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Consultation on "Complex Systems Engineering towards System-of-Systems“

An industry viewpoint on SoS challenges

Brussels, September 22nd 2011

TRT-Fr/KTD-SYS/JLG,11-0002

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Aim

Provide an industry viewpoint after some years of experience of SoS. In particular:

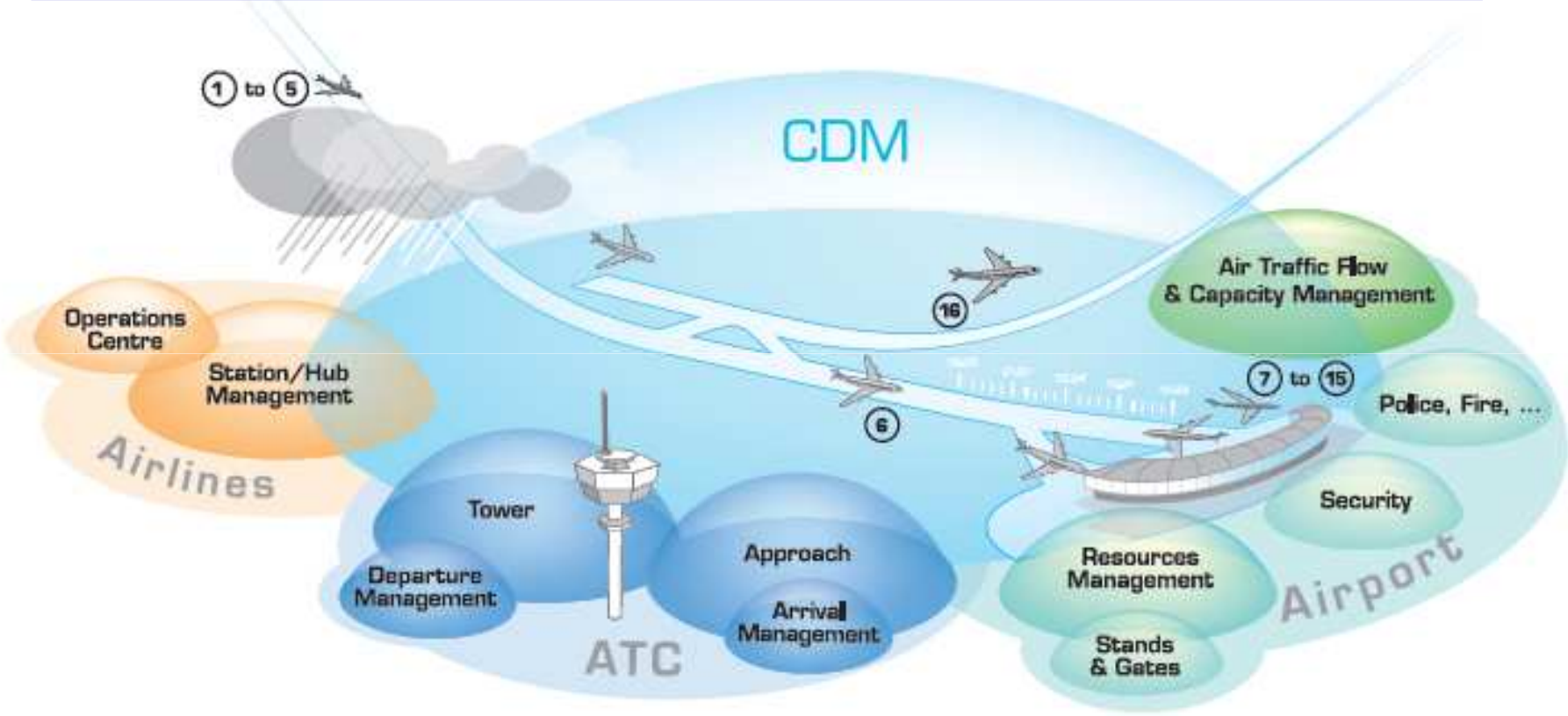
- Federation of Land Command Information Systems (DGA)
- ESA SoS RM
- G-MOSAIC European Project (E.C & ESA):
  - (Global Monitoring for Environment and Security) GMES services for Management of Operations, Situation Awareness and Intelligence for regional Crises.
- ISyCri (Interoperability of Systems in Crisis situation) (ANR)
- Architecting of the French Land Tactical Force (SCORPION-DGA)
- SESAR (Single European Sky ATM Research): methodology for European ATM Enterprise Architecture

Challenges regarding System of systems (Complex systems also)

References to "Cooperation, Theme 3, ICT" document (ref. E.C. C(2010)4900)

An example with Air Operations

Make several systems working together and get synergy towards common objectives: end-to-end services, traffic, energy, time, etc.



Implementation of SoS is already started [more or less known as such]
Any ICT progress can be transformed rapidly into a benefit.

Some definitions (but many others exist)

- A **system** is an integrated set of elements, subsystems, or assemblies that accomplish a defined objective. These elements include products (hardware, software, firmware), processes, people, information, techniques, facilities, services, and other support elements. (INCOSE SE Handbook, v3.2, 2010)
- A **capability** is the ability to achieve a desired Effect under specified standards and conditions through combinations of ways and means to perform a set of tasks (CJCSM 3170.01B, May 11, 2005).
- **SoS** is defined as a **set of arrangement of systems** that results when **independent** and useful systems are integrated into a larger system that delivers unique **capabilities** (Defence Acquisition Guide Book ch.4).

SoS definition is towards tangible business/operational objectives and socio-technical issues.

Some agreed bases… but far from being formal

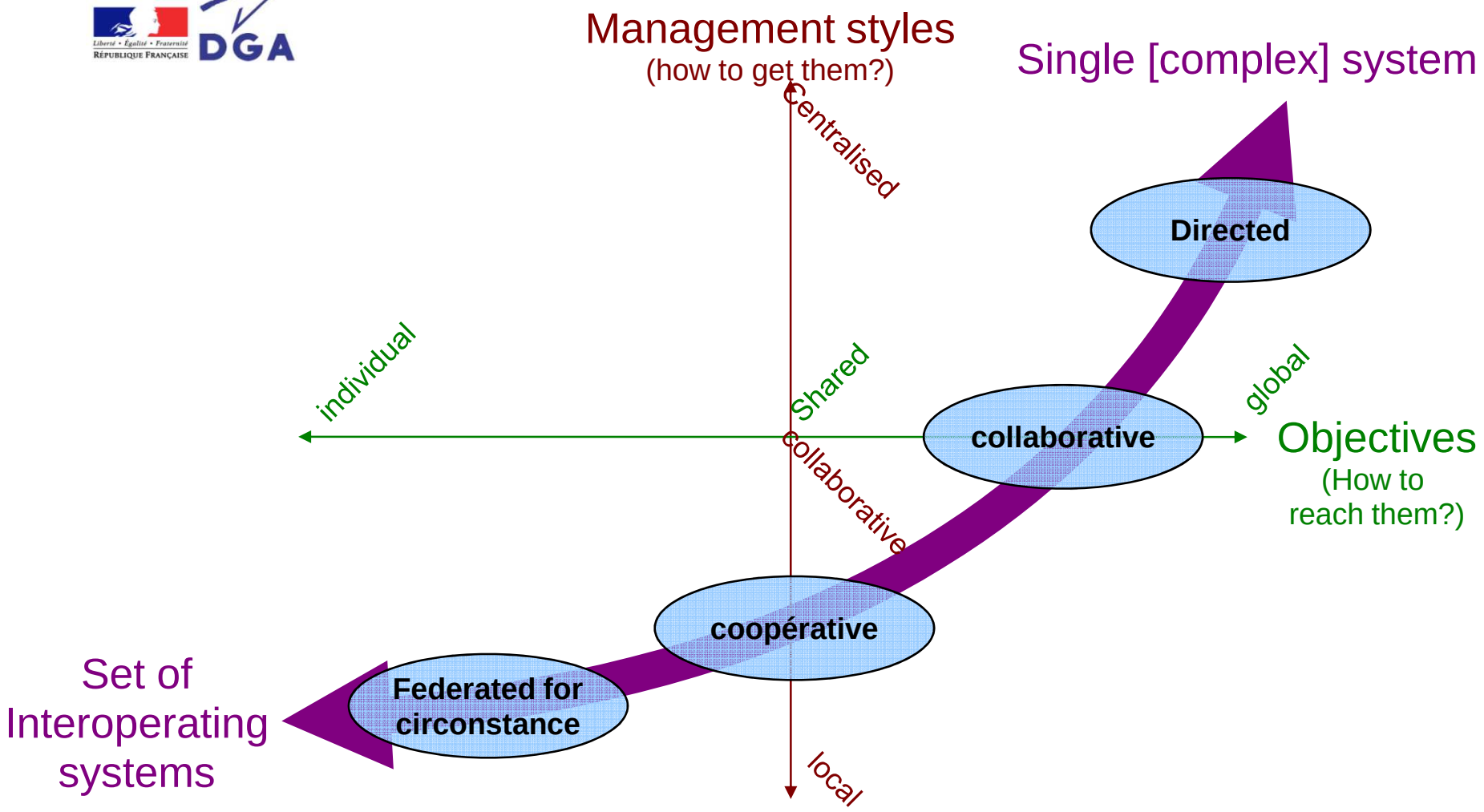
- **MAIER's criteria**
  - Operational independence of the component systems
  - Managerial independence of the component systems
  - Evolutionary development
  - Emergent behavior
  - Geographic distribution *(no shared resource)*

In reality: never totally satisfied

- **John Boardman & Brian Sauser**
  "System of Systems – *the meaning of of*"
  - Autonomy (independence) VS Belonging to SoS
  - Geographical distribution VS Connectivity
  - Diversity & Emergence VS SoS objectives

Compromise have to be got

Classification from French MOD "SoS School"



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Various types of SoS have to be considered

Challenge #1

Loose coupling within SoS (smart Interoperability)

Criteria → Geographical distribution, Operational & managerial Independence; but [physical, logical] connectivity

- Physical, procedural, semantic interoperability
- Semantic (knowledge) sharing VS independence
- Federation/scheduling/technical management features
- Exchange infrastructure VS Geographical distribution, Independence & connectivity

ICT main challenges: Socio-technical approaches, network and infrastructure, human-system integration, information mining and languages

Challenge #2

Paradigms for interaction within SoS

Criteria → Operational & managerial independence, emergence, but [physical, logical] connectivity

- **Exchange of Service, product, Data, Event and Stream**
- **How to mix these paradigms**
  - Mix for a exchange: Service for data exchange, Data exchange for service, etc.
  - Combination within functional chains
- **Real usable formalisation for Service, Quality of Services, Contract, Agreement, etc.**
  - Metamodel
  - Graphical notation for architecture description
  - Service management (link with ITIL & eTOM)

ICT main challenges: Network and service Infrastructure, operational activity management

Challenge #3

SoS behaviour

Criteria → Operational & managerial Independence, emergence

- **How to quality SoS objectives with component systems independence and emergence?**
- **Scheduling domains: priority-based, on-demand, periodic, earliest deadline first, etc.**
- **Non-functional aspects can also be considered here:**
  - SoS performance, Security and Safety
- **Architectural patterns: Orchestration & choreography**
- **Terms, concept , graphical notation for behaviour and scheduling**

ICT main challenges: Behavioural sciences, Scheduling and virtualisation (independence from implementation)

SoS Engineering activities and life-cycle

Criteria → Managerial independence of the component systems, emergence

- **SoS whole life-cycle: does it make sense for a completely open SoS architecture?**
- **Engineering activities:**
  - Toward engineering activities during operation: on-line [integration, verification, validation] with commit phase on success and roll-back on failure.
  - Verification, validation & Acceptance VS emergence
- **Collaborative engineering & risk sharing VS managerial independence**
- **Extended enterprise principles for SoS engineering**

ICT main challenges: Collaborative process for business development and engineering , Interlaced life-cycle management

Challenge #5

SoS Engineering process

Criteria → Managerial independence of the component systems

- **Engineering processes for:**
  - Objective-driven SoS engineering: Are projects like ISyCri realistic?
    I.e. Dynamic creation of a SoS to face a crisis.
  - Capability-based engineering: How to plan SoS capability with System components independence?
  - Legacy-based engineering: what is the SoS engineering process to reusing some legacy systems and building others?
  - System addition/removal: what is the process to add/remove during operation?
    I.e. most of SoS cannot be stopped for evolution.

ICT main challenges: Engineering processes, dynamic life-cycle management

Challenge #6

SoS management, ILS and training

Criteria → Managerial and operational independence of the component systems

- Management: How to monitor/supervise/(re)configure a SoS?
  I.e. Can we do more and better that supervisor of supervisor? (see E2R, E2SMS [Reference to be checked])
- Maintenance: How to update/maintain an SoS?
  I.e. sum of individual component system maintenance actions to guaranty the SoS objectives.
- Training: How to train of a whole SoS?
  I.e. same remark on sum of individual component system training.

ICT main challenges: Support and training processes, command and control, modelling and simulation of management references

Challenge #7

Modelling and Simulation

Criteria → Managerial and operational independence of the component systems

- Large SoS have to be studied before implementation, when proof a feasibility and usage is got.
- Concept Development & Experimentation through M&S is one way to explore feasibility
- Process and organisation to be studied for co-M&S
  I.e. Involvement of each model of system component is involved under responsibility of providers/customers/users with respect of intellectual properties + managerial/operational independence.
  E.g. first experimentation through NATO DNBL.

ICT main challenges: Modelling and simulation as a transverse discipline (behaviour, multi-physic, human factor "views", early validation, reference for management)

jean-luc.garnier@thalesgroup.com