Key performance indicators for PLM benefits evaluation: The Alcatel Alenia Space case study

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Alemanni Marco(1), Grimaldi Alessia(1), Tornincasa Stefano(2), Vezzetti Enrico(2)
(1)Alcatel Alenia Space (Italy)
(2)Politecnico di Torino (Italy)

ABSTRACT

From a theoretical point of view, people are used to think that the adoption of innovative business solutions, for optimizing the product lifecycle, should always guarantee a sufficient return on the investment (ROI), even if the concrete benefits that the investment has given to the company are sometimes difficult to evaluate. Looking at the technical literature it is possible to find a lot of ROI ‘s estimation metrics for the evaluation of business strategies, even if after the analysis of the theorical concepts no one faces with a real implementation of the methodology proposed.

This paper proposes a solution, based on the Key Performance Indicator (KPI) method, for evaluating the benefits introduced by the adoption of a PLM tool in a one of a kind company. The methods have been validated with its implementation into an Aerospace and Defence company (Alcatel Alenia Space), highlighting the improvement created by the implementation of the PLM solution in the every day activities and showing the system’s contribution for some key-process as Configuration, Change and Documentation.

Key words: Product lifecycle management, Product Development management, Extended Enterprise, One-of-a-kind company, Collaborative Management

1.0 INTRODUCTION

The Product Lifecycle Management (PLM) [1,2] strategy is a solution addressing many components for managing the product data. It in fact involves products, organizational structure, working methods, processes, people and information system, integrating them altogether to obtain the best results. Starting from the product and its components the PLM strategy implementation focuses its attention on the analysis of the actors involved in the “extended enterprise” that will develop and support the product throughout its lifecycle. They could include contractors, suppliers, partners, but especially customers, all of them have probably different business architecture and complex organization structures and need to be integrated creating one only well organized structure around the product, especially because the strong integration that exists with the customer. In this scenario, PLM could give a great benefit to the enterprise, managing in a structured and organized way, all types of knowledge through the identification and integration of different information systems, able to support all the product concerning activities [3]. There are many types of systems doing this job as CAD (Computer Aided Design),CAM (Computer Aided Manufacturing),NC (Numerical Control), PDM (Product Data Management),virtual reality, customer complaint management systems, part library, change management system and the PLM allows the integration between all of them guaranteeing a correct access to all the information in the format that every actor involved in the product lifecycle needs. [4,5].

The implementation of the PLM strategy is a very long-period investment and the benefits are not measurable in the short period because of the long activities of introduction of improving working condition, the optimization of the workflow, the changing of the labour habits of the employees, their resistances to these changes, and the implementation of the PDM (Product Data Management) tool.

Another aspect that increases the complexity in the evaluation of the benefits given by the PLM introduction process, is its progressive implementation. In fact in the first phases of its adoption the PLM is only focused on a specific project, while later it will be spread on some other one, up to the point of being involved in all the company’s projects.

Anyway the benefits that can occur by the introduction of the PLM can be divided into two categories:

1. **Long term benefits**, that have got an influence directly on the business area and that can be expressed in terms of the increased gross margin, improved competitive position, reduction of Time to Market. These benefits that can derive from the increased of : customers numbers, product’s quality, purchase frequency can be due by the product structure management improving, by getting product to market faster and more frequently, by developing and delivering product faster, by removing burden overhead and adding more time available for value-adding task. These are visible and measurable only after several years after the introduction of the PLM strategy.

2. **Short term benefits** that can bring back from the reduction of time spent for the everyday activities, the way of working improving, the rationalization of the processes due to the improvement of the product structure management and the reduction of the overhead activities. These can be visible and measurable looking at the less range periods.

As the long term benefits could be visible only after several years, in the benefits evaluation it is important also to consider other parameters that can show the money time value and the cost reduction in the short term, as the decrease of the product materials numbers, the process energy consumption, the cost for storing information, the cost for document printing, the rework cost, time (as cost) for searching and identifying information, penalty cost for the product delivery delay.

In order to measure and to better understand if a new strategic asset could give significant advantages, it is necessary to implement an evaluation method able to analyse the benefits given by the PLM adoption to the company asset.

Looking at the technical literature, actually, not so many works have been developed on this topic. Some papers have analysed the return of investment given by the adoption of generic IT tools, oriented to data exchange and sharing, discussing about what relation could exist between the IT investment and the firm performances [6,7].

Some others have developed more particular analysis on specific solutions, close to the PLM strategy, as CRM,SCM and ERP, focusing the attention on financial returns [8,9]. Surely many documents have also discussed, with different point of views, about the benefits given by the ERP implementation in different types of companies [10,11]. But few papers have measured the impact or benefits given by the adoption of a PLM strategy. Some documents have been produced by specialized consultants talking about the effect of specific solutions [12] for particular sectors or more specifically in well defined case studies [13]. But considering the necessity to have a more wide evaluation model disjoined by a specific PLM solution and by a specific industrial sector this paper, focusing the attention on one-of-a-kind company asset, wants to implement an evaluation method able to analyse the enterprise performances trying to synthesize also the implicit operating objectives, such as the minimization of data management costs into a set of measurable variables, in order to give to enterprise management a structured performance feedback. Starting from the first works [14,15] discussing and proposing methodologies for the conceptual design and implementation of measurements to be employed for identifying the short-term production efficiency, that include financial and technological indicators, it is possible to consider these indicators as good parameters for efficiency estimation.

The terms of Balanced Scorecard, that’s a metric reporting system and the usage of KPI are famous in the literature as the main way to capture and measure the ROI especially for the business and marketing area, but recently it has been used also for the evaluation of IT investment.

The importance of indicators seems to be evident considering the necessity of the enterprise managers to identify relevant information about the company behaviour in order to face with fast and correct decisions starting from a huge amount of data that could be involved in the entire company process.

The choice of the metrics method usage is due to the typology of reduction cost the papers intend to analise. For instance underlining the costs associated to the project, as the initial cost of the PLM and the on going cost, it is possible to use some financial methods, as the Accounting Rate of Return, the Payback time, the Net Present Value and so on, but if it is necessary to evaluate the reduction cost and the revenue of the business in relation with the usage of PLM, it is necessary to employ metrics.

A performance indicator can be defined as “a variable that quantitatively expresses the effectiveness or efficiency, or both, of a part of or a whole process, or system, against a given norm or target” [16]. Key performance indicator (KPI), is a number or value which can be compared against an internal target, or an external target ‘‘benchmarking’’ to give an indication of performance. That value can relate to data collected or calculated from any process or activity [17]. Whether a company could move in an industrial context or in another, in choosing an appropriate range of performance measures, it will be necessary however to balance them, to make sure that one dimension or set of dimensions of performance is not stressed to the detriment of others.

The mix chosen will be different in almost every instance. As first assumption, considering that PLM adoption is a recent phenomenon and that it is continuously on the upgrade, only the induced benefit in the short period will be evaluated instead of the long period improvements, as reducing of time to market, increasing revenue and clients, increasing product quality, reducing change and cost, etc… that actually cannot be evaluated but that are anyway induced by the short period benefits.

So focusing the attention on the short period benefits, there are short-term measures which have to be continually calculated and reviewed. These measures can represent: business/financial performances, productivity measurement and efficiency indicator about human contribution [18,19]. Performance areas must be measurable, in the form of performance indicators in order for the company to be able to monitor performance and goal realization.

2.0 KEY PERFORMANCE INDICATORS MODEL DESIGN FOR ONE OF A KIND COMPANY

In order to implement a general KPI model for the PLM impact evaluation, first of all it is necessary to identify a set of significant indicators that could synthesize the company behavior.

2.1 KEY PERFORMANCE INDICATORS SELECTION STRATEGY

Despite PLM is implemented into all product lifecycle management components and covers a lot of functionalities (Requirement Management, Product Management, Data Management, Configuration Management, Change Management, Asset Management, Supplier Relationship Management) this first study has been focused only on two processes: **Data and Configuration Management** [20].

This choice is due to the fact that these processes have been the first involved, in order of time, by the adoption of the PLM because they represent the most critical ones inside the company. For this reason, in order to stress better the complexity of the PLM implementation, it has been decided to start from here the implementation of the strategy in order obtain a more significant information on the return of investment evaluation of the project.

Focusing the attention on a one-of-a-kind company asset the most important expected results given by an innovative strategy adoption, should be found in the data management functions (code assignments, release, distribution and data base registration) which are very expensive in terms of time and complexity, especially for some standards, as AASI, which requires a lot of documentation for each project (i.e. 8000 doc. approximately for each space program).

Starting from the technical literature on benchmarking analysis in the manufacturing context [21] it is possible to identify a lot of parameters but for the aerospace and defence market they will be choice as the main meanfull series of parameters (Tab.1,2,3,4,5) that could give an exhaustive synthesis of an enterprise behaviour ***(Quality, Time, Infrastructure, Communication and Cost)*****.**

KPI CODE	NAME	DESCRIPTION	PROCESS
KPI-Q-01	Product traceability	The introduction of configuration management facilities allows more accurate product information and traceability	Configuration Management
KPI-Q-02	Improved documental Management	Management function (revisioning, versioning and vaulting)	Configuration Management
KPI-Q-03	Drawing changes number	Average changes number implemented inside a drawing	Configuration Management
KPI-Q-04	Part list changes number	Average changes number implemented inside a part list	Configuration Management
KPI-Q-05	Change issue number	Average change issue duration	Configuration Management
KPI-Q-06	Change issue number on the total number	Elaborated change issues number	Configuration Management
KPI-Q-07	Suspended change request number	Change request suspended number	Configuration Management
KPI-Q-08	NCR number	Number of non conformal elements during a period	Configuration Management

Table 1: Quality Key Performances Indicators

KPI CODE	NAME	DESCRIPTION	PROCESS
KPI-T-01	Start up medium time	Average time for a project start-up	Configuration Management

KPI-T-02	Time to market	Complete product development time	Product Development
KPI-T-03	Average time for ECP processing	Average time for an Engineering Change Proposal (ECP) processing	Configuration Management
KPI-T-04	Acceptance necessary time	Delay time between the document creation and its accessibility by the users	Data Management
KPI-T-05	Average time for drawing acceptance	Average time for a drawing acceptance	Data Management
KPI-T-06	Average time for document change	Average time for a drawing or document change	Data Management
KPI-T-07	Average time for document distribution	Average time for documents distribution	Data Management
KPI-T-08	Document average acceptance time by customer	Average time spent for customer document approval	Configuration Management
KPI-T-09	Change request number that become change orders	Number of change requests that become change orders	Configuration Management
KPI-T-10	Average time to create a RFW to a customer	Time for creation and completion of a Request For Waiver	Configuration Management

Table 2: Time Key Performances Indicators

KPI CODE	NAME	DESCRIPTION	PROCESS
KPI-E-01	Carry-over components percentage	Percentage of previous projects component that could be employed without changes	Product Development
KPI-E-02	Purchased components percentage	Percentage of components that should be obtained by external suppliers	Product Development
KPI-E-03	Change cost before SSR	Average cost due to a change before the SRR (System Requirement Review)	Data Management
KPI-E-04	Change cost before PDR	Average cost due to a change before the PDR (Preliminary Design Review).	Data Management
KPI-E-05	Change cost before CDR	Average cost due to a change before the CDR (Configuration Design Review)	Data Management
KPI-E-06	Document storage cost	Average cost for paper document storage	Data Management
KPI-E-07	Document searching frequency	Average frequency which the documents are searching for with.	Data Management
KPI-E-08	Document searching time	Document searching cost	Data Management
KPI-E-09	RFW processing cost	Average cost due to Request for Waiver for each program	Configuration Management
KPI-E-10	RFD processing cost	Average cost due to the Request for Deviation for each program	Configuration Management

KPI-E-11	RFW number	Average Number of Request for Waiver for each program	Configuration Management
KPI-E-12	RFD number	Average Number of the request for Deviation for each program	Configuration Management
KPI-E-13	Major type NCR number	Average Number of Non Conformal Request for each program	Configuration Management
KPI-E-15	Document printing cost	Average cost for printing documents	Data Management
KPI-E-16	External suppliers printing cost	Average cost for printing and creating the .pdf of the document	Data Management
KPI-E-17	ECP number	Average Number of Engineering Change Proposal	Configuration Management

Table 3: Cost Key Performances Indicators

KPI CODE	NAME	DESCRIPTION	PROCESS
KPI-I-01	Drawing average access time from storage	It consider the different storage methodologies employed	Data Management
KPI-I-02	Information Technology platform ownership cost	Average cost for maintaining the infrastructure	Product Development
KPI-I-03	Part number delay time between Product and Process engineering	Average time before a part number moves to the engineer area to the production one and eventually all version created.	Product Development
KPI-I-04	PLM/PDM user number	How many user organized their work using the tool	Product Development
KPI-I-05	PDM/PLM Communication number	Haw many internal and external PDM/PLM accesses	Product Development
KPI-I-06	Activated workflow number	Number of process involved into the system through the using of the workflow functionalities.	Data Management

Table 4: Infrastructure Key Performances Indicators

KPI CODE	NAME	DESCRIPTION	PROCESS
KPI-C-01	Average document approval time by customer	Time spent to allow that a document generated by the company could reach the customer, is approved and the approval is communicated to all the interested	Product Development
KPI-C-02	Average drawing searching and transferring time	The average time necessary to find a drawing and to transfer it	Product Development
KPI-C-09	Documents number generated by ISO	Average number of document generated by ISO for an order	Data Management
KPI-C-10	Internal documents number	Average number of document generated by ISO for an order	Data Management

KPI-C-11	Internal drawings Number	Average number of document generated by ISO for an order	Data Management
KPI-C-12	External documents number	Average number of document generated by ISO for an order	Data Management
KPI-C-13	External drawings Number	Average number of document generated by ISO for an order	Data Management

Table 5: Communication Key Performances Indicators

Starting from these parameters, that describe a general purpose company behaviour, the proposed procedure selects, for every specific case study, those parameters more correlated with the specific scenario involved. This selection process could be implemented developing a survey between the personnel involved in the product life cycle.

Once analysed the survey results (Fig.1), it is possible to define a first list of indicators that could give a significant analysis of the company performances. But before measuring the values of the indicators selected in the specific scenario identified for the work, it is necessary to run one more selection process working on the previous list of indicators obtained by the survey. Every parameter, identified in the survey, obtains one more evaluation thanks to the presence of a series of indicators that will describe its *significance*, *measurability*, *reliability*, *feedback rate* and *visibility*. This further filtering step is necessary in order to guarantee that the data obtained is consistent but mainly, that the analysis can be developed and the parameters really measured. In order to obtain one unique score for every parameter every indicator will be combined with the others**.** At the end of this process every parameter will be characterised by a unique score obtained as combination of the different indicators value mixed by specific weights that describe the relative importance of one variable compared with the others in relation with the industry scenario involved.

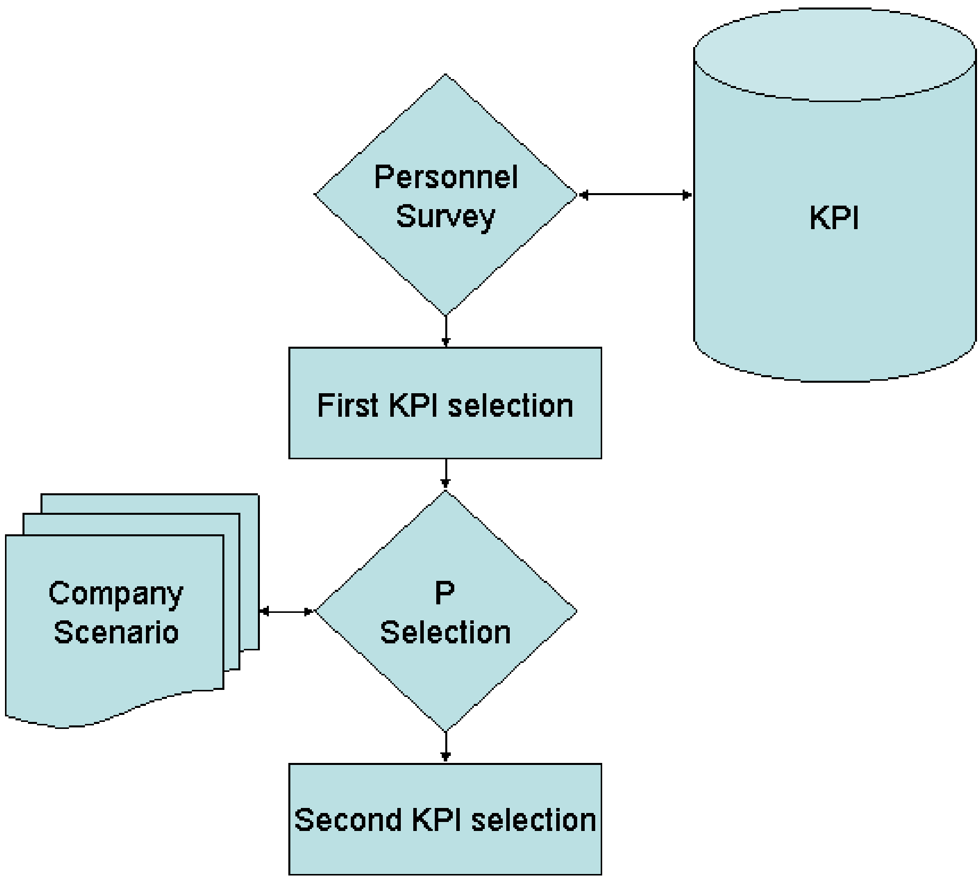

Figure 1: KPI implementation strategy

So by the combination of the variables ***S***,***M***,***R***,***F***,***V*** with their weight p_S, p_M, p_R, p_F, p_V it is possible to obtain the unique score *P* for every indicator with the following formula:

$$P = S \times p_s + M \times p_m + R \times p_r + F \times p_f + V \times p_v$$

- ***S* (Significance):** how much the indicator is correlated with the PDM introduction).
- ***M* (Measurability):** how much information is reachable to develop the measurement. Often some indicators show very high significance and their measurement would be very interesting but there is very little information about it due to the product complexity.
- ***R* (Reliability):** how much of the information obtained is correct and reliable
- ***F* (Feedback rate):** how quickly it is possible to develop analysis and data acquisitions
- ***V* (Visibility):** how much simple could the indicator be visible according to the long period making a program.
- P_S **:** relative importance of the variable ***S*** in the scenario analysed
- p_M **:** relative importance of the variable ***M*** in the scenario analysed
- p_R **:** relative importance of the variable ***R*** in the scenario analysed
- p_F **:** relative importance of the variable ***F*** in the scenario analysed
- p_V **:** relative importance of the variable ***V*** in the scenario analysed

In relation with the specific industry scenario, in which the benchmarking analysis is developed, the values of these weights could change (Tab 6).

Variable	Weight
Significance	1-10
Measurability	1-10
Reliability	1-10
Feedback rate	1-10
Visibility	1-10

Table 6: Usefulness weights ranges

Then in order to consider only those most useful indicators**,** it is possible to select only a portion of the different indicators introducing a threshold (Tab.7).

Family	Value
Low – Level	6
Middle Low - Level	7
Middle – Level	8
Middle High – Level	9
High – Level	10

Table 7: Significance Threshold Definition

After the selection of the most useful indicators for the benchmarking analysis, it is possible to develop their measures, comparing the data collected where the PLM has not been adopted with those where the PLM has been introduced and integrated in the company asset.

3.0 ALCATEL ALENIA SPACE ITALIA CASE STUDY

In order to validate the KPI model designed, a case study has been implemented involving the PLM project of Alcatel Alenia Space Italia.

3.1 "WAND" The Alcatel Alenia Space PLM architecture

Alcatel Alenia Space Italia is a Joint venture, between Alenia Space and Alcatel, born on July 2005 and represents the most important Italian space industry and is third in the world. The company has wide experience in space systems design development, assembly and testing starting from satellites for telecommunications till arriving to remote sensing meteorology and scientific applications. Considering the complexity of the products developed and the enterprise dimension, it has been decided to develop a PLM platform to improve the product data management during all the life cycle stages.

Starting to work on a commercial platform PTC-Windchill [22] the project **WAND *(Wide Alenia space Network Data)*** [23] has implemented a web based tool able to embrace all the functionalities required by the firm and by **International Standard Organisation (ISO**) and **European Collaboration on Space Standardisation (ECSS)** standards (Fig.2)[24].

Considering that Alcatel Alenia Space produces customised products, strong attention has been given to the product description system in order to assure an efficient data sharing activity between the customer, company and partner. As a consequence of the difficulties that normally the introduction of a new tool has in a traditional company, that is modifying its asset from a functional organisation to a net one, the project has been subdivided in different steps. In the first phase the platform architecture has been studied and designed.

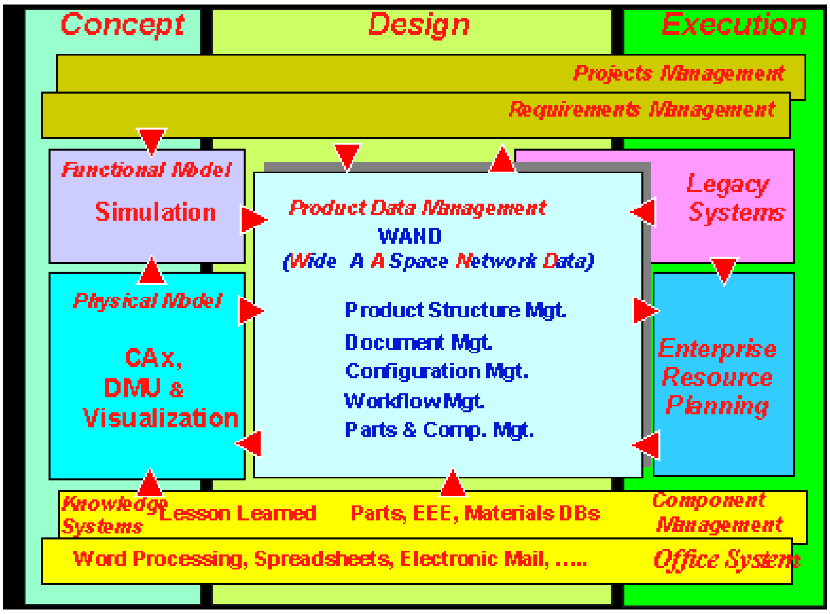

Figure 2: WAND architecture

In the second one the data vaulting functionalities, that allows document insertion and control and some workflow activities, have been implemented, the third phase has been used for the part management, EBOM (Engineering Bill of Material), CAD integration, models visualisations and the baseline management, while in the last phase the developed platform has been integrated with the ERP system, with the requirements management system and the legacy one (Fig.3).

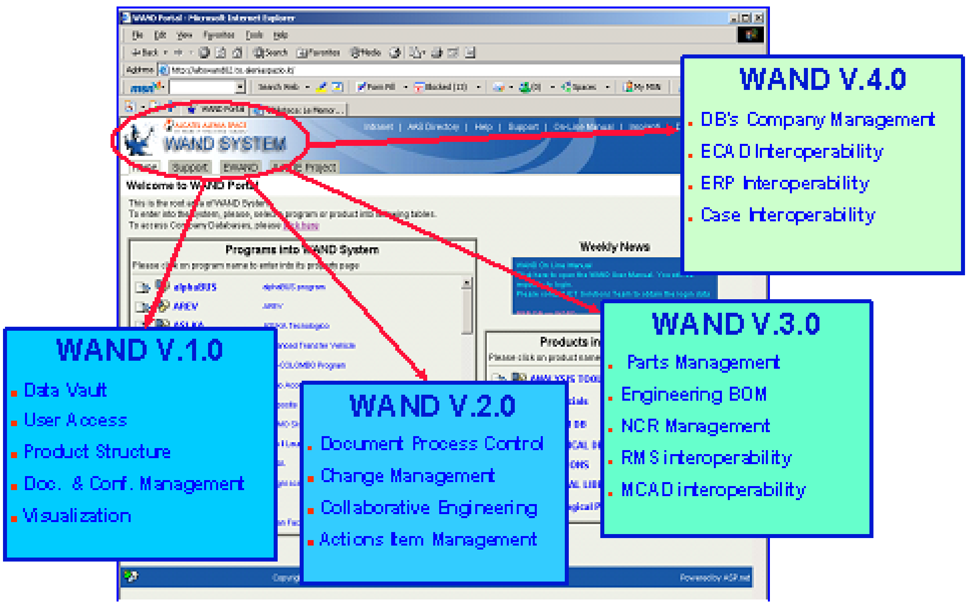

Figure 3: WAND functionalities and development phases

Following the rules declared in the ECSS standards and the base model of the product tree that represents the product data structure, WAND has been developed with a part and product structure management system. This tool includes all the configuration management tools and allows creating links between **parts, components, product items (PI)**, **configuration items (CI)**.
Thanks to this structure WAND is able to show all the relationships between the product item (PI) and the configuration item (CI). WAND allows also seeing different product views, “As designed”, corresponding to the EBOM (Engineering bill of material) or “As built”, corresponding to the PBOM (Production bill of material). This functionality is very important for the collaboration of every function (engineering, production..)
In fact the most important features of WAND is the “interoperability” with the other systems, it means that WAND supports different processes and functionality (supported by other systems), and at the same time the users can use all information’s locate in difference systems (Fig.4).

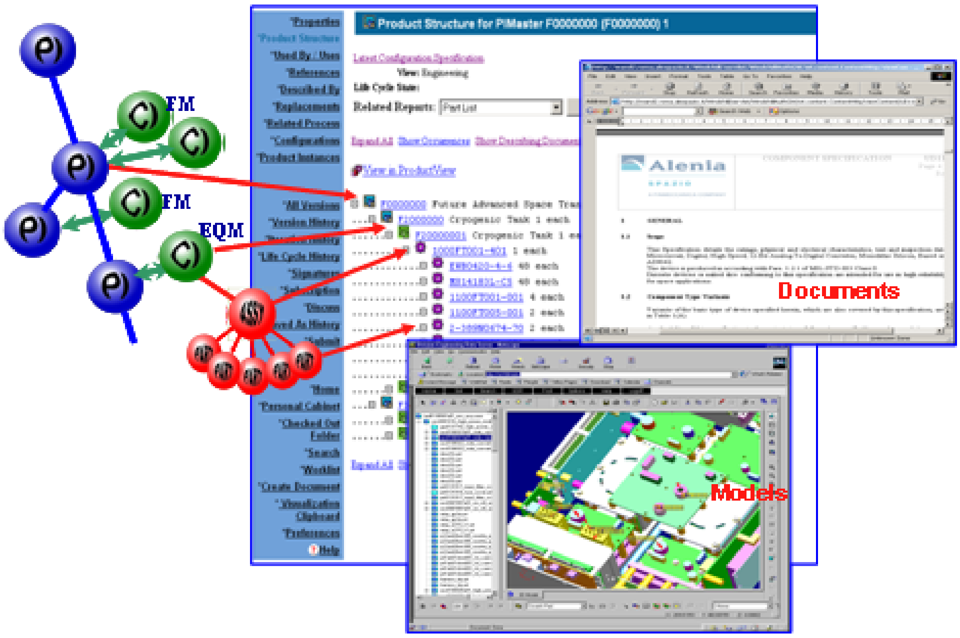

Figure 4: An example of WAND Product Tree visualisation

It supports the configuration activities of establishing and maintaining a consistent record of product functionalities and characteristics and comparing them to the requirements, during the lifecycle of the product.
The lifecycle of the product as explained in the standard ECSS (ECSS-M-40B) could be summarized as following sequence based on the baselines:

- Mission objective baseline (MOB) is established at PRR (Preliminary Requirement Review) based on the approved functional specification. This baseline establishes the purpose of the system, its associated constraints and environments, the operational and performances capabilities for each phase of its life cycle, and the permissible flexibility. It involves the mission analysis and the feasibility activities.

- Functional configuration baseline (FCB) is established at SRR (System Requirement Review) based on the approved system technical specification. This baseline establishes the system’s characteristics in terms of its technical requirements, as well as the criteria and corresponding levels of qualification and acceptance. It involves the preliminary definition activities.

- Development configuration baseline (DCB) is established at PDR (Preliminary Design Review) based on approved technical specifications (TS). This baseline establishes the product’s characteristics in terms of technical requirements and design constraints, architectural design, as well as their verification conditions.

- Design baseline (DB) is established at CDR (Critical Design Review)based on the approved design documentation. It involves the detail design activities, software implementation, integration and test activities.

- Product configuration baseline (PCB) is established at FCV/PCV (Functional Configuration Verification/Physical Configuration Verification) for serial production, or QR/AR (Qualification Review/Acceptance Review) for prototypes based on the approved set of documents containing all the functional and physical characteristics required for production, acceptance, operation, support and disposal.

Every configuration baseline contains all the documents about the products and its characteristics.

3.2 *KEY PERFORMANCE INDICATORS EVALUATION*

During the analysis of the PLM impact on the Alcatel Alenia Space activity four different projects have been considered (**ATV**, **NODO2**, **NODO3** and **MPLM**)**,** in order to reach the necessary information for benchmarking activity. The programs NODO 3 and ATV have been managed inside the PLM strategy, while the other two have been managed without PLM. It has been necessary to work with similar projects only, because this company works on customer oriented projects, so it is impossible to develop a benchmarking procedure over same products.

- **MPLM** is pressurized module employed as container to move to spatial station replacement components. This module has been developed in three different models, two of them are already in orbit, while the third is employed for replacement components. The module is composed by one only door that is employed to be connected to the spatial station and is composed by three parts: a structural and mechanical one, the avionic system, and the thermal and environmental monitor components.
- **NODO3** is a cylinder with four radial parts and an axial door necessary for the shuttle connection. This module is employed for power transfer to other modules and for astronaut survival. The NODO3 is composed by different racks, as for instance APS, that remove the CO_2 and develop the atmosphere monitoring, or the OGS that control the oxygen, the WRS that manage the drinkable water or the WHC that manage the physiological needs. Some of these modules are installed during the module launch while others are only added when the module is already in the orbit. In the NODO3 module it is possible to identify three components: the mechanical system, the avionic and the thermal one. This module is still under construction.
- **NODO2**, has the same functionalities NODO 3 but has some little more innovations.
- **ATV** is a capsule that gives logistic functionalities to a spatial station. ATV will be employed in about ten years. This module is composed by two main elements: the pressurized module and the fluid storage (water, gas …). The module contains also the electronic commands the racks employed for the furniture of water, gas and other products (Fig.5)

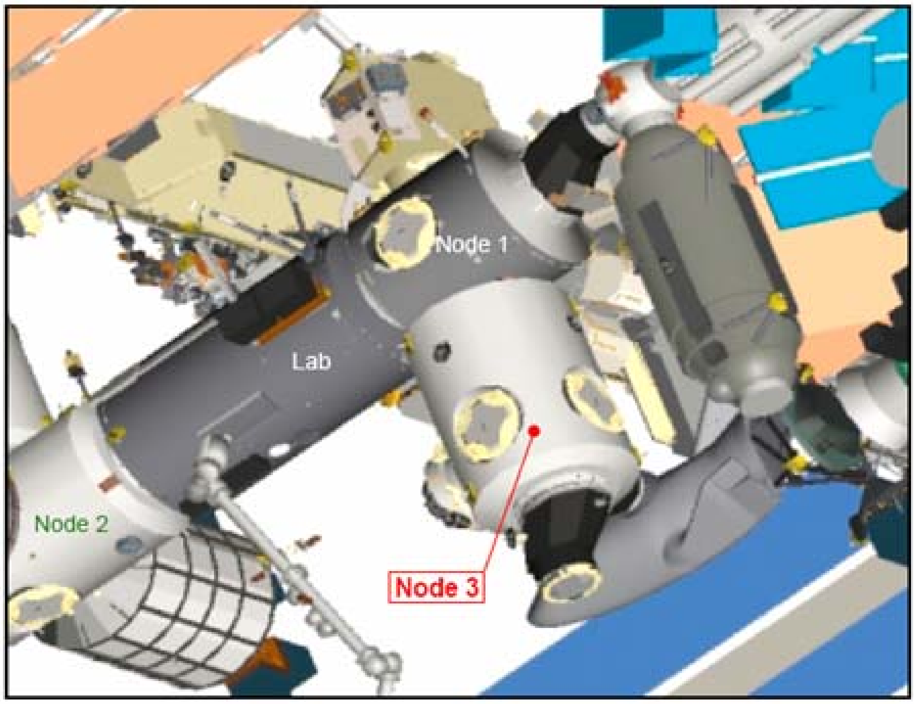

Figure 5: Particular of the International Space Station.

The first step of the benchmarking activity have been developed implementing a survey between the technical operators involved in the different project development. From the results got from the survey the indicators selected for the **change management** process have been: **Number of non Conformal elements (NCR)**, **Request of Deviations (RFD)** and **Request of Waiver (RFW)** with their costs and times in order to understand if the PLM adoption is able to move in advance, in the first project conceptualisation phases, a significant quantity of changes. For the **data management** process the indicators selected analyse the time employed for document distribution, document change or document approval.

Considering the complex scenario of Alcatel Alenia Space the indicators selection has been developed setting the relative importance of the criteria (weight) (Tab.8) with great attention to significance and measurability, often very difficult in a company as Alcatel Alenia Space and less importance for visibility and feedback rate. Working on the score obtained by the different indicators and trying to identify only the most useful ones the first indicators employed have been ***changes number***, **KPI-E-11** ***request for waiver (RFW)***, that represents hardware changes, obtained for example for the presence of a non conformity referring to the original customer specifications, and **KPI-E-12** ***request for deviation (RFD)***, that represents specifications changes and **KPI-E-17** ***engineering change proposal (ECP)*** that represents the answer to the customer specification change requests.

Variable	Weight
Significance	10
Measurability	10
Reliability	6
Feedback rate	4
Visibility	2

Table 8: Usefulness weights values

Comparing the values of these first criterias between those projects where the PLM has been involved and those where the PLM has not been involved, the number of **RFW** and **RFD** has been decreased by 50% obtaining, as a consequence, a significant reduction of cost and work connected. In order to understand better where this reduction has been obtained inside the project development, because it is very important to be able to locate the most in advance possible RFW,RFD and ECP, three milestones have been fixed. The ***Preliminary Design Review (PDR)*** represents the first milestone to respect in which the company should have defined the documentation to be produced. The ***Critical Design Review (CDR)*** is the second milestone that needs the 80% of the constructive drawings describing with detail the manufacturing product. The last milestone is represented by the ***Final Acceptance Review (FAR)*** in which all the customer specifications are controlled in order to verify if they have been respected. Comparing the results obtainable with and without the PLM it is possible to see (Fig.5) that the number of changes decreases in the last phase meanwhile increased in the previous ones.

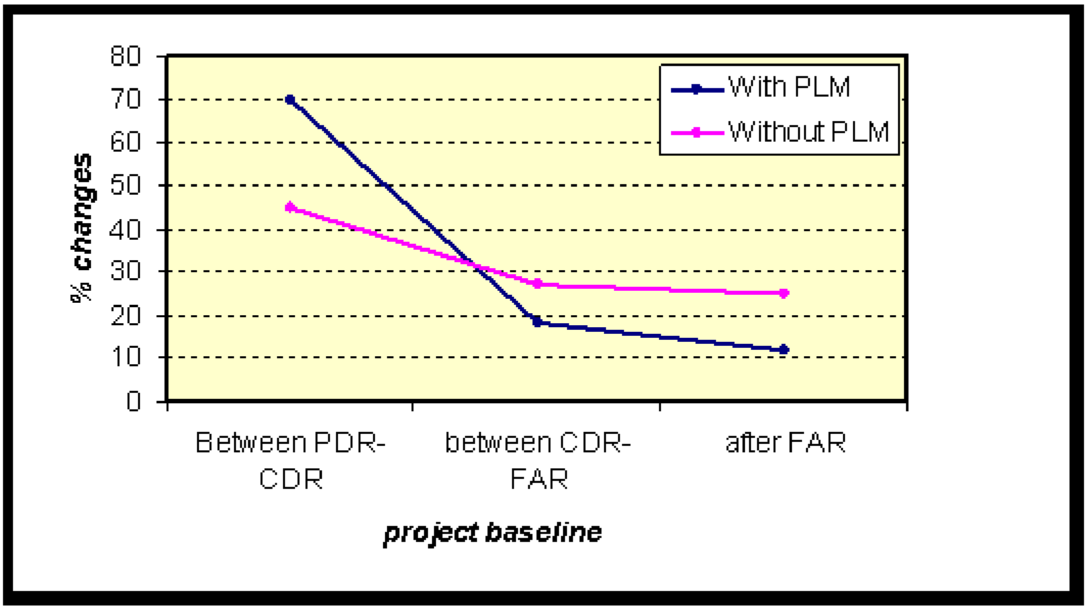

Figure 6: Number of changes along the project milestones

Going ahead in the measurement of the indicators obtained from the selection process (Tab.9) some measures of time have been developed. Normally as a consequence of the evaluation of customer requests an **Engineering Change Proposal (ECP)** is generated (technical proposal from the engineering department) and it will be validated by the customer. If the customers accept the proposal he will do a specific order called “**Engineering Change Order” (ECO)**. Looking at the results obtained by the comparison between a project developed with and without the use of PLM strategy the time reduction evaluated is around the 40% and mainly due to the reduced time necessary for the document flow management. Also the presence of a reliable workflow management system has introduced a reduction of the 14% of the personnel engaged in the process. Before the WAND implementation some problems about the specification management appeared because there was a certain uncertainty about the documentation creation for the customer at specific milestones. Considering that the customer asks many documents proving the respect of the specification asked, the efficient production of specific technical document is important. More than this it is very important for the customer to receive the change proposal in advance in order to have more time to analyse the changes and reduce in this way other changes necessities or eventually mistakes. Focusing the attention on the time necessary to start a Request for Waiver (RFW) the presence of WAND has assured a reduction of the 30% thanks to the reduced number of operations asked to the personnel in the document management.

Engineering Change Proposal (ECP)	WAND before	WAND after	Saving %
KPI-T-03			
Average time for a Space Station Change Notice evaluation	2,5 months	2,5 months	/
Average time to finalise an ECP	2,5 months	1,5 months	**40%**
Number of team member engaged in the process	7	6	**14%**
Team member time spent for an ECP	25 hours	25 hours	/
Average time spent for an ECP	175 hours	150 hours	**14%**
Man hours for a set (15) of 30 ECP	5250	4500	**14%**

Table 9: Processes comparison before and after the WAND implementation about ECP

Other time could be saved thanks to the presence of a workflow team composed by Engineering, Quality Manager and others that are stimulated, on screen, to move ahead the document in its workflow. This improved efficiency of the team gives the possibility to parallelize more activities at the same time, to respect the customers’ requests faster, reducing the document control time. All these aspects have allowed a time reduction for RFW of 60% (Tab.10).

Request For Waiver (RFW)	WAND before	WAND after	Saving %
KPI-T-10			
Average time for generating a RFW for a costumer	30 days	21 days	**30%**
Number of team member engaged	5	4	**20%**
Average team member time spent for a RFW	36 hours	24 hours	**33%**
Average time spent for a RFW	180 hours	96 hours	**47%**
Average time for star-up processing	4 days	2 days	**50%**

Table 10: Processes comparison before and after the WAND implementation about RFW

The samples employed for this last analysis has shown a significant time reduction, justified by some resources duplication erase and by a better management of the change process thanks to the workflow system.

The second part of the key performance indicators analysis wants to evaluate the advantages obtained in **the documentation management** activity. In this context the main problem is represented by the difficulty of finding the electronic copy of the document instead of the paper ones. Normally in fact the documents generation time is very long and its tracking becomes difficult. Since the introduction of WAND (Tab.11) the average waiting time has been reduced of 60% considering that the document distribution was a manual activity.

KPI	WAND before	WAND after	Saving %
Average time for document distribution (**KPI-T-07**)	4 days	1 day	**75%**
Average time for a document change (**KPI-T-06**)	3 days	1 day	**67%**
Average time for document approval (**KPI-T-04**)	7 days	4 days	**43%**

Table 11: Document Data Management

Considering the man hours saved from WAND adoption in the different projects considered, with a team group composed by 50 members and an average user document production of 2 documents per day, it is possible to obtain a project time reduction of 16%.

Focusing the attention on costs saving there is a correlation with the possibility to avoid the engagement of an external supplier for the pdf document production from the paper ones. Supposing a cost of 0,03 € for a page it is possible to make a consistent comparison between the previous situation and the new one with WAND. With the WAND introduction it is only necessary to print the first document page in order to allow its subscription with personal signs, the cost benefits due the reduction of the copies cost, papers have been estimated around the 90%.

4.0 CONCLUSION

The introduction and the implementation of PLM in a one-of-a kind company usually requires a lot of resources and time (2/7 years) because it involves all the process and changes the way of working of the company. The benefits of its introduction are then visible and measurable during the years. Moreover the duration of each project (sometime until nine years before the launch of the space module) makes the possibility to analyze and formalize the performance of the instrument harder than in a company working with standard and serial production. According to these difficulties and these variables, it has been tried to create a procedure to study the process more involved by the system and at the same time looking for some good results giving some number to quantify the benefits that are already visible and noticeable in everyday working.
Starting really from the benefits of everyday working, the KPI discovered and measured have highlighted a lot of improvements in terms of cutting cost, time and better management of the program visible in the short term. But if we project in the time the results obtained, they will show as more return of investment as the system seep into the company.

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