SAE TECHNICAL PAPER SERIES

2011-36-0387
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XX SAE BRASIL International
Congress and Exhibition
São Paulo, Brasil
October, 4th to 6th

AV. PAULISTA, 2073 - HORSA II - CJ. 1003 - CEP 01311-940 - SÃO PAULO – SP

ISSN 0148-7191

SAE The Engineering Society For Advancing Mobility Land Sea Air and Space® INTERNATIONAL

2011-36-0387

Current Trends Driving the Aerospace and Automotive Systems Architectures

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ABSTRACT

In this work we discuss current trends driving the aerospace and automotive systems architectures. This includes trends as: 1) pos-globalization and regionalization; 2) the formation of knowledge oligopolies; 3) commonality, standardization and even synergy (of components, tools, development process, certification agents, standards); 4) reuse and scalability; 5) synergy of knowledge and tools convergence; 6) time, cost and quality pressures and innovation speed; 7) environmental and safety issues; and 8) abundance of new technologies versus scarcity of skilled manpower to apply them. Based on that we summarize their impacts on: 1) the aerospace and automotive system needs and their system requirements; 2) the system development and certification standards (SAE-ARP 4761, SAE-ARP 4754, RTCA DO-297, RTCA DO-254, RTCA DO-178B/C, RTCA DO-160, etc.); 3) the management levels of an organization (executive management, portfolio management and program management) 4) the applicable guidelines (CMMI®, OPM3®, BSC®) to organize and conduct them successfully.

INTRODUCTION

AN OVERVIEW OF THE SYNERGY BETWEEN THE AUTOMOTIVE AND AEROSPACE INDUSTRIES

Traditionally, the automotive industry contemplated additional functions based on mechanical and hydraulic components. With the advance of electronic devices, these absorbed the introduction of these additional functions and become even more involved in the essential functions, like, break, steering, air-conditioning etc.

These facts fed back the evolution of the automotive products, stimulating the development of new functions with a higher level of performance and with significant cost and size reduction. In consequence, the x-by-wire system appeared, bringing together the concepts from the aerospace industries.

Progressively, the automotive industry demanded an increasing number of products with more dynamics. Components Of The Shelf (COTS), like Microprocessors (MPs), Digital Signal Processors (DSPs), and Programmable Logic Devices (PLDs) were created under a standardization process to assure the quality of the products according to the criticality of the functions executed by them.

Today, we are watching an inverted process of diffusing the technology, i.e., the technology developed by the automotive is migrating to the aerospace industry, e.g., the COTS exemplified above, providing reduction of costs and shorter periods of development front a robust solution of engineering.

CURRENT TRENDS DRIVING AEROSPACE AND AUTOMOTIVE SYSTEMS ARCHITECTURES

The synergy pointed above is one of many trends currently observed in both industries. Such industries always had strong differences and strong commonalities. In the past, their differences were more powerful than their commonalities, preventing them from cooperating in practically any levels of products (from components to standards), in any phase of the life cycle processes (from capture of needs to disposal/retirement), in any kind of organization (from requirements teams to test facilities), or in any certification authorities and procedures. However, today and in the near future, their commonalities are becoming more powerful than their differences, stimulating them to cooperate in many levels of products (from components to standards), in some phase of the life cycle processes (from capture of needs to disposal/retirement), in some parts of organizations (from requirements teams to test facilities), and even in some certification authorities and procedures.

These changes in the trade-off of commonalities versus differences are due to trends located mainly outside such industries but that are shaping their structure and behavior. Among the current trends driving aerospace and automotive systems architectures we highlight:

1) Pos-globalization of information and knowledge intensive activities like Engineering Management and Design; and regionalization of energy and commodities activities like Engineering Production and Maintenance due to decreasing costs of communication and increasing costs of transportation;

2) The formation of knowledge oligopolies, like aerospace contractors and its partners; or automotive chains;

3) Commonality, standardization and even synergy (of components, tools, development process, certification agents, standards) like COTS or GOTS parts;

4) Reuse and scalability, like in small cars and regional jets;

5) Synergy of knowledge and tools convergence, like in analogous aerospace and automotive activities as Requirements and Verification Engineering and Management;

6) Cost pressure and innovation speed, like a cheaper and new model per year;

7) Environmental and safety issues, like pollution prevention and control; and preventing or correcting pilot or driver mistakes;

8) Abundance of new technologies versus scarcity of skilled manpower to apply them.

IMPACTS OF CURRENT TRENDS ON SOME CHARACTERISTICS OF SYSTEMS ARCHITECTURES

As consequences of these trends some characteristics of both industries are changing more than others in the same industry, towards reducing their differences among industries. They can be summarized as follows:

1) Cost of design, operation and maintenance versus the capacity and useful life of the systems.

2) Intensity of use and platform independence of computer and communication systems.

3) Particularly, in these systems the degree and levels of:

   a. Platform resources shared by multiple applications;

   b. Robust partitioning of shared resources;

   c. Well defined interfaces between different applications meaning well defined liability;

   d. Configuration and reconfiguration of platform resources;

   e. Independence in application designs;

   f. Incremental acceptance;

   g. Integration onto a platform without unintended interactions with other applications;

   h. Reusability;

   i. Scalability; and

   j. Independent modifiability.

4) Architectures of collision avoidance systems and safe critical systems.

5) Environmental issues and pollution management (avoidance, tolerance, correction, prognosis, etc.).

6) Safety issues and fault management (avoidance, tolerance, correction, prognosis, etc.).

As already well discussed by Levenson [10], "the automotive industry is quickly increasing the complexity and coupling in their new vehicle designs. This complexity is starting to outstrip our ability to provide high confidence that unexpected interactions between components will not lead to accidents".

CONVERGENCE OF AEROSPACE AND AUTOMOTIVE INDUSTRIES

Analyzing the current trends we perceive that one important convergence area will be commonality and standardization and even synergy in certification agents, standards, development process, tools and components. Because aerospace and automobile handles the same main function, namely: "To transport a person or a cargo with safety and comfort from point A until point B", meaning with safe-critical requirements, it makes sense for a country, a group of countries or even all countries to unify the certification agencies as well the applicable standards. The evolution of human knowledge and most specifically in the Systems Engineering and related disciplines in the latest years, combined with the mentioned standardization, guide all small development companies to have similar or even the same development process, including tools. This process will be defined on selected or at least accepted standards, by big contractors.

In the tools area, based on past, current, and future verticalization in the software market, where are the most important development engineering tools, there will be no more than a few realistic options, if any, for small companies to select their own tools. The future show us the big contractors, the players in the knowledge oligopolies, providing the development frameworks, including development lifecycle, all tools, project structure, deliverables and indicators for them to monitor and control de project.

In the components area, the most important convergence will be the reusable computational platform based on a standard like the Integrated Modular Avionics (IMA). The aerospace industry will benefit from the scalability in the automotive industry while this will benefit from the computational power concentration and the safe critical certification process from that. Currently, this is the most important system architecture modification in aerospace and car: for each system there will be sensors, actuators and the control (all logic processing) for each system running in only one computational platform, distributed or not, managed by a "Operational Flight or Operational Drive Program" including a complete and continuous health monitoring system. This architecture complies with the requirements from both sides and allows each system developer to implement, certify and maintain its application, keeping the secrets of its knowledge; while the system integrator retains the knowledge in a system level functions and the capability to integrate, validate, certify, maintain, support, upgrade and reuse the whole system.

THE AEROSPACE AND AUTOMOTIVE SYSTEMS NEEDS AND THEIR SYSTEM REQUIREMENTS

A reusable computational platform compliant with a proposed standard will allow the possibility of different suppliers for the same hardware components and different platform integrators, providing the same computational functions, certified according to the safe-critical standards. It permits the independent applications development and incremental certification process.

The proposed guidelines are applicable, with minor customizations, to the IMA components suppliers, platform integrators, application developers, and the top level integrator.

REUSABLE COMPUTATIONAL PLATFORM

The computational platform should be defined and developed independently of the specific functions and the hosted applications. It must be supplied with "approval" from the certification agencies including the necessary paperwork for future incremental integration and certification.

As stated in [3] the computational platform and application development process must considers Health Monitoring and Fault Management, Overview of the Certification Process, Aircraft or Car Integration of IMA System (Including V&V), Change of Modules or Applications, Reuse of Modules or Applications, Safety Assessment, Responsibilities, Validation, Verification, Configuration Management, Quality Assurance, Certification Liaison, Training, Maintenance, and Post Certification Modifications.

THE INTEGRAL PROCESS

Due to the high level of integration inherent in IMA systems it is necessary to implement an integral process that supports system design consistence, safety and security requirements allocated to each system, robust portioning avoiding adversely affecting, health monitoring and fault management, configuration management, human factors requirements, and certification requirements. The right way to develop a component, application or system IMA compliant is to focus the organization in the process and process improvement instead of objects.

BENEFITS OF PROCESS IMPROVEMENT

According to the [11], the following are some of the benefits and business reasons for implementing process improvement:

1) The quality of a system is highly influenced by the quality of the process used to acquire, develop, and maintain it.

2) Process improvement increases product and service quality as organizations apply it to achieve their business objectives.

3) Process improvement objectives are aligned with business objectives.

THE SYSTEM DEVELOPMENT AND CERTIFICATION STANDARDS

The proposed standards combination to implement a development process necessary to provide an organization with capability for aerospace and automotive system development and certification must consider the interplay between major techniques and processes as presented in Figure 1. There are other standards and processes that complement the organization, but here we are focused on those that guideline the development process in a safe-critical aerospace and/or automotive industry. The standards definitions are exactly according to their organization providers.

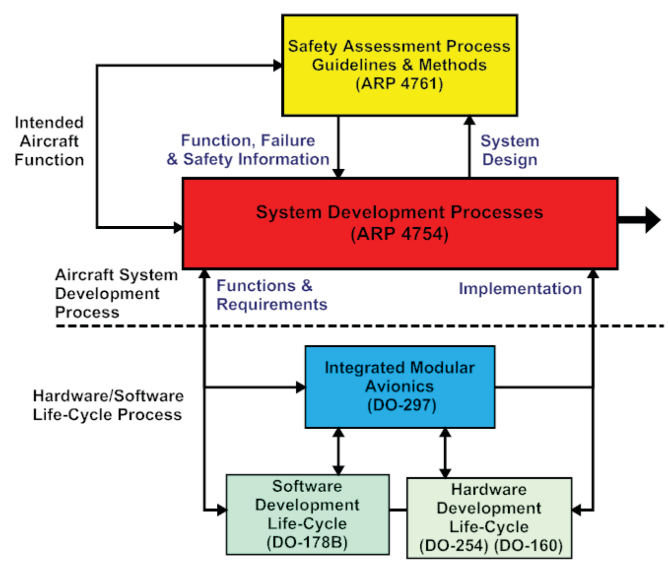

***Figure 1 – Interplay between major techniques and processes** (redrawn from ARP-4754).*

SAE STANDARDS

Aerospace Standards (AS), Aerospace Recommended Practices (ARP), and Aerospace Information Reports (AIR) are the guidelines for the design and production of thousands of aerospace parts and components. AS are design and/or part standards applicable to missile, airframe, ground-support equipment, propulsion, propeller, accessory equipment, and airline industries.

ARP4761 [1]

This document describes guidelines and methods of performing the safety assessment for certification of civil aircraft. It is primarily associated with showing compliance with FAR/JAR 25.1309 [12]. The methods outlined there identify a systematic means, but not the only means, to show compliance. A subset of this material may be applicable to non-25.1309 equipment. The concept of Aircraft Level Safety Assessment is introduced and the tools to accomplish this task are outlined. The overall aircraft operating environment is considered. When aircraft derivatives or system changes are certified, the processes described therein are usually applicable only to the new designs or to existing designs that are affected by the changes. In the case of the implementation of existing designs in a new derivation, alternate means such as service experience may be used to show compliance.

ARP4754 [2]

This document discusses the certification aspects of highly-integrated or complex systems installed on aircraft, taking into account the overall aircraft operating environment and functions. The term "highly-integrated" refers to systems that perform or contribute to multiple aircraft-level functions. The term "complex" refers to systems whose safety cannot be shown solely by test and whose logic is difficult to comprehend without the aid of analytical tools.

The guidance material in this document was developed in the context of Federal Aviation Regulations (FAR) and Joint Airworthiness Requirements (JAR) Part 25. It may be applicable to other regulations, such as Parts 23, 27, 29 and 33. In general, this material is also applicable to engine systems and related equipment. Final regulatory approval of all systems is assumed to be accomplished in conjunction with an aircraft certification.

The Simplified portrayal of safety processes according to the ARP4754 is presented in Figure 2.

RTCA STANDARDS

DO-297/ED-124 [3]

It contains guidance for Integrated Modular Avionics (IMA) developers, application developers, integrators, certification applicants, and those involved in the approval and continued airworthiness of IMA systems in civil certification projects. It is focused on IMA-specific aspects of design assurance.

IMA is described as a shared set of flexible, reusable, and interoperable hardware and software resources that, when integrated, form a platform that provides services, designed and verified to a defined set of requirements, to host applications performing aircraft functions. The primary industry-accepted guidance for satisfying airworthiness requirements for IMA components is included and it describes application properties as they relate to their integration with a platform.

DO-178B/ED-12B [4]

It provides guidance for determining, in a consistent manner and with an acceptable level of confidence that the software aspects of airborne systems and equipment comply with airworthiness requirements. An upcoming new version will be called DO-178C/ED-12C and is due to be finalized in 2011.

DO-254/ED-80 [6]

This document is intended to help aircraft manufacturers and the suppliers of aircraft electronic systems assure that electronic airborne equipment safely performs its intended function. The document identifies design life cycle processes for hardware that includes line replaceable units, circuit board assemblies, application specific integrated circuits (ASICs), programmable logic devices (PLDs), etc. It also characterizes the objective of the design life cycle processes and offers a means of complying with certification requirements.

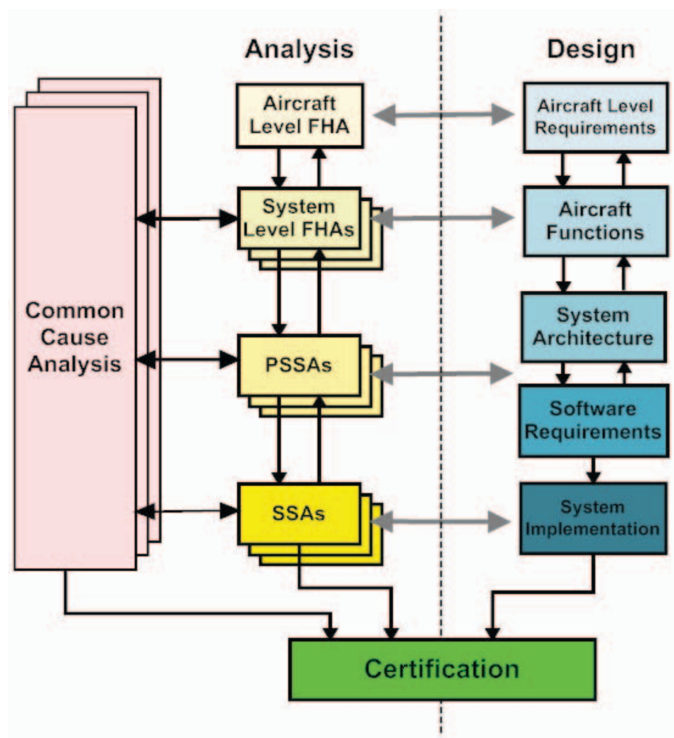

***Figure 2 – Simplified portrayal of safety processes** (taken from ARP-4754).*

DO-160F/ED-14F [7]

It contains standard procedures and environmental test criteria for testing airborne equipment for the entire spectrum of aircraft from light general aviation aircraft and helicopters through the "Jumbo Jets" and SST categories of aircraft. The document includes 26 Sections and three Appendices. Examples of tests covered include vibration, power input, radio frequency susceptibility, lightning and electrostatic discharge. Coordinated with EUROCAE, RTCA/DO-160F and EUROCAE/ED-14F are identically worded. DO-160F is recognized by the International Organization for Standardization (ISO) as de facto international standard ISO-7137.

THE MANAGEMENT LEVELS OF AN ORGANIZATION

The proposed management level for an organization that wants to be a system or application development suppliers in the aerospace or automotive production chain must be focused on processes and considers the distinct management goals: Executive Management, Portfolio Management, and Program Management.

THE EXECUTIVE MANAGEMENT

It defines the vision and the strategy of the organization and provides the organization with a capability to document and share best practices, organizational process assets, and learning across the organization able to control and verify if the organization results are aligned with its larger-scale objectives. This is responsible for the *ENTERPRISE MANAGEMENT LEVEL.*

THE PORTFOLIO MANAGEMENT

It establishes all process areas to cover the portfolio management activities related to identification, categorization, evaluation, selection, and authorization each project and provides the infrastructure to integrate the management information from all programs and projects creating a complete view about the organization business. It provides the upper level with the indicators necessary to control an organization as a whole and, simultaneously, it provides themselves the necessary information to manage the conflicts between projects, and it provides the lower management level with necessary indicators for program managers and team members monitor and control the programs. This is the *SYSTEMS MANAGEMENT LEVEL.*

THE PROGRAM AND PROJECT MANAGEMENT

It must define the process areas to cover the development and maintenance activities that are shared across engineering disciplines and process areas to cover the activities that support product development and maintenance. It must be clear understood that any product development is always a "Program", in other words a group of related projects managed in a coordinated way. This is the *SYSTEMS ENGINEERING LEVEL.*

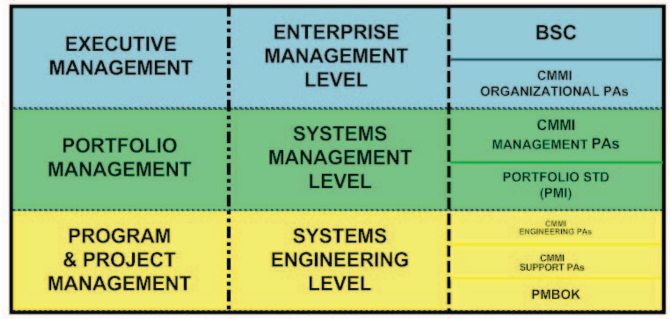

Figure 3 – Organization Management Levels with applied foundation guidelines.

THE APPLICABLE GUIDELINES TO ORGANIZE AND CONDUCT THEM SUCCESSFULLY

Is Capability Maturity Model® Integration (CMMI) from Carnegie Mellon® Software Engineering Institute (SEI) the appropriate framework for the process improvement initiative that is planned for our proposal? According to our experience the answer is yes. In fact it is a meta-model for process organization and does not define how we implement the solution, and then it allows us to organize others process under its big umbrella.

CMMI from Carnegie Mellon® Software Engineering Institute (SEI) is a process improvement approach that provides organizations with the essential elements of effective processes. It can be used to guide process improvement across a project, a division, or an entire organization. CMMI helps integrate traditionally separate organizational functions, set process improvement goals and priorities, provide guidance for quality processes, and provide a point of reference for appraising current processes.

Since 1984, the Carnegie Mellon® Software Engineering Institute (SEI) has served the USA as a federally funded research and development center. The SEI works closely with defense and government organizations, industry, and academia to continually improve their software-intensive systems [13].

And what about OPM3® from Project Management Institute? Must it as well their associated standards for portfolio, program and project management considered? According to our experience the answer is yes too. One good example to show the nature and relationship of the two models and how to use them together is presented in [14].

PMI is the leading membership association for the project management profession. PMI is actively engaged in advocacy for the profession, setting professional standards, conducting research and providing access to a wealth of information and resources.

ENTERPRISE MANAGEMENT LEVEL

At this level this work is based on knowledge from three different organizations.

PMI Standards

"The Standard for Portfolio Management" [15] from PMI is the basis for understanding the portfolio management with generally recognized good practices. It is applied with a smooth and tied integration with other ones.

CMMI Organizational Process

The selected process areas from CMMI to be applied in the enterprise management level are those from process management category, level 3, and their definition according [8] are presented bellow.

OPF – "The purpose of Organizational Process Focus is to plan, implement, and deploy organizational process improvements based on a thorough understanding of current strengths and weaknesses of the organization's processes and process assets."

OPD – "The purpose of Organizational Process Definition is to establish and maintain a usable set of organizational process assets, work environment standards, and rules and guidelines for teams."

OT – "The purpose of Organizational Training is to develop skills and knowledge of people so they can perform their roles effectively and efficiently."

Balanced Scorecard (BSC)

The proposal and our actual work are to match the balanced scorecard concept with CMMI model, for the enterprise management level. For the lower levels the same indicators used in process areas implementation are the ones considered in the BSC.

The BSC began as a concept for measuring whether the smaller-scale operational activities of a company are aligned with its larger-scale objectives in terms of vision and strategy.

The balanced scorecard is a strategic planning and management system that is used extensively in business and industry, government, and nonprofit organizations worldwide to align business activities to the vision and strategy of the organization, improve internal and external communications, and monitor organization performance against strategic goals (www.balancescorecard.org).

Key Performance Indicators perspectives are reproduced bellow according to the Balanced Scorecard Institute description.

The financial perspective examines if the company's implementation and execution of its strategy are contributing to the bottom-line improvement of the company. It represents the long-term strategic objectives of the organization and thus it incorporates the tangible outcomes of the strategy in traditional financial terms. (Cash flow, ROI, Financial Result, Return on capital employed, Return on equity).

The customer perspective defines the value proposition that the organization will apply in order to satisfy customers and thus generate more sales to the most desired (i.e. the most profitable) customer groups. (Delivery Performance to Customer - by Date, Delivery Performance to Customer - by Quality, Customer satisfaction rate, Customer Loyalty, Customer retention).

The internal process perspective is concerned with the processes that create and deliver the customer value proposition. It focuses on all the activities and key processes required for the company to excel at providing the value expected by the customers both productively and efficiently. These can include both short-term and long-term objectives as well as incorporating innovative process development to stimulate improvement. (Number of Activities, Opportunity Success Rate, Accident Ratios, Overall Equipment Effectiveness).

The learning and growth perspective is the foundation of any strategy and focuses on the intangible assets of an organization, mainly on the internal skills and capabilities that are required to support the value-creating internal processes. The learning and growth perspective is concerned with the jobs (human capital), the systems (information capital), and the climate (organization capital) of the enterprise. (Investment Rate, Illness Rate, Internal Promotions %, Employee Turnover, Gender/Racial Ratios).

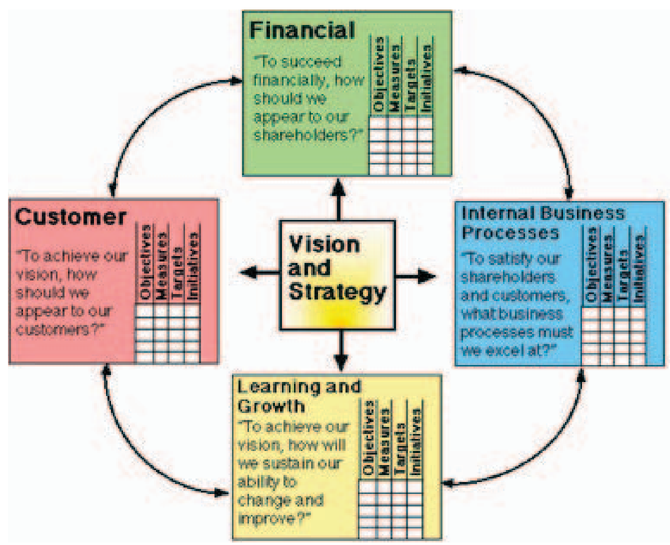

***Figure 4 – Overview of Project Management Knowledge and Project Management Process** (taken from Balanced Scorecard Institute).*

SYSTEM MANAGEMENT LEVEL

CMMI Management Process

The selected process areas from CMMI to be applied in the system management level are those from project management category, level 2 and 3, and their definition according [8] are presented bellow.

PP – “The purpose of Project Planning is to establish and maintain plans that define project activities”.

REQM – “The purpose of Requirements Management is to manage requirements of the project’s products and product components and to ensure alignment between those requirements and the project’s plans and work products.”

PMC – “The purpose of Project Monitoring and Control is to provide an understanding of the project’s progress so that appropriate corrective actions can be taken when the project’s performance deviates significantly from the plan.”

SAM – “The purpose of Supplier Agreement Management is to manage the acquisition of products and services from suppliers.”

IPM – “The purpose of Integrated Project Management is to establish and manage the project and the involvement of relevant stakeholders according to an integrated and defined process that is tailored from the organization’s set of standard processes.”

RSKM – “The purpose of Risk Management (RSKM) is to identify potential problems before they occur so that risk handling activities can be planned and invoked as needed across the life of the product or project to mitigate adverse impacts on achieving objectives.”

PMI - Program Management and PMBOK

The proposal is to use The Standard for Program Management [16] as a general recognized reference and to match the PMBOK [17] process with CMMI model, for the system management level, using the CMMI and PMBOK mappings studies developed by SEI.

It is Project Management Knowledge and Project Management Process shown in Figure 5.

SYSTEMS ENGINEERING LEVEL

As said before CMMI is a maturity model and it was developed based on an extensive experience from DoD. Any organization that wants to develop highly integrated and complex safe critical systems is mandatory to understand the history and “body of knowledge on systems engineering” represented by a wide literature. It is essential to understand the standards EIA-632 [18] and MIL-STD-498 [19] (non certifiable software) and have proficiencies as proposed, as short example, by Eisner [20], Stevens [21], Sage [22].

CMMI Engineering Process

The selected process areas from CMMI to be applied in the system engineering level are those from engineering category, level 2 and 3, and their definition according [8] are presented bellow.

RD – “The purpose of Requirements Development is to elicit, analyze, and establish customer, product, and product component requirements.”

TS – “The purpose of Technical Solution is to select, design, and implement solutions to requirements. Solutions, designs, and implementations encompass products, product components, and product related lifecycle processes either singly or in combination as appropriate.”

VER – “The purpose of Verification is to ensure that selected work products meet their specified requirements.”

PI – “The purpose of Product Integration is to assemble the product from the product components, ensure that the product, as integrated, behaves properly (i.e., possesses the required functionality and quality attributes), and deliver the product.”

VAL – “The purpose of Validation is to demonstrate that a product or product component fulfills its intended use when placed in its intended environment.”

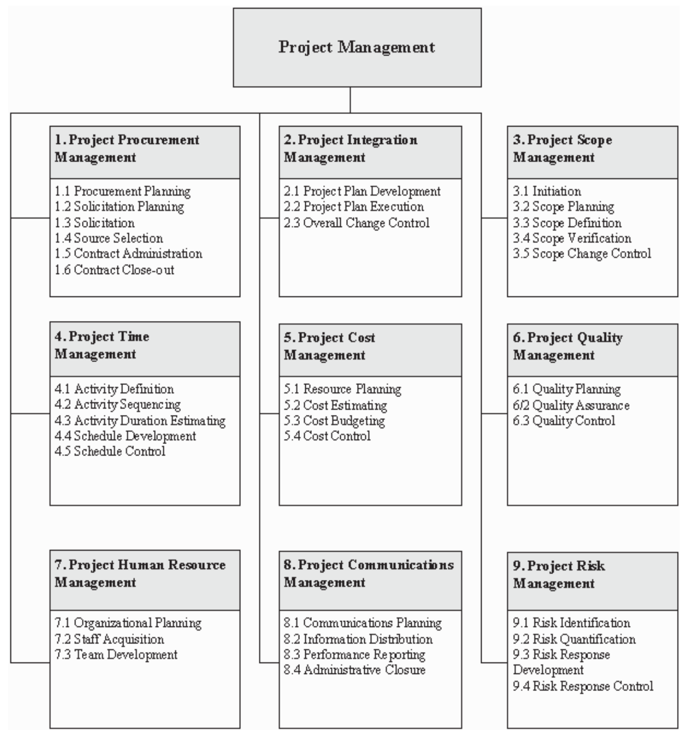

***Figure 5 – Overview of Project Management Knowledge and Project Management Process** (taken from PMI).*

CMMI Support Process

The selected process areas from CMMI to be applied in the system engineering level includes those from support category, level 2 and 3, and their definition according [8] are presented bellow.

CM – “The purpose of Configuration Management is to establish and maintain the integrity of work products using configuration identification, configuration control, configuration status accounting, and configuration audits.”

PPQA – "The purpose of Process and Product Quality Assurance is to provide staff and management with objective insight into processes and associated work products."

MA – "The purpose of Measurement and Analysis is to develop and sustain a measurement capability used to support management information needs."

DAR – "The purpose of Decision Analysis and Resolution is to analyze possible decisions using a formal evaluation process that evaluates identified alternatives against established criteria."

Specific Aerospace Process Areas

The Technical Solution process area from CMMI includes the activities to develop the specific aerospace process areas, but it is better to detach them according to SAE proposal, in order to have a clear certification process.

CC - Certification Coordination: The objective of the certification process is to substantiate that the vehicle and its systems comply with applicable worthiness requirements. In most situations the vehicle certification is accomplished through compliance with a series of system certification plans. Planning and coordination are vital to establish effective communications between the applicant and the certification authority and to reach agreement on the intended means of showing that the vehicle and its systems comply with worthiness requirements. One of the characteristics of highly-integrated or complex systems is the need to use development assurance methods as part of the evidence supporting system certification.

SA - Safety Assessment: The safety assessment process provides analytic evidence showing compliance with worthiness requirements. The process includes specific assessments conducted and updated during system development and interacts with the other system development supporting processes. The primary safety assessment processes are: Functional Hazard Assessment (FHA), Preliminary System Safety Assessment (PSSA), System Safety Assessment (SSA) and Common Cause Analysis (CCA).

BASIC PROJECT STRUCTURE AND GUIDELINES

The new product development is a group of related projects that we need control accordingly in order to have a "Program" control. Then we need to have some common control properties in all projects as necessity to provide program control.

Based on such impacts, we propose a basic project structure and guidelines to support the development of current and envisaged systems architectures, with a clear interface between the system engineering and system management levels, necessary project management data to implement the measurement and analysis to maintain the connections between indicators in all proposed management levels.

PROCESS VIEW

The proposal is to manage all development projects in an organization using the process view presented in Figure 6. It means that all projects must be organized in the first levels according to the process areas implemented. But there is something very important at this point, the process power (process budget) must be clear taken from project manage and transferred to each responsible for the process area. The process meaning is: the relations between people, tools and equipments, and methods and procedures. It means that the allocated resources for people training and motivation, tools and equipments and their definition, and methods and procedures development are responsibility of the area managers.

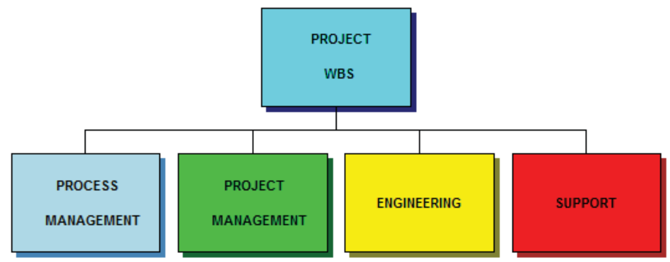

Figure 6 – Project view from process viewpoint.

ENGINEERING VIEW

The proposal is that under system view the project manger has the right to plan the system development using engineering view presented in Figure 7. The project management power is very clear: it controls the defined system components, the allocated financial resources, the allocated man hour according to his planned requirements, and the approved risk management resources. The project manager has the freedom to develop the project according to the defined an approved plan and presents the results using the organization indicators. Any modification out of the approved scope must be negotiated with enterprise management level when means resources and with process area managers when it implies in any process component: people, tools, and methods and procedures.

SYSTEM MANAGEMENT AND SYSTEM ENGINEERING INTERFACE

If we want control something, we need measure it. It means if we want control the organization in all levels we must have a clear set of indicators for all levels and the indicators from upper levels must be a function of lower level indicators. There are some indicators related to exclusive to one level. The enterprise management level control depends on the system management level control that is based on integrated information from all projects from the system engineering level. In order to integrate the information from all development projects it is necessary to have a common at least at same level.

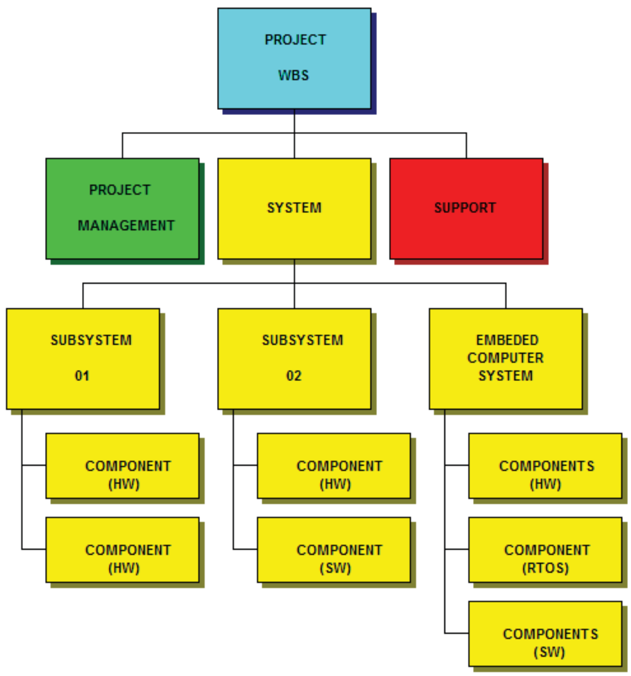

Figure 7 – Project view from engineering viewpoint.

The proposed project structure is presented in Figure 8. If we implement a management process that controls the facto the project we have the necessary information database to control an organization in the system management level and with more elaboration with necessary information for enterprise management control de facto.

SUMMARY/CONCLUSIONS

In this work we discussed current trends driving aerospace and automotive systems architectures and their impacts on CMMI® Organizational Structures. This included trends as: 1) pos-globalization and regionalization; 2) the formation of knowledge oligopolies; 3) commonality, standardization and even synergy (of components, tools, development process, certification agents, standards); 4) reuse and scalability, 5) synergy of knowledge and tools convergence; 6) cost pressure and innovation speed; and 7) environmental and safety issues; 8) abundance of new technologies versus scarcity of skilled manpower to apply them. Based on that we summarized their impacts on: 1) the aerospace and automotive systems needs and their system requirements, 2) the system development and certification standards (SAE-ARP 4761, SAE-ARP 4754, RTCA DO-297, RTCA DO-254, RTCA DO-178B/C, RTCA-DO-160), 3) the management levels of an organization (executive management, portfolio management and program management) 4) the applicable guidelines (CMMI®, OPM3®, BSC®) to organize and conduct them successfully. Based on such impacts, we proposed a basic project structure and guidelines to support the development of current and envisaged systems architectures, with a clear interface between the system engineering and system management worlds, necessary project management data to implement the measurement and analysis to maintain the connections between indicators in all proposed management levels. The guidelines discussed may help small and medium aerospace and automotive companies to adopt CMMI® as a reference maturity model. The proposed "standards package" may serve as reference to organize their business and to survive as suppliers of such current and envisaged aerospace and automotive systems architectures, especially the Standardization in Development Process Area. They included: Process focused organization (people, tools and equipments, methods and procedures), Managed organization (CMMI level 2 and PMBOK), Managed Engineering (CMMI level 3), Safe Critical Development (Specific Process Areas), System Management and System Engineering Interfaces.

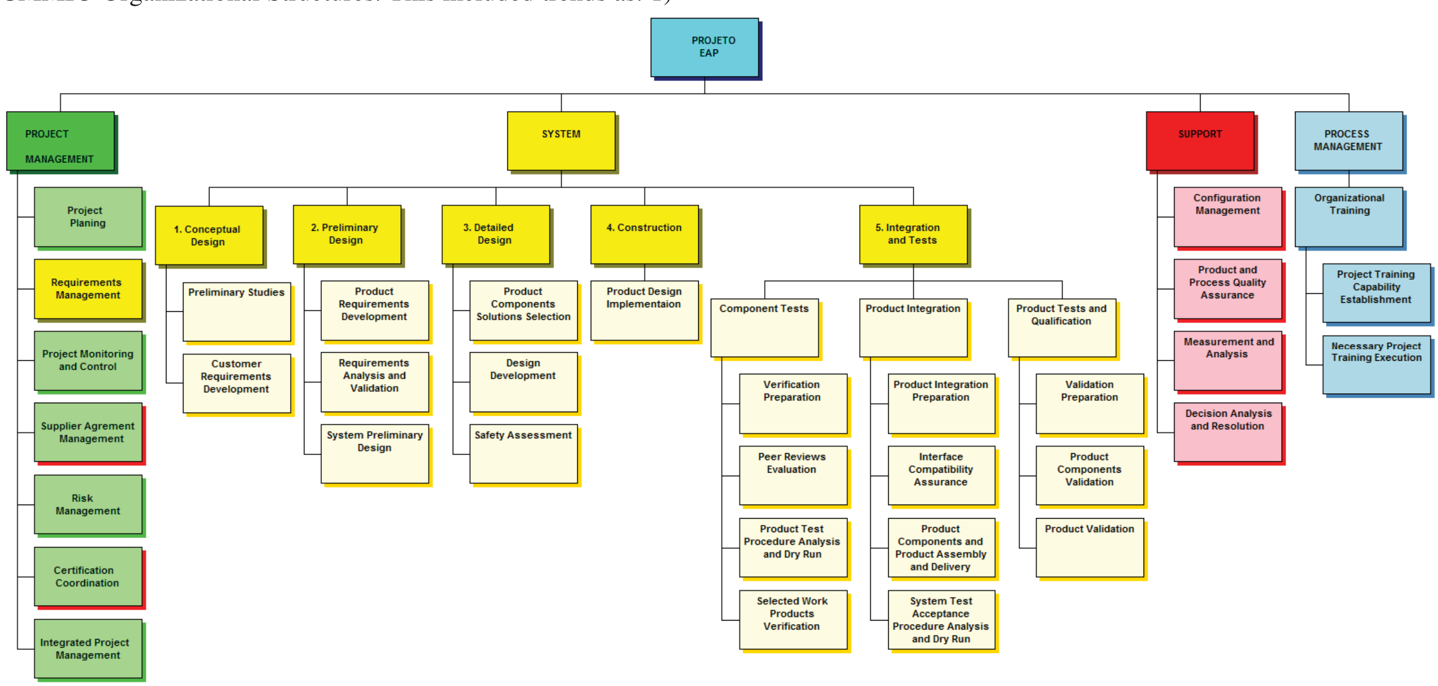

Figure 8 – The proposed interface between System Management and System Engineering.

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ACKNOWLEDGMENTS

The authors thank the National Institute for Space Research - INPE of Brazil, its Coordination of Space Engineering and Technology-ETE, its Division of Space Mechanics and Control-DMC, and the Coordination for Improvement of the Personnel for Superior Teaching–CAPES for providing them the necessary infrastructure to conduct the bibliographical survey for this paper, and for supporting the Laboratory of Computational Environments for Simulation, Identification and Modeling of AOCS (LABSYSTEMS) where this work was also done.

The second author also thanks: 1) INPE and Embraer S. A. for providing him an opportunity to work in big development projects and to access the great management experiences of their professionals; 2) Mectron EIC S. A. for the opportunity to manage the establishment of the Sensors and Avionics Business Unit based on CMMI maturity level three; 3) Vale Soluções em Energia-VSESA, NAVCON Navegação e Controle e Indústria e Comércio Ltda., and other aerospace companies for the opportunity to share experiences as an independent consultant and instructor; and 4) Homine Informática, Educação e Tecnologia Ltda. for supporting him during this work.

DEFINITIONS/ABBREVIATIONS

AIR – Aerospace Information Reports
ARP – Aerospace Recommended Practices
AS – Aerospace Standards
ASICs – Application Specific Integrated Circuits
BSC – Balanced Scorecard
CC – Certification Coordination
CCA – Common Cause Analysis
CM – Configuration Management
CMMI – Capability Maturity Model® Integration from SEI
COTS – Components Of The Shelf
DAR – Decision Analysis and Resolution
DO – Document Order at RTCA

DoD – Department of Defense of USA
DSPs – Digital Signal Processors
ED – EUROCAE Document
EIA – Electronic Industries Alliance
EUROCAE – European Organization for Civil Aviation Equipment
FAR – Federal Aviation Regulations
FHA – Functional Hazard Assessment
GOTS – Government Of The Shelf
IMA – Integrated Modular Avionics
IPM – Integrated Project Management
ISO – International Organization for Standardization
JAR – Joint Airworthiness Requirements
MA – Measurement and Analysis
MIL – Military Standards (MIL-STD)
MPs – Microprocessors
OPD – Organizational Process Definition
OPF – Organizational Process Focus
OPM3® – Organizational Project Management Maturity Model
OT – Organizational Training
PI – Product Integration
PLDs – Programmable Logic Devices
PMBOK – Project Management Book Of Knowledge
PMC – Project Monitoring and Control
PMI – Project Management Institute
PP – Project Planning
PPQA – Process and Product Quality Assurance
PSSA – Preliminary System Safety Assessment
RD – Requirements Development
REQM – Requirements Management
ROI – Return On Investment
RSKM – Risk Management
RTCA – Radio Technical Commission for Aeronautics
SA – Safety Assessment
SAE – Safety Assessment
SAM – Supplier Agreement Management
SEI – Software Engineering Institute from Carnegie Mellon®
SSA – System Safety Assessment
SST – Supersonic Transport
STD – Standards (MIL-STD)
TS – Technical Solution
USA – United States of America
V&V – Verification & Validation
VAL – Validation
VER – Verification