Tutorial: The Methodological and Technological Dimensions of Technology Transfer for Embedded Systems in Aeronautics and Space

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This tutorial is in two parts, to elaborate the two pillars of technology transfer in the context of the aeronautics and space industry. The first part illustrates the methodological pillar, showing the state of the art in the industrial approaches to technology transfer. The second part illustrates the technological pillar, giving an overview of recent successes in technology transfer and emerging trends and opportunities, for both hardware and software. These two pillars are further mirrored in the two technical sessions.

Part 1 Best practices for embedded systems design in aeronautics and space

Systems engineering is key for complex products, subject to demanding operational environment, and aiming at delivering highly integrated services and business value. The case of large commercial aircraft is particularly significant of these problems, where in addition to the paramount requirement of safety, the emergence of operability requirements is emerging very quickly and demandingly: of course, not forgetting that the traditional key requirements (performances, recurring costs) must also be satisfied.

The world in which aircraft systems operates is increasingly distributed: Air Traffic Management systems, interconnection of Airlines operational system with the aircraft are some outstanding illustration of this fundamental trend. In another dimension, the demanding search for energy optimization also leads to consider the aircraft from an holistic perspective. Of course, controlling the aircraft, within the framework of mission optimized scenarios, remains an essential core duty of the aircraft architect and integrator.

Based on some examples extracted from large commercial aircraft systems design and development experience, the tutorial addresses the fundamentals of systems engineering, highlights best practices and draws some trend lines for the future. The development cycle of embedded systems (from upstream to down stream) is fully developed and widely illustrated. In particular, the following key aspects are introduced, which are further elaborated in a later technical session: management of technologies, especially technologies obsolescence and risk of dependence to suppliers model-based development of embedded control systems assessment process of safety-critical software (esp. applicable regulation and acceptable means of compliance) in the frame of aircraft certification

Some cues about organizational and human aspects of systems engineering and of the associated necessary transformation are also addressed.

Part 2 Recent evolutions and future trends in embedded systems technologies for industrial aeronautics and space applications

Embedded Systems and novel integration technologies are key technologies that will help to master the challenges that are addressed by the aeronautic and space industry defined in the year 2020 vision.

The next generation of air and space vehicle has to be cost-effective, time efficient, and highly customer oriented. Obviously it is also expected that the highest safety levels and much enhanced environmental standards will be met. One measure to achieve these goals will be the much wider use of highly integrated smart systems composed of sensors, electronics, software as well as actuators. With this approach it is possible to contribute to most of the highly contradictory top-level requirements. Improved, highly cost-effective maintenance systems, for example will rely on new low weight, low cost wireless, self-organizing sensor networks that can by easily mounted and integrated in the vehicle.

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The technical requirements as well as the complexity of embedded systems in the aeronautic, space and defence domains are continuously growing. Conventional development methods and processes can not master all these tasks. These can only be handled by using specifically structured development processes and technologies, which allow to minimize the dependencies between the components of a complex system. Guidance and recommended practices for the development of highly integrated or complex aeronautic systems that need to be certified are existing such as described in SAE ARP4754.

The development process has to cover the complete development cycle: requirement analysis and management, system architecture and design, software implementation and hardware realization, integration and test. The process is supported by all technologies avoiding any kind of unnecessary dependencies in the embedded system and during development. The tutorial presents for the SW development part essentially three promising technologies:

- Model based development: development phases and many different aspects of an embedded system are formally described and connected in one complete and consistent model, e.g. an UML-model.
- Hardware-software-codesign for hybrid Microprocessor-FPGA-systems: based on one formal model, different software modules are mapped to the appropriate processing devices - even in late project phases.
- RT-Java: Java decouples the domain application from hardware and operating system. RT-Java virtual machines have demonstrated that Java is ready for embedded systems.

The processing power of embedded systems will be limited in the future by single core processors. In customer and non-safety critical industry applications is the trend to multi core CPUs but these modern CPUs are very critical in the certification process. The most modern architectures are based on distributed embedded systems. Therefore, these architectures need a cost efficient fault tolerant communication network. A Time Triggered Architecture TTA could be a cost efficient and reliable solution in aeronautic and space applications. Most of the used hardware parts are complex components. The certification of these components is labor and cost intensive. Formal methods are adequate to save cost and time as well as support a systematic way in the certification process. Furthermore certification arguments, obtained by formal methods can be reused across different platforms.

Embedded systems based on low cost, high reliable MEMS technology can be used for flow control, conformable antennas, maintenance and other embedded systems with sensing and actuating functions. The main advantage of this technology is the small volume and weight compared to the conventional technology.