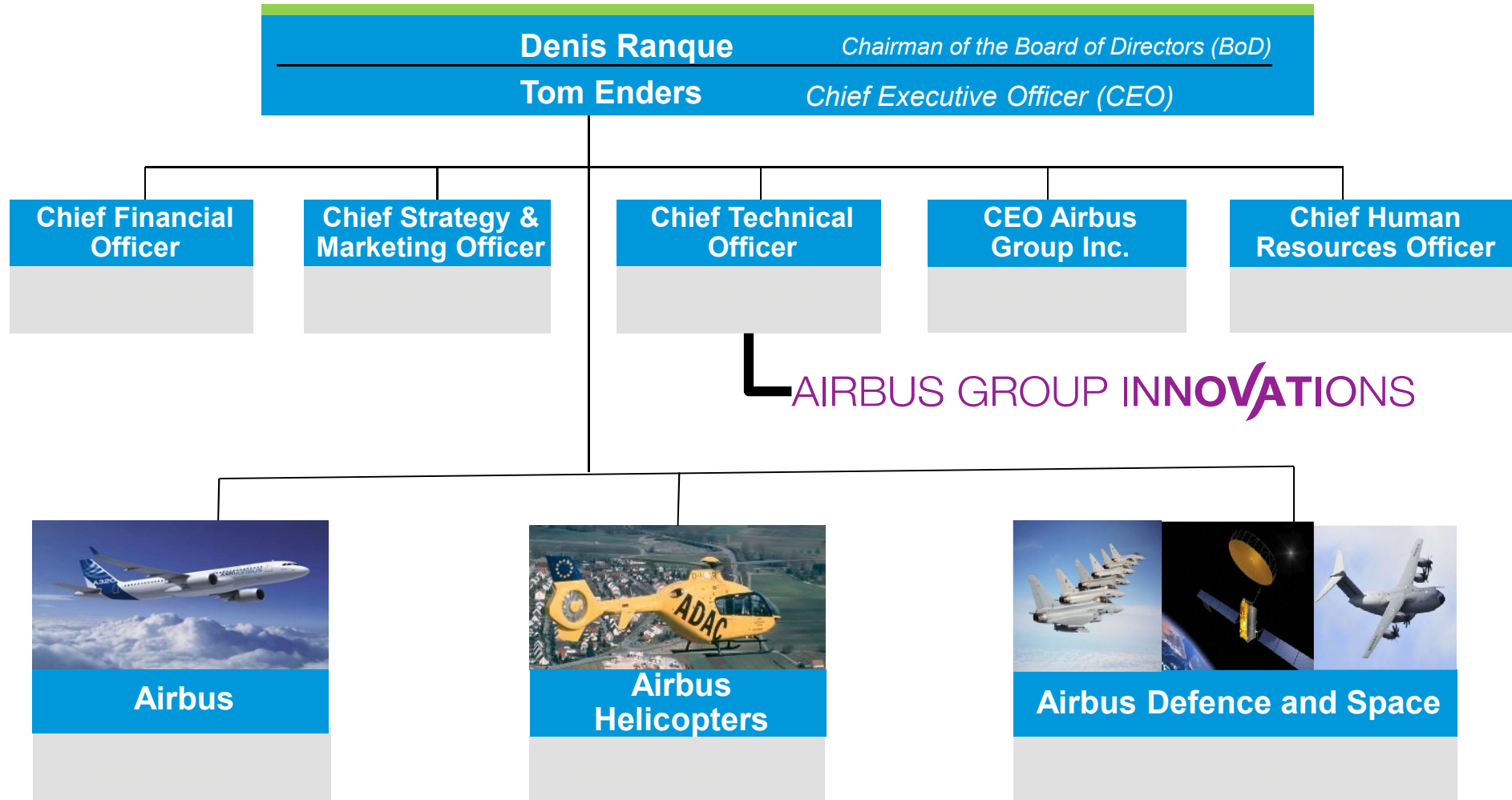
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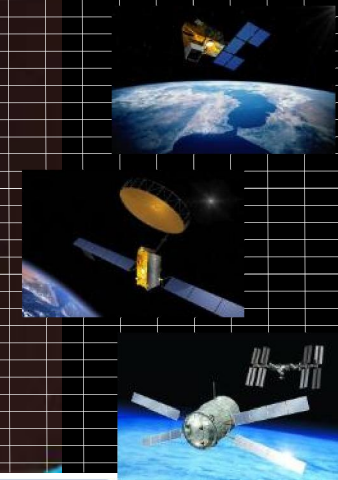
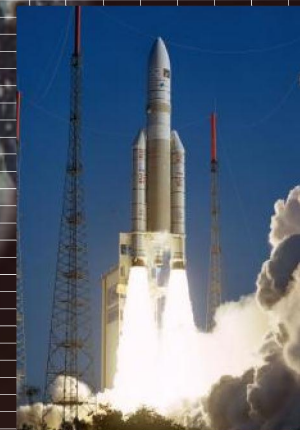
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WHO WE ARE

Airbus Group Top Management Structure



Airbus Group – Complex Products



The interaction of the operating systems and their environment is playing an increasingly important role



Why do we care about Urban Mobility?



Urban Mobility – A System of Systems

A System is a "System of Systems" if it exhibits significant amounts of:

- **Emergent behavior** - SoS performs functions not achievable by the independent component systems
- **Geographic distribution** - geographic extent forces the elements to exchange information in a remote way
- **Evolutionary development** - functions and purposes are added, removed and modified in an ongoing way
- **Operational independence** - component systems have purpose even if detached
- **Managerial independence** - component systems are developed and managed for their own purposes

Mark Maier 1998, *Architecting Principles for SoS*, Systems Engineering (INCOSE)

SoS Design Challenges

SoS Engineering

- SoS Evolution
- Frequent/ continuous changes and additional system functions along the operational lifecycle
- Adaptive Systems: Reconfigurable, modular, flexible...

Enabling Systems Integration

- Distributed applications on different organisations & sites
- Several kinds of databases and formats
- Access to information
- Interoperability and availability of global and/ or partial models for joint analysis



Model Based System Design at Airbus Group

a glimpse of SoA

Model Based System Engineering (MBSE) is 'is the formalized application of modelling to support system requirements, design, analysis, verification and validation, beginning in the conceptual design phase and continuing throughout development and later life cycle phases' (INCOSE).

State of the Art at Airbus Group:

- **SoS Level**

- *Architecture Frameworks (DoDAF, MODAF, NAF and lots of customized derivatives)*
- *Mostly static ("Pictures")*
- *What about SoS characteristics: managerial & operational independence, continuous evolution of constituent systems (and many more...)*

- **System Level** (OMG SysML, Modelica, ModelicaML)

- *Static Architecture definition*
- *Functional and Logical behaviour specification and simulation*
- *Model in the Loop analysis (MiL)*
- *Formal Model Checking (static analysis of system architectures)*
- *Interface specification + compatibility analysis*

- **Software Level**

- *Timing analysis for Realtime Systems (OMG MARTE)*
- *Formal verification & analysis*



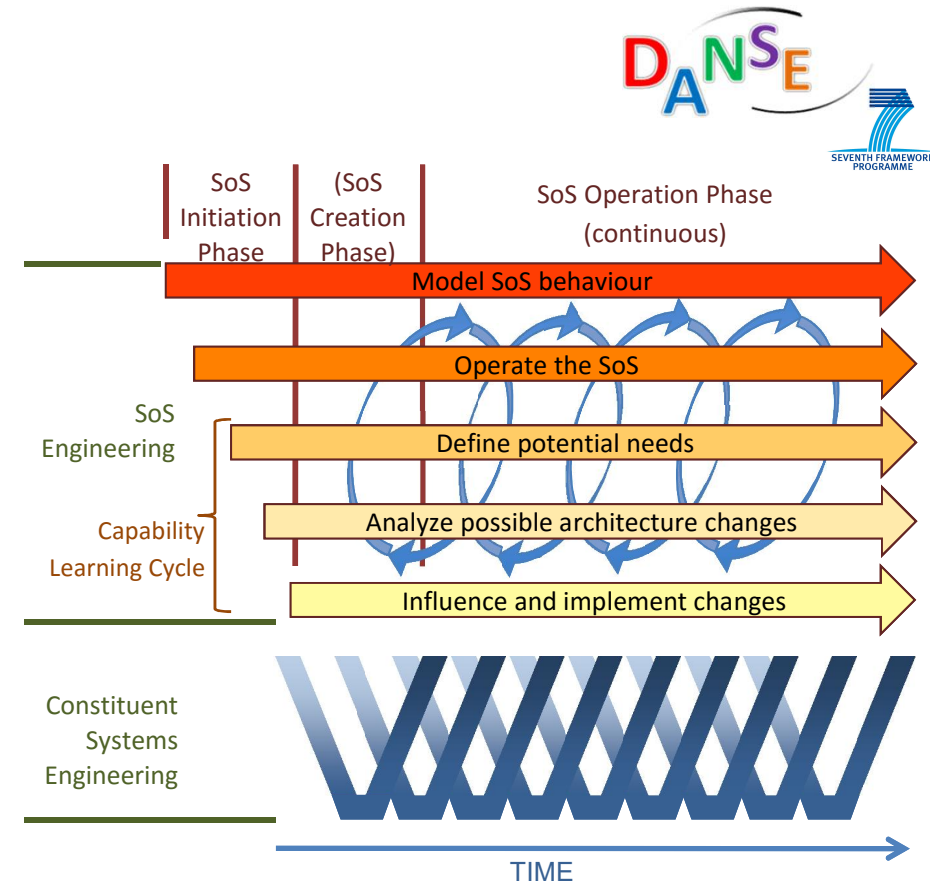
**Capitalize from
existing MBSE
SoA**

Enhancement to existing Model-Based Architecting Frameworks supporting the SoS Engineering Lifecycle

DANSE* Project:

- Extend current MBSE (model based systems engineering) practices in the frame of applying Architecture Frameworks (“AF”, such as NAF, MODAF, DoDAF) using **UPDM**™ as a reference for implementation
- Consider specific characteristics of Systems of Systems (managerial and operational independence, SoS evolution/ dynamicity, etc.)
- Make use of AF Models as direct input to analysis and simulation activities supporting early design verification (and during acquisition)

➤ Take a look at our incubators!



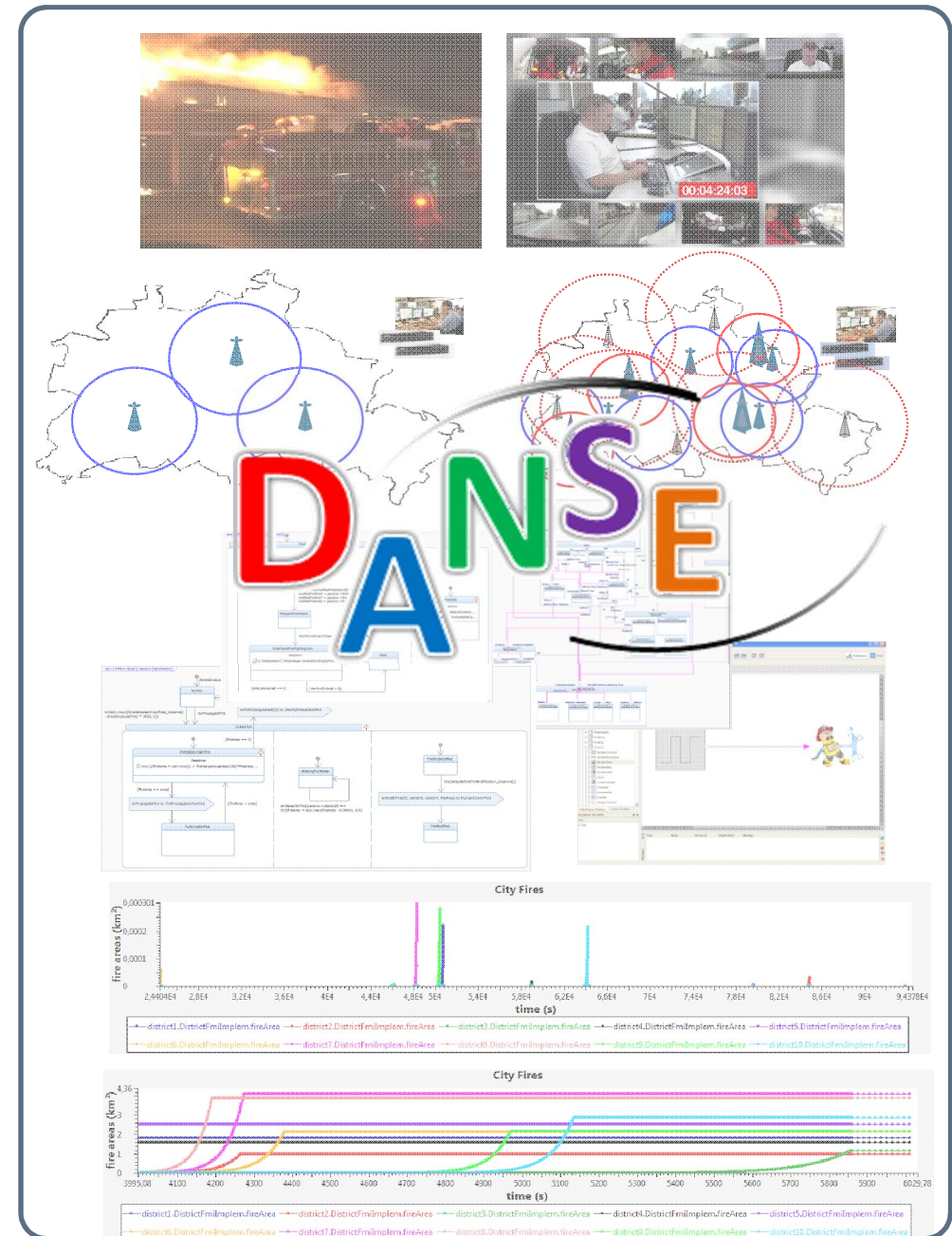
www.danse-ip.eu

*Designing for Adaptability and evolution in System of systems Engineering

DANSE Results

Model-Based SoS Architecting Methodology, incl. methods for:

1. Architecture Trade Off
 - Concise Modelling Technique
2. Timing Analysis
 - Enrich modelling profiles with real time characteristics
3. (Emergent) Behaviour Simulation
 - Integrated simulation of heterogeneous discrete and continuous models
4. Conflicting Goals Detection
 - Use of formalisation techniques and languages
5. Extended SoS Architecting Tool Chain



Next Steps/ Future Challenges

Europe's leading industries shall be able to drive future key disruptive innovations in the area of Urban Mobility and need to be able to anticipate to rapidly changing market needs!

This requires further improvement of:

- **SoS Architecture Adaptability**
 - (re)configurable, modular, flexible, robust
 - responsiveness to changing market needs
- **SoS Architecture Consistency**
 - Manage Models over Lifetime
 - Handle incremental deployment
- **Address safety and security at the same time**

