System Engineering Education for Experienced Engineers: Experience Feedback

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Outline

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Motivation

- System engineering evolution and adoption around the world have been unevenly supported by education programs.

- The current strong emergence of system engineering needs in several industries combined with inappropriate education support in the past resulted in strong demands for lilelong education programs.

- Most mid career engineers with very significant technical project experience in major french companies graduated in engineering programs with no education in system engineering beyond short trainings.

Motivation

- Often, they have been exposed to system engineering processes through participation in large programs but only in a partial manner.
- This is typical of a general transition period inside companies with internal struggles on the exact role and scope of system engineering.
- Economic crisis and downturns may affect learning through projects

Training philosophy

- Direct link with French MoD/DGA for their requirements
- This course will be based upon INCOSE ASEP certification (Associate Systems Professional Engineering) reference and INCOSE Systems Engineering Handbook.
- Addition of Systems of Systems course
- Addition of NAF Architecture framework
- 50 % theory and 50% practice
- Intensive use of professionnal recognized software tools
- Collaborative work a must: teamwork with teams of 5 to 6 engineers
- 276 hours from march to july
- 2 days a week : Thursday/friday

FAIS on line collaborative tools

- To help both the speakers and the trainees in their collaborative activities, ENSTA ParisTech deployed an on line tool based on Alfresco/Share.
- This tool offers of the functionalities of electronic document management, blog, wiki, as well as access management.
- Three sites were open.
- •The first, FAIS is a teaching place of exchange between the speakers in whom reference documents are deposited (such as the INCOSE Systems Engineering Handbook), as well as the case study and its related data sheets. The speakers are guests to deposit their support of course to facilitate coordination between them.

FAIS on line collaborative tools

- To supplement this coordination, a matrix crossing the speakers' various modules was elaborated in order to identify the links between modules.
- The second, FAISADMIN, draught of the administrative aspects for the speakers.
- Lastly, the third site, FAISELEVES, is a place of exchange between speakers and trainees, to deposit the supports of course as well as the reference documents.
- The classroom computers were configured with systems engineering tools needed by the speakers, for instance, without claiming exhaustive, DOORS and MEGA with remote access for trainees from their home

FAIS speakers

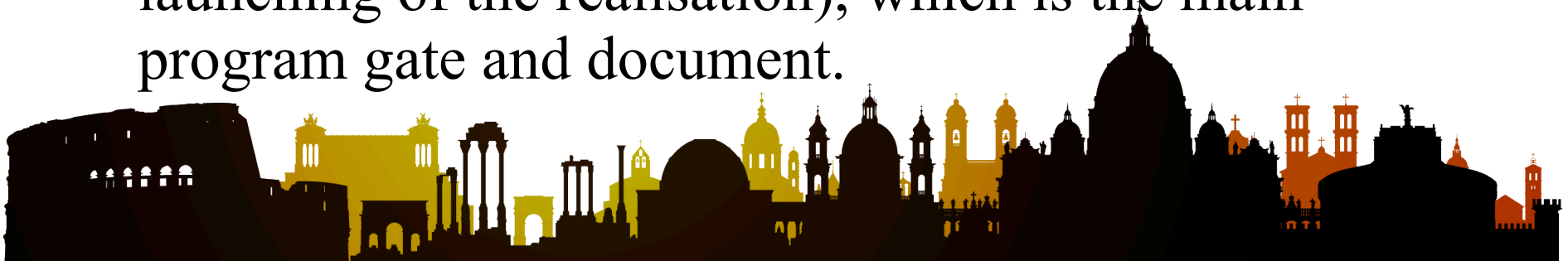
- The speakers of the FAIS course are systems engineering senior engineers who practise systems engineering in industry and government projects and teach it while benefitting from the experiment which is theirs.
- These speakers come from different companies (Thales, ADN, Eiris Conseil, Air France…) in order to have a large range of experiences.

FAIS speakers

- This diversity of expert testimonies offer to the trainees the large range of the experiences of the speakers by avoiding an orthodox and obscure methodologist speech.
- Among the speakers, two are certified CSEP.

FAIS validation process

- In complement of certification ASEP of the INCOSE, the process of validation of the FAIS course is based on the elaboration of a dissertation by the trainees and the viva of this dissertation in front of a jury, at the end of the course.
- In order to effective and pragmatic being with respect to the activities which the engineers will have to undertake in the programs, it was decided that the dissertation will be equivalent with a DLR (File of launching of the realisation), which is the main program gate and document.



FAIS validation process

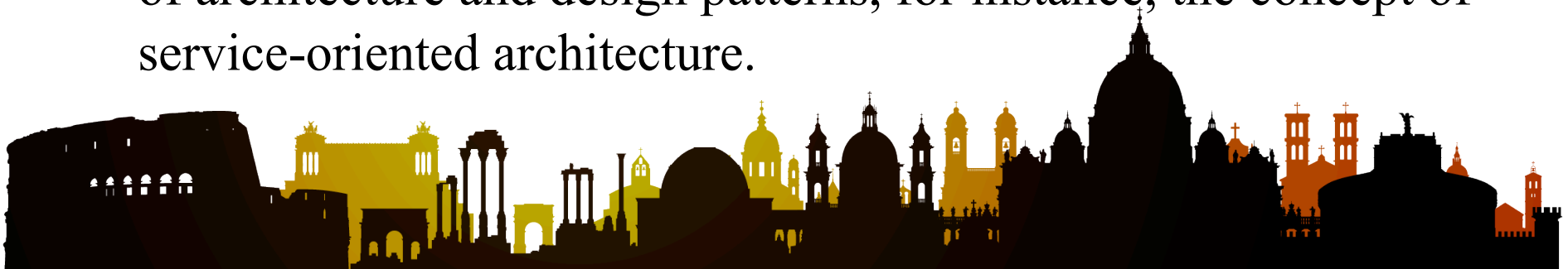
- That makes it possible to the trainees to understand their coherency and the necessary application of systems engineering, both for acquirers and suppliers.
- A groundwork of DLR was given to the trainees at the beginning of the course.
- It is supplemented, as the progression of the course, with models of documents (technical specification, systems engineering plan…) in order to take into account the outputs of the various modules of the course which make it possible to fill this groundwork (reference operational situation description, operational environment description, use cases models, …).

"Multi-sensors observation system" case study

- The "multi-sensors observation system" case study was made in order to give to the trainees a concrete and realistic example, compared to their activities of systems engineering and architect.
- So they can apply the systems engineering concepts, methods and tools that they acquire during FAIS course.
- Moreover, this case study allows the speakers to have an example which transcends their respective modules in order to offer to the trainees a red thread structuring the whole of the course.

Case study

- The case study calls to the key concepts and methods of systems engineering, putting forward the interactions of the multi-sensors observation system with other systems of its environment.
- It allows to show how to organise functional and physical architecture starting from a reference scenario of use which expresses the services that the multi-sensors observation system provides.
- Trainees learn to translate the functional requirements into technical requirements in order to elaborate a technical specification.
- In addition, the case study makes it possible to apply concepts of architecture and design patterns, for instance, the concept of service-oriented architecture.



Case study

- Lastly, the case study implements various views of the NATO Framework Architecture.
- The multi-sensors observation system case study is used to elaborate the dissertation for the course validation.
- It was requested that the speakers use this case study for their examples and exercises.
- So the trainees can implement systems engineering concepts and apply them in the dissertation elaboration, for instance to model functional architecture or to make the cost analysis.

Case study

- **Waited capabilities.** .

Apple-pie is a little state that needs to protect itself again summer catastrophic forest fires and its shores again traffics. Apple-pie states to dispose the following capabilities:

- Intervene as soon as possible before fires spread; that mean:
  - Detect a fire less than 5 minutes, on average, after it occurs,
  - Intervene on the fire, less than 20 minutes after alert,
  - Stop spread 80% of detected fires,
  - Identify and correct recurrent problems that contribute to fires' spread,
-

Case study

IIntercept and stop as soon as possible any illegal activities (various traffics, …) on seashore, that means:

- o Detect as soon as possible illegal activities,
- o Pursue trafficker with discretion,
- o Intervene at the opportune moment,

Dispose of all pieces if evidence of illegal activities, and recognize static and dynamic objects within proximal environment.

Case study

- Elaboration of capability view (SoS module) –capability vision et capability taxonomy
- ➔ CASE tools : IBM System Architect or MEGA, with a NAF configuration
- ➔ Implement functional analysis (high level, black-box)
- ➔ Quantitative valorisation of performances (average time, percentage, …)
- ➔ Implementation of elicitation methods such as creativity ones

Training feedback

- Experienced engineers are eager to learn and adopt new methods and tools
- They immediately project new learnings in their current working environments and feedback on it
- They stress very much the constraints of applying clean and neat methods in strongly evolving environments
- Cost issues and time gains are questionned: what are *exactly* the quantitative benefits of SE ?
- The use of software tools is appreciated but the integration of these tools in existing modelling and

Training feedback

- projects at the time of the training and contacted in a regular basis (email, phone, etc…)
- They are not given free time for their training: Thursday and Friday classes result in work absence that has to be compensated during week ends
- The rythm of education and the content should be permanently relevant to their expectations: attention span (disconnect)
- **Next edition:** improve relevance and break the training into modules with various granularity

RETEX

The new edition: March – June 2012

- RETEX: return on experiences
- What went wrong ?
- What does not work ?
- What beyond standards, norms ?
- The unique experience of competitors sharing mistakes, project and program failures

Conclusion

- The first edition of the FAIS program was successful but numerous lessons have been drawn .
- Tackling the challenge of diversity of experiences, knowledge and expectations in a single system engineering education program requires fundamentally both a smoothing framework and careful exploitation of differences through group assignments.
- More needs to be done to carefully match this diversity.

Conclusion

- This requires nurturing an eco-system around the program going beyond education and establish a framework of system engineering experience sharing through both R&D programs and regular seminars and conferences.
- Experienced engineers: a unique expectation
- Building common vocabulary and methods
- A very clear and rich added value through RETEX
- A collaborative work

Thanks to our numerous partners and adjunct professors

Thanks to French Ministry of Defense/DGA for their financial support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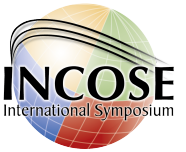
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