Universidad Carlos III de Madrid

Electronics Technology Department

FINAL PROJECT

Guided Process across Project Management;

Preliminary phase: Contract Preparation

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ABSTRACT

Guided Process across Project Management; Preliminary phase: Contract Preparation

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This final project establishes and describes the necessary steps for to apply common processes in the Aeronautical Project Management.

The main objective is to detail all project management processes to be considered for development projects in the concept, definition and development phases (full project lifecycle). The Project Management processes described would be applicable to every kind of project, adapting those processes depending on the nature of the project itself.

In particular, this has been performed for UAV (Unmanned Air Vehicle) Programme, and therefore the Project Management Processes are described for the UAV Project as they have been/are being applied.

It is important to note that many of the processes within project management are iterative in the progressive elaboration throughout the project's life cycle. Project Management is one of the Integral Sub-Processes defined in the Vee model, therefore this activity is essential during all project, not only in a preliminary phase.

To be fully understood all processes group UAV programme will function as an example.

Keywords: Project Management, Processes Groups, Project Set-Up, WBS, SoW, Master Schedule, Milestone, Risk.

ACKNOWLEDGMENTS

I would like to make a special mention of my family; thanks to them I can do what makes me happy. Thanks for being there.

I would like to thanks Mr. Bernardo Delicado.

TABLE OF CONTENTS

LIST OF FIGURES

1. OBJECTIVE

The aim of this document is to provide a complete vision of project management, and develop a group of standard processes.

The purpose of this specific project is to apply common processes in the Aeronautical Project Management following one methodology that can be successfully applied, Verification and Validation Model.

2. INTRODUCTION

The prospects for the near future do not show a new major aircraft programme on the horizon. The expected unmanned aircraft and mission aircraft programmes will not have the financial volume like the manned combat aircraft programmes. Therefore, projects need to be acquired that are much smaller than the aircraft development programmes of the past.

For smaller projects, it is not feasible to define project specific processes from scratch for various reasons:

- The effort to be spent for the creation of project specific processes is too high relative to the overall project volume.
- Shifting engineers between programmes requires a significant amount for training to learn the project specific terminology and processes.
- The risk that defined processes are not effective or not efficient resulting in degraded competitiveness.

This project will try to fulfill the following objectives:

- ✓ Provide an overview what Project Management consists on.
- ✓ Define the process breakdown of the overall project management processes, with special emphasis on Project Set-Up.

- ✓ Clarify the common terminology used with definitions and explanations contained in this document.
- ✓ Detail all process management processes to be considered for development projects in the concept, definition and development system life cycle phases.

Nowadays Unmanned Air Vehicle (UAV) is considered the future of the aviation by determinates application; therefore this type of programme will function as an example.

3. VALIDATION AND VERIFICATION (V&V) METHODOLOGY

The generic system life cycle defines the six life cycle phase's concept, definition, development, production, in service and disposal.

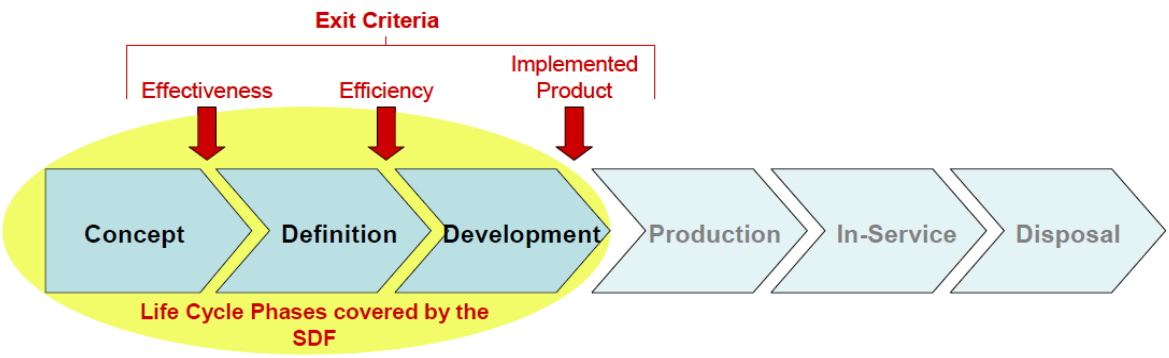

Figure 1: The Generic System Life Cycle

In the concept phase, solution alternatives for existing or evolving customer needs are evaluated in the applicable mission scenarios. The outcome of the concept phase is the selection of a preferred solution for which the effectiveness that the intended missions will be.

When the definition phase is completed a prognosis of the system efficiency has to be available. At this stage all stakeholder needs must be analyzed and the operational concept

must be fully defined. A complete and consistent set of requirements for the system must be available.

The development phase translates the system requirements into the real system. This may include the manufacturing of prototypes. Usually, the effort to be spent for implementing the requirements exceeds the effort for the concept and definition phases by far.

The production phase is concerned with series production and the establishment and operation of the necessary production environment.

The in-service phase comprises the time span in which the system is performing its intended missions.

After the end of the operational life, the disposal phase concludes the system life cycle.

Particularly during the Concept and Development Stages the Vee model (V-model) is used to visualize the system engineering focus. The Vee highlights are:

- the need to define verification plans during requirements development.
- the need for continuous validation with the stakeholders.
- and the importance of continuous risk and opportunity assessment.

The V-model provides a useful illustration of the SE activities during the lifecycle stages. The System Development Framework (SDF) process breakdown makes a distinction between development sub-processes and integral sub-processes (Figure 2).

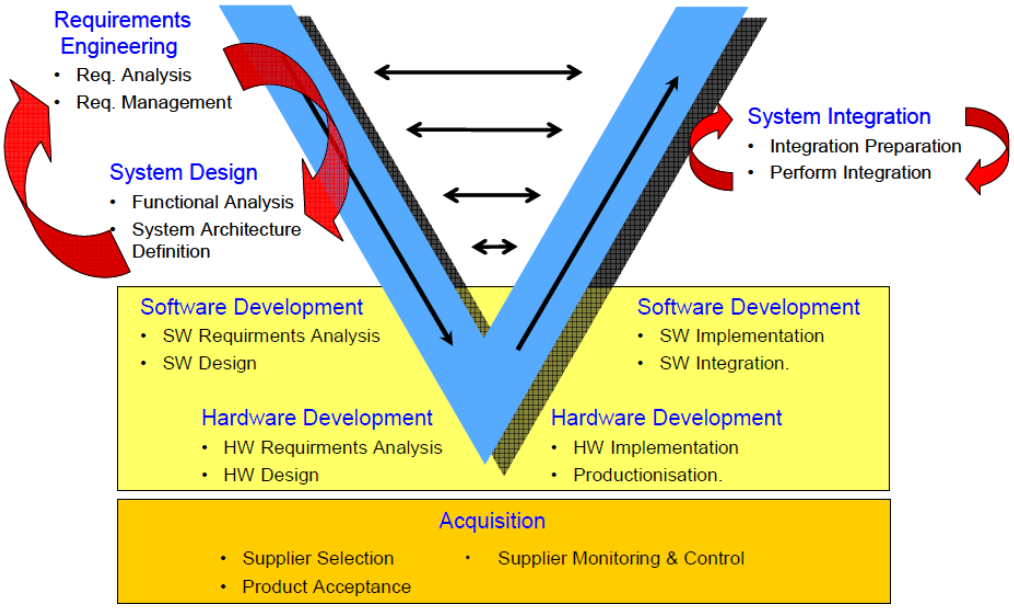

Figure 2: V&V Model. Development Sub-Processes

Development sub-processes comprise the design, the implementation and the integration of systems. Integral sub-processes are invoked across the project when the development sub-processes are performed.

The development sub-processes may be arranged in the V-model as illustrated in Figure 3.

Figure 3: SDF Process Breakdown. Development Sub-processes

In the left part the system design is detailed. For each system level, the sub-processes Requirements Engineering and System Design are performed. The number of system levels is not predefined. It depends on the complexity of the system how many system levels are appropriate.

Development starts on the highest system level. This may be an airborne system in a network environment, an airborne platform alone, or just a sub-system like avionics or flight control supplied to another party. When the requirements allocated to the system are analyzed, system design defines the systems on the next level below and allocates requirements to these sub-systems. This process is recursively repeated on the lower levels until hardware or software development can be commenced.

Alternatively to hardware and software development, a sub-process Acquisition is defined. This sub-process may be entered when the development of hardware or software, a combination of both or a system is sourced out to other parties.

In the SDF, the sub-process Acquisition is more limited in its scope because it only covers the technical aspects. The procurement activities run not under the lead responsibility of engineering. Engineering supports the procurement department with their technical knowledge.

The right side of the V-model is dedicated to the sub-process System Integration. System Integration starts on the lowest system level and is recursively performed until the complete top level system is integrated. The number of integration steps parallels the number of system levels.

Figure 4: SDF Process Breakdown. Integral Sub-processes

The integral sub-processes are:

• Certification

• Configuration Management

- Process Assurance
- ***Project Management***
- Qualification
- Safety Assessment
- Security Assessment
- Validation
- Verification

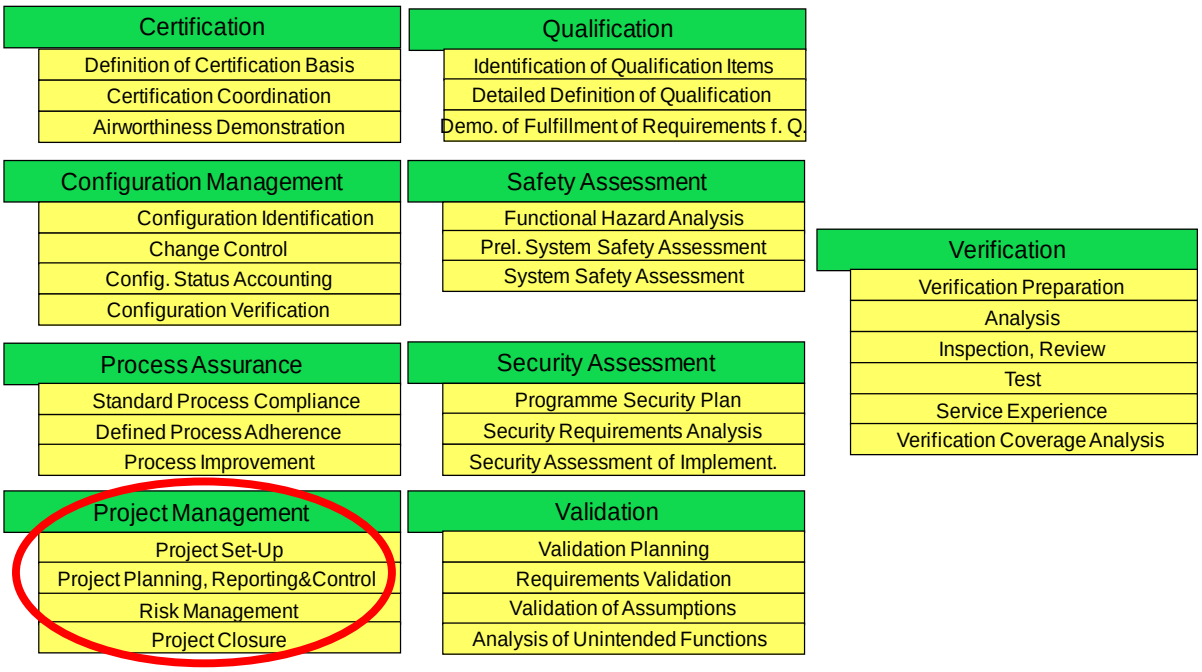

Figure 5: Integral Sub-Processes

Project Management comprises the management of the technical processes including project set-up, project planning, reporting and control, risk management and project closure. All this processes will be explained in detail in Chapter 4 and illustrated as an example the UAV Programme in Chapter 5.

Regarding quality project management is dependent from the outcome of integral processes including verification, validation and process assurance.

An overall overview about Project Management, in the Vee Model, is shown below (Figure 6):

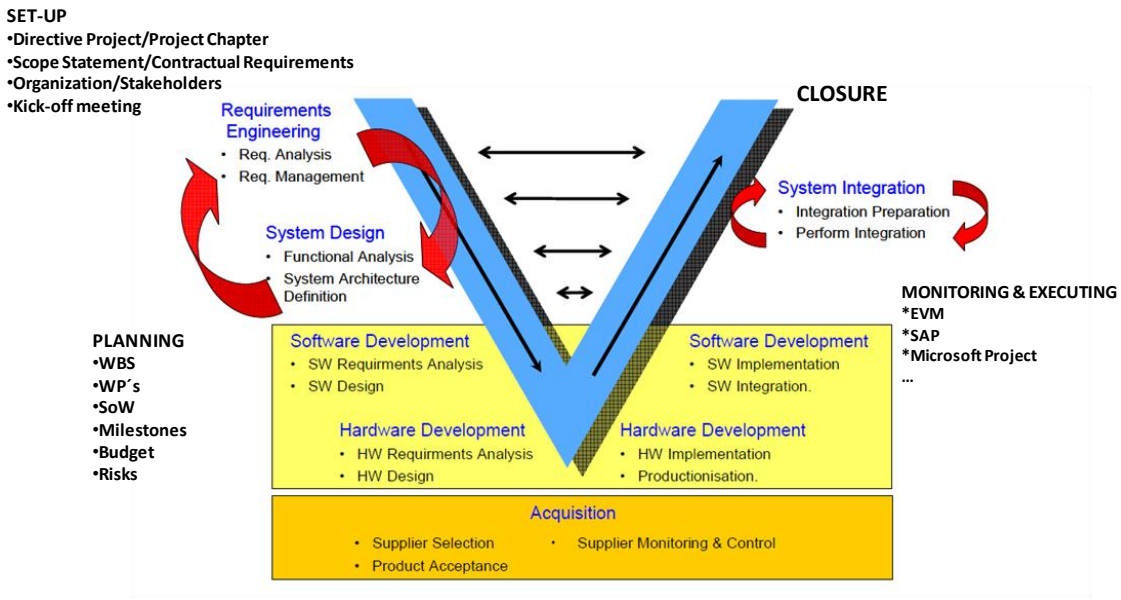

Figure 6: Project Management in the Vee Model

Also an overall overview UAV Programme, in the Vee Model, is shown below (Figure 7):

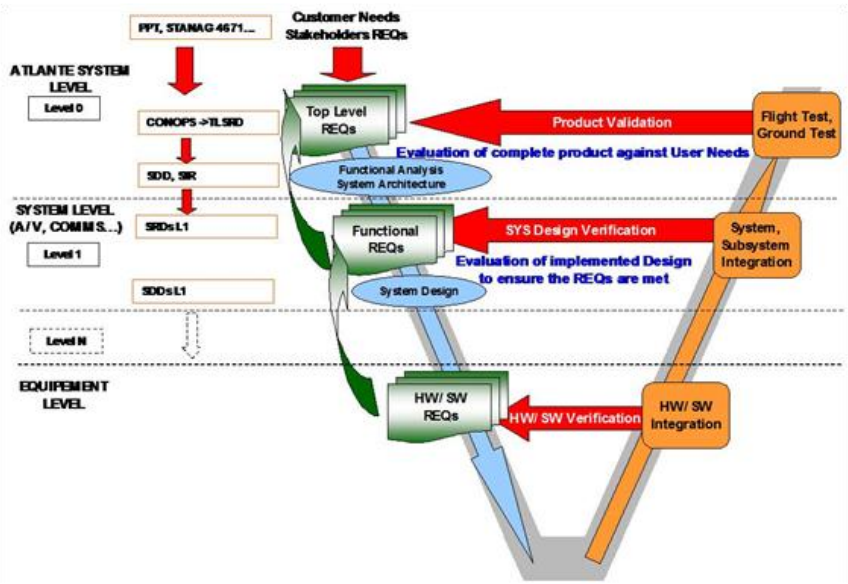

Figure 7: UAV Programme, Development Processes

4. INTRODUCTION TO PROJECT MANAGEMENT PROCESS GROUPS

The target of this chapter is to explain theoretically the Project Management Process Groups, so that when illustrating in chapter 5 a real case, UAV Programme, will be fully understood.

Project management is the application of knowledge, skills, tools and techniques to project activities in order to meet project requirements.

The most important characteristics that must be taken into account are:

• Identifying requirements.

• Establishing clear and achievable objectives.

• Balancing the competing demands for quality, scope, time and cost.

• Adapting the specifications, plans, and approach to the different concerns and expectations of the various stakeholders.

It is very important the “triple constraint”—project scope, time and cost—in managing competing project requirements. Project quality is affected by balancing these three factors. High quality projects deliver the required product, service or result within scope, on time, and within budget. The relationship among these factors is such that if any one of the three factors changes, at least one other factor is likely to be affected.

It is important to note that many of the processes within project management are iterative because of the existence of, and necessity for, progressive elaboration in a project throughout the project’s life cycle. That is, as a project management team learns more about a project, the team can then manage to a greater level of detail.

The project management processes, common to most projects most of the time, are associated with each other by their performance for an integrated purpose. The purpose is to initiate, plan, execute, monitor and control, and close a project. These processes interact with each other in complex ways.

Project management is an integrative undertaking. Project management integration requires each project and product process to be appropriately aligned and connected with the other processes to facilitate their coordination. These process interactions often require tradeoffs among project requirements and objectives. A large and complex project may have some processes that will have to be iterated several times to define and meet stakeholder requirements and reach agreement on the processes outcome. Failure to take action during one process will usually affect that process and other related processes. Successful project management includes actively managing these interactions to successfully meet sponsor, customer and other stakeholder requirements.

This project describes the nature of project management processes in terms of the integration between the processes, the interactions within them, and the purposes they serve. These processes are aggregated into five groups, defined as the Project Management Process Groups and constitute the project life cycle:

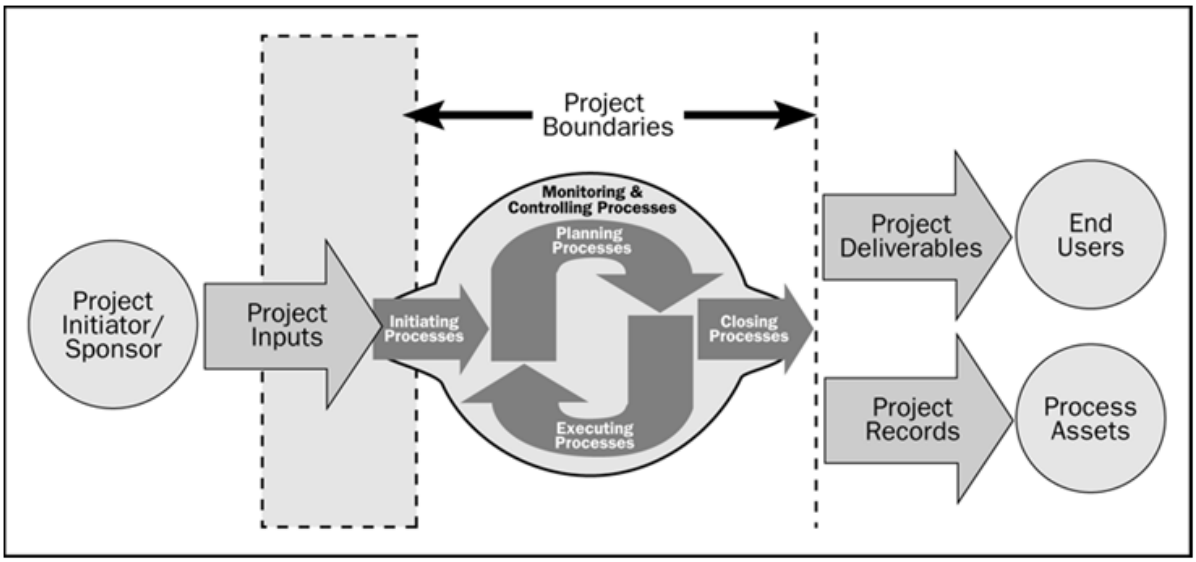

Figure 8: Project Boundaries and Project Process Groups

1. **Initiating Process Group:** Defines and authorizes the project or a project phase
2. **Planning Process Group:** Defines and refines objectives, and plans the course of action required to attain the objectives and scope that the project was undertaken to address.
3. **Executing Process Group:** Integrates people and other resources to carry out the project management plan for the project.
4. **Monitoring and Controlling Process Group:** Regularly measures and monitors progress to identify variances from the project management plan so that corrective action can be taken when necessary to meet project objectives.
5. **Closing Process Group:** Formalizes acceptance of the product, service or result and brings the project or a project phase to an orderly end.

4.1 Initiating Process Group

This group consists of the processes that facilitate the formal authorization to start a new project or a project phase. Initiating processes are often done external to the project's scope of control by the organization or by program or portfolio processes, which may blur the project boundaries for the initial project inputs.

Before beginning the Initiation Process Group activities:

- The organization's business needs or requirements are documented.
- The feasibility of the new undertaking may be established through a process of evaluating alternatives to pick the best one.
- Clear descriptions of the project objectives are developed, including the reasons why a specific project is the best alternative solution to satisfy the requirements.
- The documentation for this decision also contains a basic description of the project scope, the deliverables, project duration, and a forecast of the resources for the organization's investment analysis.

- The framework of the project can be clarified by documenting the project selection processes.
- The relationship of the project to the organization's strategic plan identifies the management responsibilities within the organization.
- The initial scope description and the resources that the organization is willing to invest are further refined during the initiation process.
- The project manager will be selected.
- Initial assumptions and constraints will also be documented.

All this information is captured in the Project Charter and, when it is approved, the project becomes officially authorized.

The Project Charter is primarily concerned with authorizing the project or a project phase. In some organizations/companies the concept Project Charter is covered by the named Project Directive.

It is the pivotal starting point for the project. It serves as the foundation for all future project efforts and should be accepted by stakeholders as well as committed by all project team members.

As summary, the Project Charter/Directive should contain the following aspects:

- Define business needs, and contain high-level project description, or product requirements that the project is undertaken to address.
- Project purpose or justification.
- Assigned Project Manager and authority level.
- Stakeholder influences; identify the organizational units or project team roles that are responsible for all major work activities and supporting processes. Identify other internal and external project stakeholders who are not specifically members of the project team.

Figure 9: Main Internal and External Stakeholders

- Functional organizations and their participation; Describe the internal structure of the project organization. It might be helpful to include organization charts or matrix diagrams to illustrate lines of authority, responsibility, and communication.
- Master schedule and summary milestone schedule
- Summary budget.
- Initial assumptions and constraints will also be documented.
- Risks assessments & Opportunities.

It will be very important to review the plan every time the product requirements specification or when project constraints or resources change, therefore in case of changed premises and for further Program phases this document will be adjusted.

All aspects, mentioned above, will be illustrated for the UAV in the following chapter, and in particular as it were approved and signed in section 5.9.

Other document that should be developed is Project Scope Statement. This is necessary for producing a preliminary high-level definition of the project using the Project Charter with other inputs to the initiating processes.

This process addresses and documents the project and deliverable requirements, product requirements, boundaries of the project, methods of acceptance and high-level scope control. In multi-phase projects, this process validates or refines the project scope for each phase.

A project scope statement includes: project and product objectives, product or service requirements and characteristics, product acceptance criteria, project boundaries, project requirements and deliverables, project constraints, project assumptions, initial project organization, initial defined risks, schedule milestones, initial WBS, order of magnitude cost estimate and project configuration management requirements.

In some organizations or depending of the nature of the project, project scope statement could be fused with Project Charter/Directive.

In case of UAV, this information was included in Project Charter/Directive; in section 5 will be described in detail.

Reviewing the initiating processes at the start of each phase helps to keep the project focused on the business needs that the project was undertaken to address. The entry criteria are verified, including the availability of required resources. A decision is then made whether or not the project is ready to continue or whether the project should be delayed or discontinued.

Repeating the initiating processes at each subsequent phase also enables the project to be halted if the business need no longer exists or if the project is deemed unable to satisfy that business need.

Involving the customers and other stakeholders during initiation generally improves the probability of shared ownership, deliverable acceptance, and customer and other stakeholder satisfaction. Such acceptance is critical to project success.

The Initiating Process Group starts a project or project phase, and the output defines the project's purpose, identifies objectives, and authorizes the project manager to start the project.

As summary, is this phase:

- Budget is approved and available.
- Availability of resources is checked and resources are allocated by functional manager/ department.
- Involved departments are aware of / prepared for the forthcoming project.
- Project sponsor is officially designated and accepts his role to be actively involved.
- Project manager is nominated and accepts his role in the project.
- Initial project team is officially introduced to the project with a joint Kick-off Meeting.
- All project documentation including the lessons learnt is stored in a project repository.
- Business objectives are defined SMART.

It is very important to define the project objectives SMART and clearly distinguish between objectives and other related concepts.

Specific: the goal and methods are clearly defined.

Measurable: the objectives are measured numerically.

Achievable: possible, and the project has all the required resources.

Relevant: avoid the temptation of defining a goal just because it fits nicely to the previous three criteria.

Time framed: set deadlines.

The figure 10 can help you better understand it means SMART:

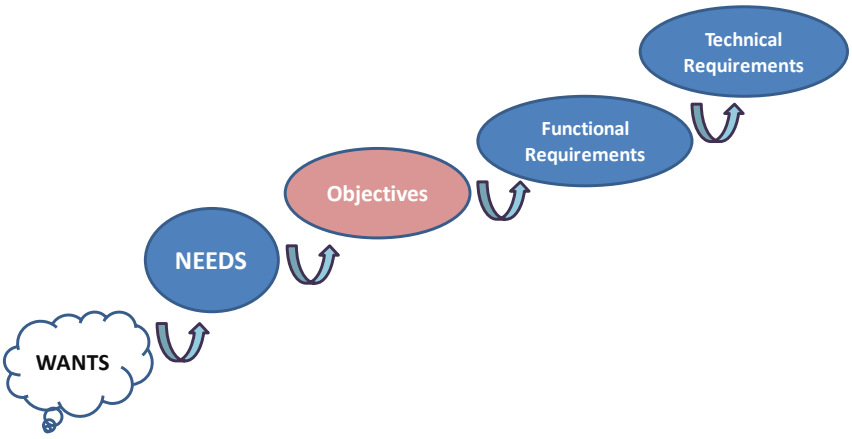

Figure 10: Defining SMART objectives

Wants and needs are very rough, which represent desires and necessities respectively. In contrast objectives are very specific goals related to the project.

Functional requirements describe the project's product features or things the product must do.

Objectives are NOT wants, needs, functional or technical requirements.

Technical requirements are derived from the functional requirements. They define the parameters for a technology solution or for a product addressing topics such as the number of users, the numbers and types of transactions, that need to be processed, and the types of technology components that need to interact.

- Defined deliverables are products which prove that an objective has been achieved.
- Scope definition in the Project Charter clearly indicates what is included in / excluded from the project.
- Verification that the proposed solution for the project is still valid.
- Major phases / milestones of the project and their end dates are defined.
- Known assumptions and constraints have been considered and documented.
- Major project stakeholders have been identified and all parties actively involved in the project understand and agree with the defined roles and responsibilities.
- Project Charter is agreed with key stakeholders and signed-off by project sponsor.

On the following pages the different project management elements will be defined and established to explain the connection between them, because is the key to success of the project.

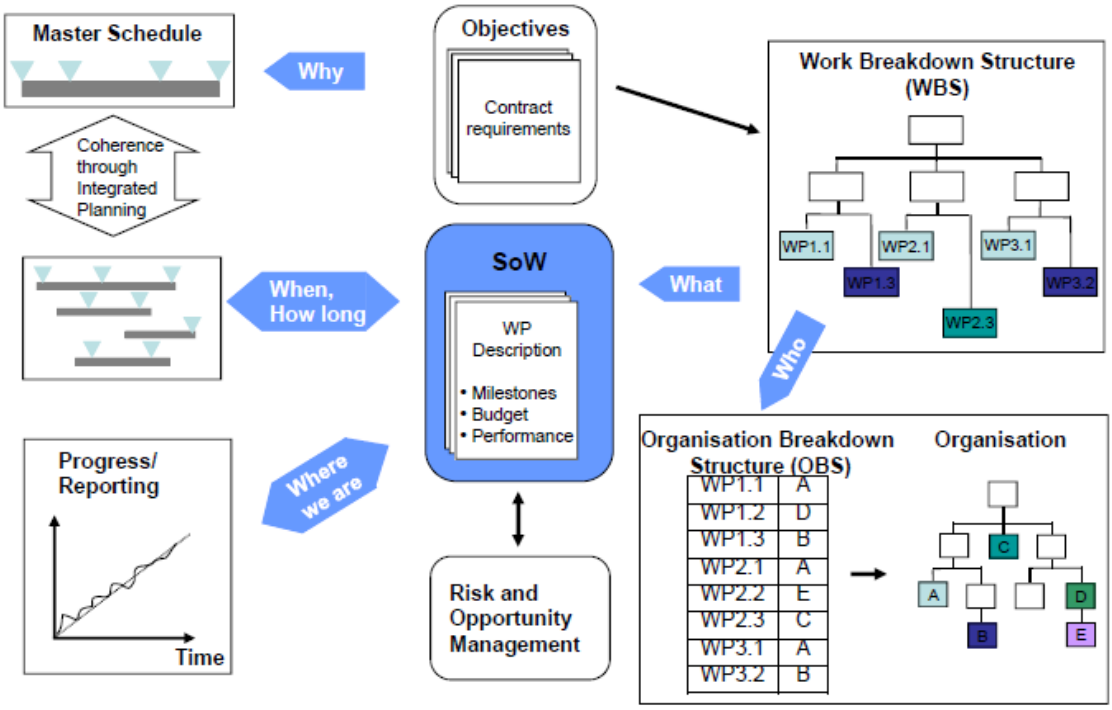

Figure 11: Project Management Elements

Note that all these elements: WBS, SoW, Budget, Milestones, Master Schedule…etc. are defined and established during Project Initiating, nevertheless they are used from now until the end of project, serving as support on all project management processes.

4.1.1 Work Breakdown Structure (WBS)

It is determined that project managers need a tool to help capture and control their project scope. This tool is Work Breakdown Structure.

The WBS organizes and defines the total scope of the project.

The WBS subdivides the project work into smaller, more manageable pieces of work, with each descending level of the WBS representing an increasingly detailed definition of the project work.

A WBS is a deliverable-oriented hierarchical decomposition of the project work, so it is one of the most important tasks to develop and maintain in the project life cycle

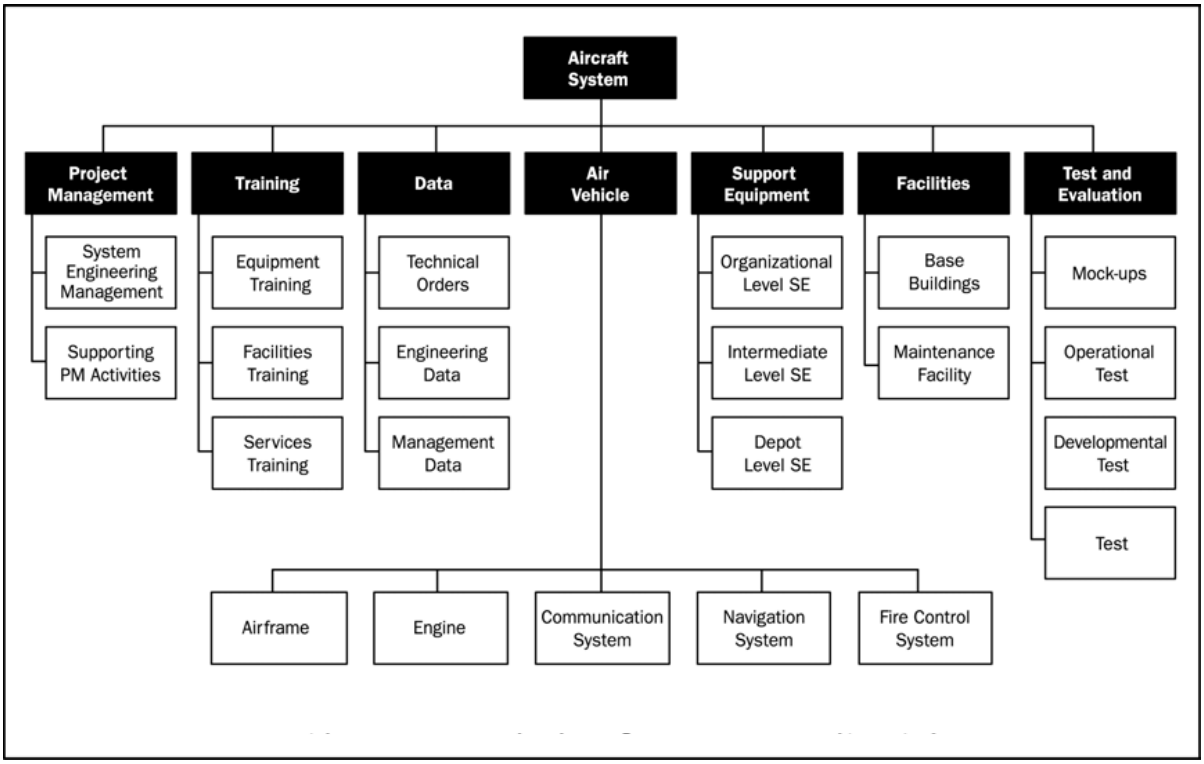

Figure 12: Work Breakdown Structure for Defense Materiel Items

The planned work contained within the lowest-level WBS components, which are called work packages, should be scheduled, cost estimated, monitored, and controlled.

In section 5.4 an overall overview of UAV WBS will be introduced.

A work package includes a Statement of work (SOW), assumptions / exclusions and deliverables, a time schedule including milestones shall be established, the effort shall be

estimated and resources shall be allocated for each implementation increment, and should be clearly defined

Each WBS component, including work package and control accounts within a WBS, is generally assigned a unique identifier from a code of accounts (SAP). These identifiers would be used to provide costs, schedule, and resource information. It uses SAP tool for project planning and management.

SAP is a modular system that covers real-time and on-line processing for all business areas within an organization.

SAP Project structure will be in line with WBS, and can be modified according to projects needs. An example is illustrated in section 5.5 by UAV SAP Project Structure.

SAP R3 was implemented in 1997 in order to replace various legacy systems in regards to planning, order placement, entry of cost data, calculations and staff allocation planning.

The SAP network has been established as work package for UAV planning purposes. This is the planning object for work, costs, schedules and accounting elements.

The SAP network is the planning tool for work, costs and schedules and the accounting tool for time and costs. The SAP network is allocated to exactly one customer order item and one work breakdown structure element (WBS element).

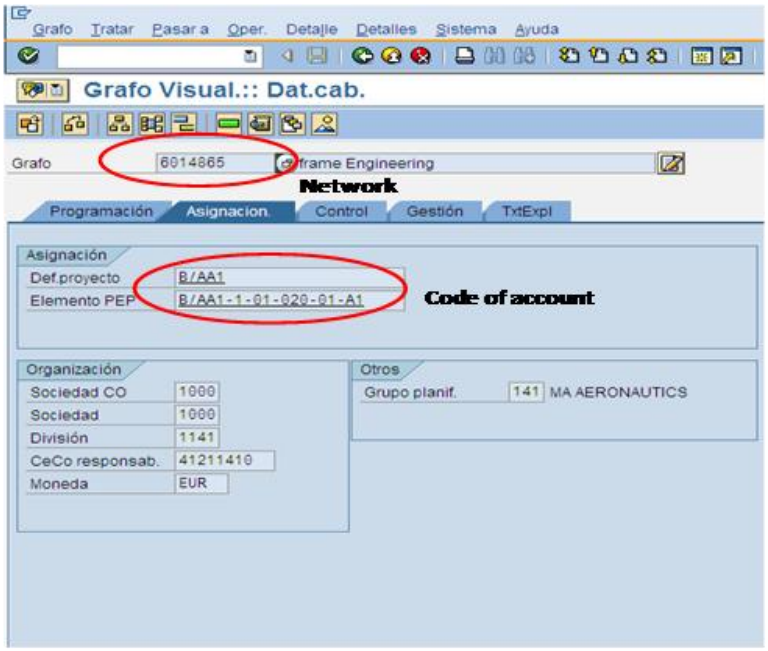

Figure 13: Example in SAP

4.1.2 Statement of Work (SoW)

As it was mentioned above relating to WBS, a SoW must be defined for each work packages.

The SoW details the work to be completed within the scope of the project. It is prepared by the group responsible of the activities and coordinated by the area Planning & Control, in cooperation with Chief Engineer and supporting the Program Manager.

Usually includes the following information: description of activities, inputs required outputs of itself, assumptions, exclusions, milestones, risks identification…etc.

4.1.3 Master Schedule

A Master Schedule or Master Plan is a summary-level project schedule that identifies the major deliverables and work breakdown structure components and key schedule milestones. List the major items to be delivered to the customers, subcontractors, integrators, or other parties.

During Project Initiating Processes schedule development can require that duration estimates and resource estimates are defined, reviewed and revised to create an approved project schedule that can serve as a baseline against which progress can be tracked.

Therefore a Master Schedule should be created during Project Initiating and maintained along full project lifecycle. In section 5.6 UAV Master Schedule is attached.

Master Schedule is managed by PMO with the support of Planning and Control department, chief engineer, customer requirements and other requirements.

To manage and control a project detailed plans at work package level must be created. Each element of the WBS should have a defined schedule that depicts how it will be delivered. It determines planned start and finish dates. In section 5.6 is attached a detailed planned.

Schedule activities are connected to other schedule activities or schedule milestones with logical relationships, and are decomposed from work packages.

Schedule development continues throughout the life cycle of the project, therefore project manager/team will have to maintain, monitor and adjust this schedule/s.

4.1.4 Project Budget

Costs for schedule activities are estimated for all resources that will be charged to the project. This includes, but is not limited to, labor, materials, equipment, services, facilities, information technology, subcontracting, licenses, travels...etc.

More detailed cost estimation begins upon completion of the project WBS, often in parallel with schedule development. Cost estimates are created for each work package and later decomposed for schedule activities.

Estimating work package costs involves developing an approximation of the costs of the resources needed to complete each work packages

Cost estimation method is estimate the cost of individual work packages / activities and then rolls up these estimates to come up with an overall project estimate.

Project budget is controlled during project execution, depending on the different level of responsibility: by WP responsibility, by Planning & Control department and all coordinated by PMO.

The control, as it was mentioned above, is performed using SAP tool.

4.1.5 Risk and Opportunity Management

An opportunity or a risk is an uncertain event or condition that, should it occur, will have a positive or negative effect on at least one project objective, such as time, cost, performance (scope and quality).

Figure 14: Cause/Risk &Opportunity/Impact

Risk and Opportunity Management aims to identify and proactively manage the project risks and opportunities during the project life cycle in order to:

- Decrease the probability of occurrence and impact of events adverse to the project.
- Increase the probability of occurrence and impact of events beneficial to the project.

Every person involved in the project (at least the work package managers) is responsible to identify all risks / opportunities known to him, and reports them to the next management layer.

Risk Management is a continuous process along the Project Lifecycle, as displayed on next figure. The process begins with Risk Management Plan definition.

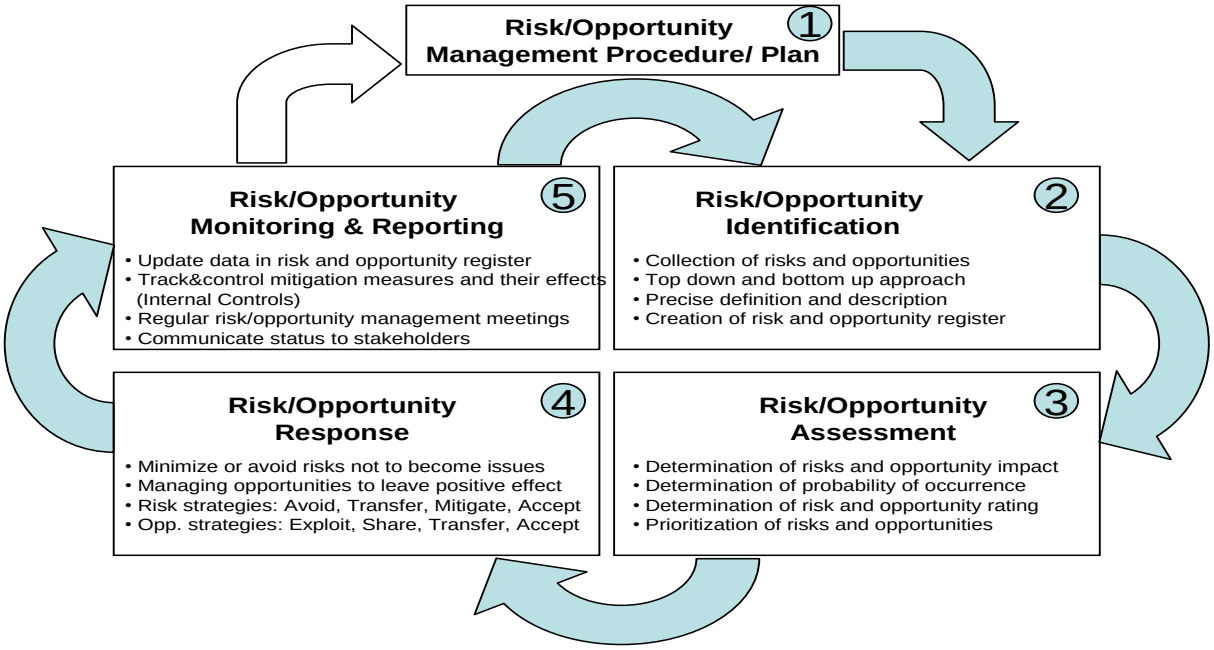

Figure 15: Risk and Opportunity Management Cycle

The Risk and Opportunity Management Plan described herein will be the general approach to identification and handling areas of risk and opportunity throughout the Programme. The process is iterative and consists of the following steps:

- Risk and Opportunity Identification.

  Different categories have to be considered: technical (requirements, technology, performance / quality etc.), schedule, commercial (terms and conditions, penalties, currency fluctuation), external (suppliers, market, customer etc.), organizational (project dependencies, resources, funding etc.) and project management (planning, controlling, communication etc.).

  Opportunities shall be furthermore distinguished as:

  - Project opportunities (improvements in processes, technology, organization) which may lead to a reduction of the existing work-packages, or in case when project opportunities will lead to additional business, an extension of existing work-packages or new work-packages.

  - Programme opportunities (modification / changes of existing contract or additional contracts) which may lead to an extension of existing work-packages or introduction of new work-packages.

- Risk and Opportunity Assessment & Rating.

  The purpose is to determine the risk and opportunity impact on budget, schedule and performance as well as the probability of occurrence. The assessment shall be done qualitatively and quantitatively (calculating impacts).

- Registration and Consolidation.

  Risk Data in the tool shall be maintained by the Risk and Opportunity Manager.

- Risk and Opportunity Active Handling, Monitoring, Controlling and Reporting.
    - Keeping track of the identified & residual risks and opportunities.
    - Identifying emerging risks and opportunities.
    - Ensuring response plan execution.
    - Evaluating effectiveness of response plans.
    - Closing down risk or opportunities.
- Risk and Opportunity Closure.

  Risks and Opportunities will only be closed after formal approval given by the Manager.

  Closure will be considered when:

    - Target Index is achieved or exceeded after thorough fulfilment of the response plan
    - There is no Risk or Opportunity exposure any more
    - Risk or Opportunity has materialized
    - Risk or Opportunity is transferred to another party
- Lessons learned

  Continuous process improvement is highly recommended to be performed throughout the entire Risk and Opportunity Management process lifecycle in order to reduce effort and cost for future programmes.

  A lesson learned session should be performed at least at the end of each programme / project phase.

4.2 Planning Process Group

The Planning Process Group helps gather information from many sources with each having varying levels of completeness and confidence.

One the project is approved, project charter is approved, the project management elements must be review, completed, updated and approved.

The planning process develops the project management plan (PMP). This process also identify, define, and mature project management elements described above (in section 4.1) the project scope, project cost, and schedule the project activities that occur within the project.

The project management plan, developed as an output of the Planning Process Group, will have an emphasis on exploring all aspects of the scope, technology, risks, and costs,

The PMP contains the management plans, the project baselines that will be used to measure the progress and status of the project, define the strategy for managing the project: how to plan, manage, and monitor scope, time, costs, quality, sub-contractors, communications, client relationship etc, describe roles & responsibilities, processes, templates, tools for the project.

The Project Management Plan can be either summary level or detailed, depending on the nature and dimension of the project to be managed.

When new project information arises, additional dependencies, requirements, risks, opportunities, assumptions, and constraints will be identified or resolved. The multi-dimensional nature of project management causes repeated feedback loops for additional analysis. As more project information or characteristics are gathered and understood, follow-on actions may be required. Significant changes occurring throughout the project life cycle trigger a need to revisit one or more of the planning processes and, possibly, some of the initiating processes.

Updates arising from approved changes during project execution may significantly impact parts of the project management plan. Project management plan updates provide greater precision with respect to schedule, costs, and resource requirements to meet the defined project scope as a whole. Updates can be limited to the activities and issues associated with the execution of a specific phase. This progressive detailing of the project management plan is often called “rolling wave planning,” indicating that planning is an iterative and ongoing process (Figure 16).

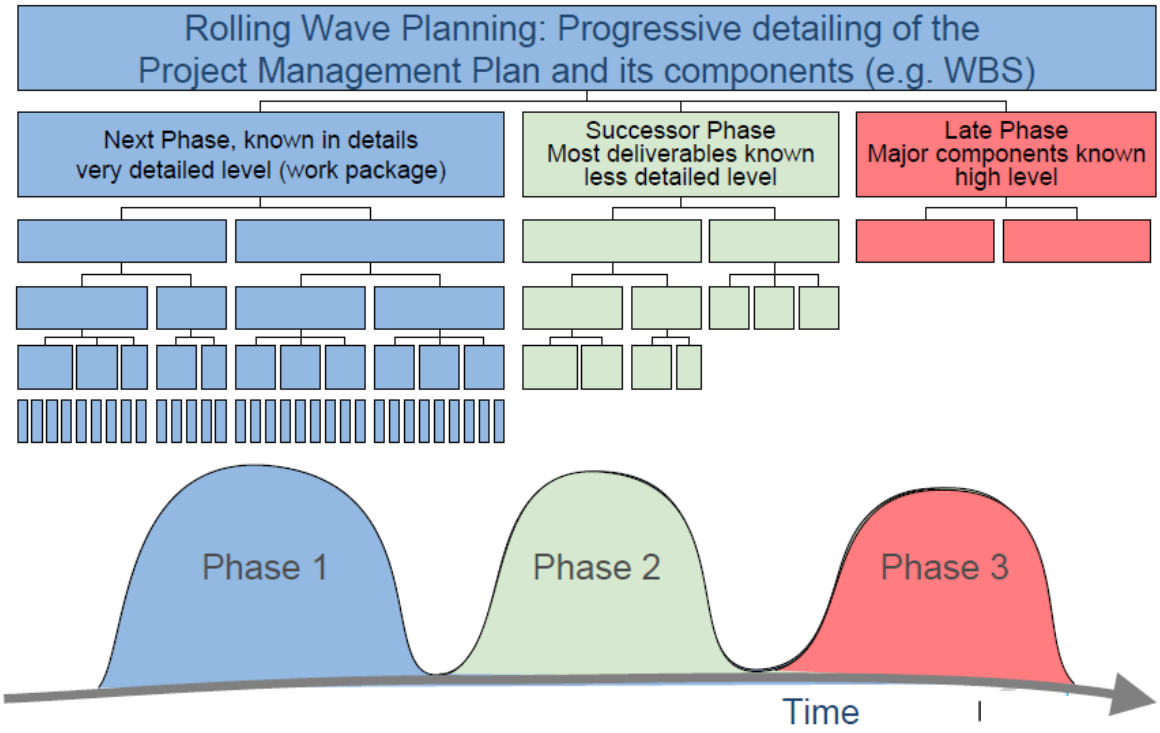

Figure 16: Rolling Wave Planning

While planning the project, the project team should involve all appropriate stakeholders, depending upon their influence on the project and its outcomes. The project team should use stakeholders in project planning since the stakeholders have skills and knowledge that can be leveraged in developing the project management plan and any subsidiary plans. Additionally a high level of stakeholder implication since early processes assures their commitment and will facilitate the project deliverables acceptance at the final stage of the

project. The project team must create an environment in which stakeholders can contribute appropriately.

Since the feedback and refinement process cannot continue indefinitely, procedures set by the organization identify when the planning effort ends. These procedures will be affected by the nature of the project, the established project boundaries, appropriate monitoring and controlling activities, as well as the environment in which the project will be performed.

Other interactions among the processes within the Planning Process Group are dependent on the nature of the project. For example, on some projects there will be little or no identifiable risk until after most of the planning has been done. At that time, the team might recognize that the cost and schedule targets are overly aggressive, thus involving considerably more risk than previously understood. The results of the iterations are documented as updates to the project management plan.

4.3 Executing Process Group

The Executing Process Group consists of the processes used to complete the work defined in the project management plan to accomplish the project's requirements.

Once a project completes the planning, the project team starts to perform project activities and to develop the project's products. It is where the concepts of planning turn into the realization of outcomes.

Directing and Managing Project Execution:

- Require the project manager and the project team to carry out multiple actions in an effective and efficient way.
- The project team should determine which of the processes are required for the team's specific project.
- The project team ensures that measurements against plans, specifications and business case are collected, analyzed and appropriate actions defined.

- This Process Group involves coordinating people and resources, as well as integrating and performing the activities of the project in accordance with the project management plan.
- Require executing the Project Management Plan and accomplishing the work defined in the project scope statement.
- Implementing
    - Approved corrective actions to bring anticipated project performance in line with the plans.
    - An approved preventive action to reduce the probability / impact of negative consequences is essential for achieving the project's goals.

This Process Group also addresses the scope defined in the project scope statement and implements approved changes. These variances can include activity durations, resource productivity and availability and unanticipated risks. Such variances may or may not affect the project management plan, but can require an analysis. The results of the analysis can trigger a change request that, if approved, would modify the project management plan and possibly require establishing a new project baseline. The vast majority of the project's budget will be expended in performing the Executing Process Group processes.

Managing project changes, change requests and issues, conducting quality audits, managing the contractors, communicating with stakeholders and reporting performance are other important activities during project execution.

4.4 Monitoring and Controlling Process Group

The Monitoring and Controlling Process Group consists of those processes performed to observe project execution so that potential problems can be identified in a timely manner and corrective action can be taken, when necessary, to control the execution of the project.

The project team should determine which of the processes are required for the team's specific project. The key benefit of this Process Group is that project performance is observed and measured regularly to identify variances from the project management plan. The Monitoring and Controlling Process Group also includes controlling changes and recommending preventive action in anticipation of possible problems. The Monitoring and Controlling Processes Group includes, for example:

- Monitoring the ongoing project activities against the project management plan and the project performance baseline.
- Influencing the factors that could circumvent integrated change control so only approved changes are implemented.

This continuous monitoring provides the project team insight into the health of the project and highlights any areas that require additional attention.

The Monitoring and Controlling Process Group not only monitors and controls the work being done within a Process Group, but also monitors and controls the entire project effort. In multi-phase projects, the Monitoring and Controlling Process Group also provides feedback between project phases, in order to implement corrective or preventive actions to bring the project into compliance with the project management plan. When variances jeopardize the project objectives, appropriate project management processes within the Planning Process Group are revisited as part of the modified plan-do-check-act cycle. This review can result in recommended updates to the project management plan. For example, a missed activity finish date can require adjustments to the current staffing plan, reliance on overtime, or tradeoffs between budget and schedule objectives. Figure 17 indicates some of the process interactions that are essential to this Process Group.

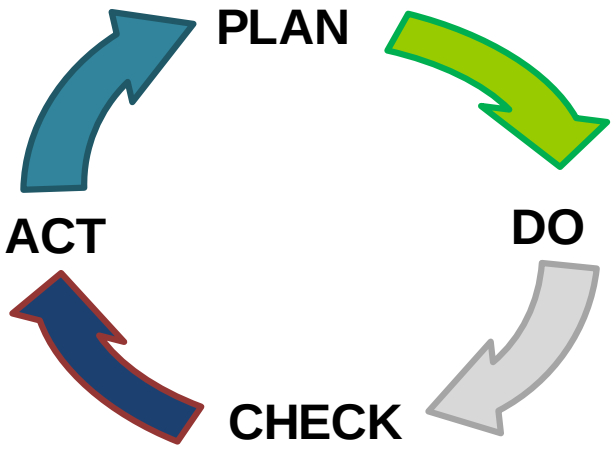

Figure 17: Process Interactions

- ✓ PLAN: Establish project objectives and project management plan.
- ✓ DO: Execute the project management plan.
- ✓ CHECK: Monitor and evaluate project performance against plan and objectives; report project progress.
- ✓ ACT: Define and implement corrective and preventive actions.

Also in monitoring and controlling process group must specify the intervals or points at which cost reporting is needed and the methods and tools that will be used to manage the budget.

Planning and Control is responsible for forecasting and controlling all project management elements previously described (including budgets and expenses) on a periodical basis, and responsible for tracking actual values and for reporting actual and estimated project management elements.

When overruns of budget allocated in total and for each implementation increment become evident corrective actions including risk management activities shall be initiated.

Also within the Monitoring and Controlling processes the reporting mechanisms should be specified, report contents, and information flows used to communicate the status of

requirements, schedule, budget, quality, risks, and other status indicators both within the project and to external stakeholders.

In this process group must be specify the control mechanisms used to measure the cost of work completed, compare actual to budgeted cost, and implement corrective actions when actual cost deviates excessively from budgeted cost.

As part of Key financial and non-financial metrics used to quantify objectives to reflect performance of an organization or process Performance Indicators (KPI) are established. KPIs are therefore used to measure project performance, too

- KPIs reveal a high-level snapshot of the project. They should both reflect the project goals and should be quantifiable
- KPIs can be:
    - Qualitative or quantitative: quantitative KPIs are based on measurable project performance data, qualitative KPIs give essential qualitative evaluations of project status (by the project manager or major stakeholders).
    - Leading or lagging: a lagging indicator is one that follows an event, whereas leading KPIs signal future events and may be used as a predictor.
    - Current number or changes (absolute or percentage) of issues, changes, risks/opportunities.
- The most popular KPIs in project performance management are the metrics provided by the earned value analysis: schedule and cost variance as well as schedule and cost performance index. These are explained in the following paragraphs.
- Other metrics are:
    - Estimate at Completion EAC:

  The EAC is the actual cost to date plus an objective estimate of costs for remaining authorized project work. The objective in preparing an EAC is to provide an accurate projection of cost at the completion of the project. There are multiple ways and

varying degrees of detail to calculate EAC, and they will be covered in a future module.

The most common is:

- EAC = Actual Cost (AC) + Estimate to Complete (ETC)

- Estimate to Complete (ETC):

The ETC is the cost of completing the authorized remaining work.ç

✓ ***Earned Value Management (EVM)***

EVM is one of the most effective success measurement techniques for projects. Earned Value analysis clearly shows where a project is (status) and where it is going (forecast). It indicates potential deviations from cost and schedule baselines.

In figure 19 can be seen as EVM compares the PLANNED amount of work with what has actually been COMPLETED, to determine if COST, SCHEDULE, and WORK ACCOMPLISHED are progressing as planned.

Provides transparency of project progress for the client and senior management, puts a focus on the effort of project team members that is often missing and requires attention on adhering to important, basic rules during project planning

A basic approach is:

- Performance measurement baseline is established
- Performance data for following basic indicators are regularly gathered (weekly, biweekly, monthly…)
  - Earned Value (EV)
  - Actual Costs (AC)
- Work performed is measured by predefined methods
- Basic indicators are determined
- Project status and forecasts are calculated

- Corrective actions are initiated and re-baselining, if necessary

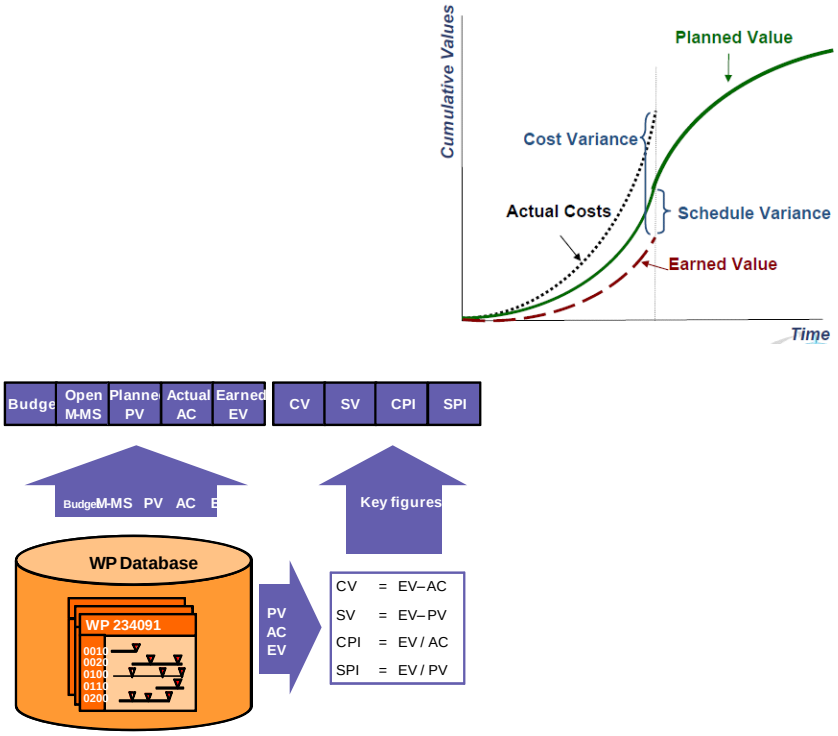

Figure 18: EVM Basic Indicators

Definitions according to International Standard

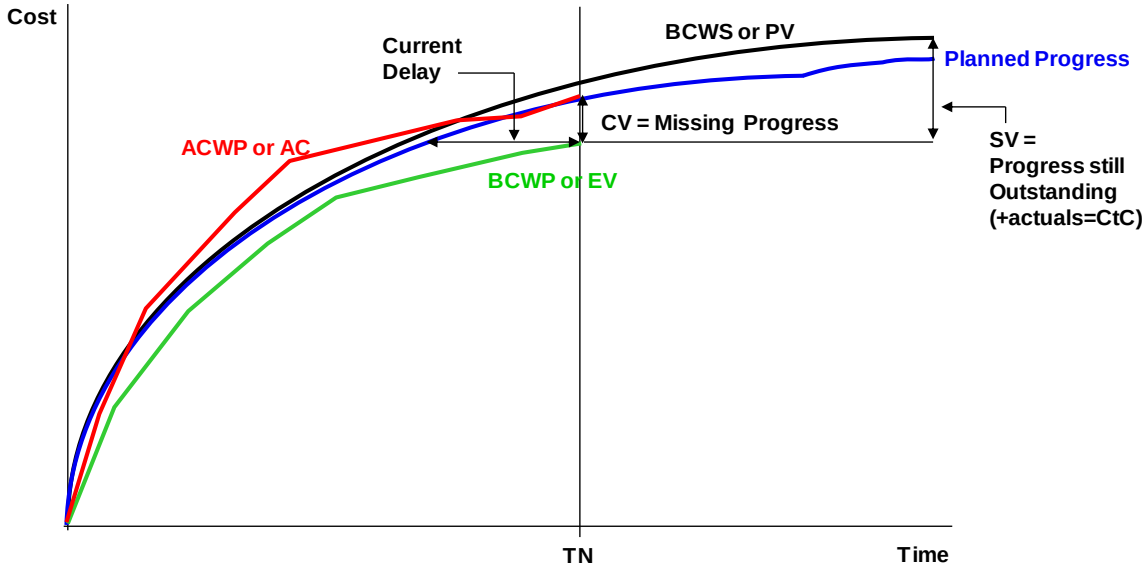

Figure 19: EVM Trend Analysis

ACWP or AC – Actual Cost of Work Performed – Actual Cost

BCWP or EV – Budget Cost of Work Performed – Earned Value

BCWS or PV – Budget Cost of Work Scheduled – Planned Cost or Planned Value

- What is the earned value in relation to the actual costs?

CV = Cost Variance = EV - AC

CPI = Cost Performance Index = EV/AC

- What is the earned value / progress in relation to the plan?

SV = Schedule Variance = EV - PV

SPI = Schedule Performance Index = EV/PV

The method of calculating EV used is Milestone Weights.

The Milestone Weighting method assigns budget value to each milestone. Not until full completion of each milestone is the budget earned. Milestone Weighting is used as a method for work packages with long term durations and ideally should have milestones each month or accounting period.

The dates for each milestone are given, along with the value for each milestone upon completion.

Although the focus of this project is not to deepen the process of Monitoring & Controlling, it has been considered convenient to introduce here an example of Earned Value Management (EVM) through UAV Programme as an example of applicability.

The following figure shows WBS (Work Breakdown Structure) defined milestones and the weights that they represent. It establishes a Planned Date, if there is any delay a Forecast Date must be defined. If everything will go/ goes according to plan the planned/forecast date will be changed to/by Achieved Date.

E-PEP		Milestones	Baseline Date	Forecast	Achieved	%	% Accumulated
Overall System Engineering	B/AA1-1-01-010-01						
	Draft EH / Sys. CONOPS	Draft Enviromental Handbook	31-1-2009		31-1-2009	0,64%	**0,64%**
		System CONOPS	13-2-2009		13-2-2009	0,41%	1,05%
	TLSRD / SDD L0	SDD L0	28-2-2009		28-2-2009	0,41%	**1,46%**
		TLSRD	5-3-2009		13-2-2009	0,22%	1,68%
	SRD (A/V - AMS - COMMS - GCS) L1	SRD A/V L1	30-3-2009		30-3-2009	0,22%	1,90%
		SRD AMS L1	30-3-2009		30-3-2009	0,22%	2,11%
		SRD COMMS L1	30-3-2009		30-3-2009	0,22%	2,33%
		SRD GCS L1	30-3-2009		30-3-2009	0,22%	**2,55%**
		SDD A/V L1	15-4-2009		30-4-2009	1,36%	**3,91%**
	SRD (Airframe - GS - Propulsion - FCS) L2	SRD Airframe L2	31-5-2009	10-6-2009	3-7-2009	0,41%	4,32%
		SRD General System L2	31-5-2009	30-6-2009	3-7-2009	0,41%	4,73%
		SRD Propulsion L2	31-5-2009	30-6-2009	3-7-2009	0,41%	5,14%
		SRD FCS L2	31-5-2009	30-6-2009	3-7-2009	0,41%	**5,55%**
		V&V Plan	28-6-2009		30-6-2009	0,39%	5,94%
	Final EH + Sys/Sub Matrix + DS & Mod + TLFT	System/Subsystem Matrix	30-6-2009		10-7-2009	0,27%	7,46%
		Definition of Drawing Set and Modification Syste	30-6-2009		10-7-2009	0,27%	7,73%
		ATLANTE Top Level Family Tree (TLFT)	30-6-2009		30-6-2009	0,27%	8,00%
	Select. (Surf. Prot./Processess/Stand. Parts/Design Stand.)	Selection of Surface Protections	30-6-2009		30-6-2009	0,27%	6,38%
		Selection of Processess applicable	30-6-2009		30-6-2009	0,27%	6,65%
		Selection of Standard Parts	30-6-2009		30-6-2009	0,27%	6,92%
		Selection of Documentation and Design Standar	30-6-2009		30-6-2009	0,27%	7,19%
	Final EH + Draft Antennas Alloc. Rprt.	Final Enviromental Handbook	30-6-2009		30-6-2009	0,39%	6,33%
		Draft Antennas Allocation Report	30-6-2009		30-6-2009	0,39%	**8,27%**
		Updated TLSRD	7-9-2009			5,31%	13,58%
		SDD Final L0	21-9-2009			5,31%	**18,90%**
	SRD (A/V - AMS - COMMS - GCS) Final L1	SRD A/V Final L1	5-10-2009			0,59%	19,49%
		SRD AMS Final L1	5-10-2009			0,59%	20,08%
		SRD COMMS Final L1	5-10-2009			0,59%	20,67%
		SRD GCS Final L1	5-10-2009			0,59%	21,26%
		SDD A/V Final L1	19-10-2009			0,59%	21,85%
		Final Antennas Allocation Report	30-10-2009			0,59%	**22,44%**
	SRD (Airframe - GS - Propulsion - FCS) Final L2	SRD Airframe Final L2	2-11-2009			0,61%	23,05%
		SRD General System Final L2	2-11-2009			0,61%	23,67%
		SRD Propulsion Final L2	2-11-2009			0,61%	24,28%
		SRD FCS Final L2	2-11-2009			0,61%	**24,89%**
		EMC Test Procedures DSC1	27-12-2010			27,51%	**52,40%**
		EMC Clearance Plan	15-1-2011			1,48%	53,88%
		EMC Test Report DSC1	15-4-2011			2,22%	56,10%
		EMC Test Procedures DSC2	26-4-2011			2,22%	**58,32%**
		EMC Test Procedures DSC3	1-8-2011			2,96%	61,28%
		EMC Test Report DSC2	15-8-2011			2,96%	**64,23%**
		EMC Test Report DSC3	15-10-2011			2,96%	**67,19%**
		EMC Test Procedures DSC4	2-12-2011			2,95%	**70,14%**
		EMC Test Report DSC4	15-3-2012			5,45%	**75,59%**
		TLSR Verification Report	31.12.2012			12,21%	87,80%
		TLSR Validation Report	1-4-2013			12,21%	**100,00%**

Figure 20: Milestone Database

4.5 Closing Process Group.

The Closing Process Group includes the processes used to formally terminate all activities of a project or a project phase, hand off the completed product to others or close a cancelled project.

This Process Group, when completed, verifies that the defined processes are completed within all the Process Groups to close the project or a project phase, as appropriate, and formally establishes that the project or project phase is finished. It has to guarantee that all deliverables will be available in time, to budget and in the necessary quality, so that the customer will accept them.

Project Closure also has to assure, that all development data relevant for subsequent life cycle phases are available and will be delivered to the organization responsible for these life cycle phases.

Support for subsequent life cycle phases may also be required in form of sustained engineering capability and maintaining some of the engineering environments.

Remaining project risks and their potential impact on subsequent life cycle phases also has to be recorded to allow effective risk mitigation.

In order to profit in future projects from the experiences those were made in this project, finally a lessons learnt exercise has to be performed.

All project team members, premises and environments no longer needed after project termination for subsequent life cycle phases have to be identified and released.

4.6 Project Management Process Groups and Project Lifecycle

As conclusion, the different phases are linked by the objectives they produce. The output of one process generally becomes an input to another process or is a deliverable of the project. The Planning Process Group provides the Executing Process Group a documented Project Management Plan and Project Scope Statement, and often updates the Project Management Plan as the project progresses. In addition, the Process Groups are seldom either discrete or one-time events; they are overlapping activities that occur at varying levels of intensity throughout the project. Figure 21 illustrates how the Process Groups interact and the level of overlap at varying times within a project. If the project is divided into phases, the Process Groups interact within a project phase and also may cross the project phases.

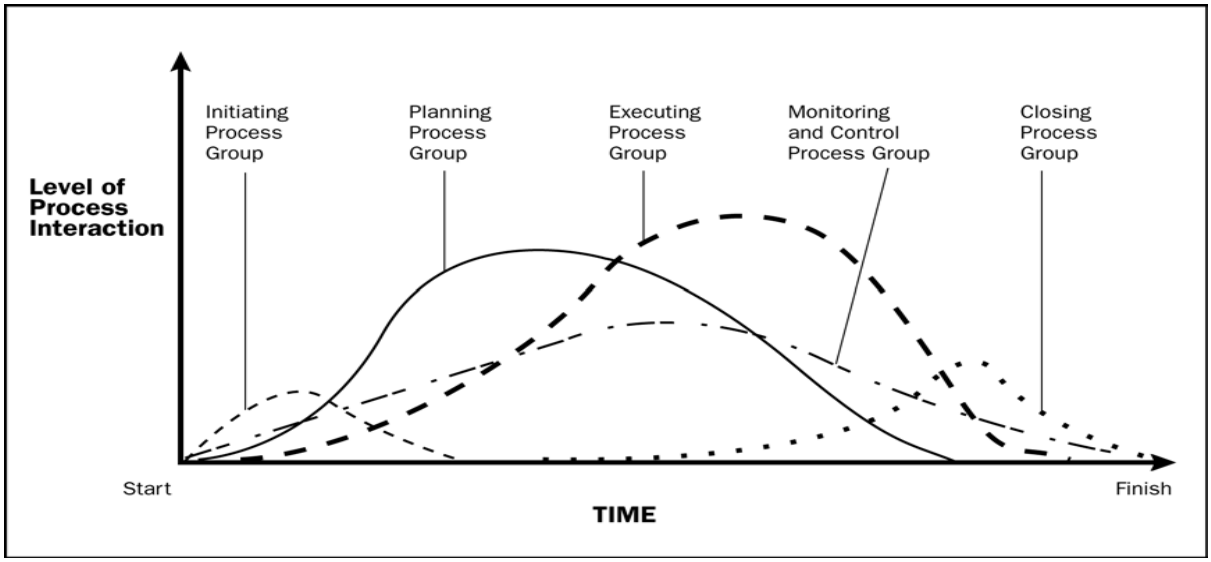

Figure 21: Process Groups Interact in a Project

Process Groups are normally repeated within each phase throughout the project's life to effectively drive the project to completion. Process Groups are normally repeated within each phase throughout the project's life to effectively drive the project to completion. The Process Groups and their relationships are illustrated in figure 22.

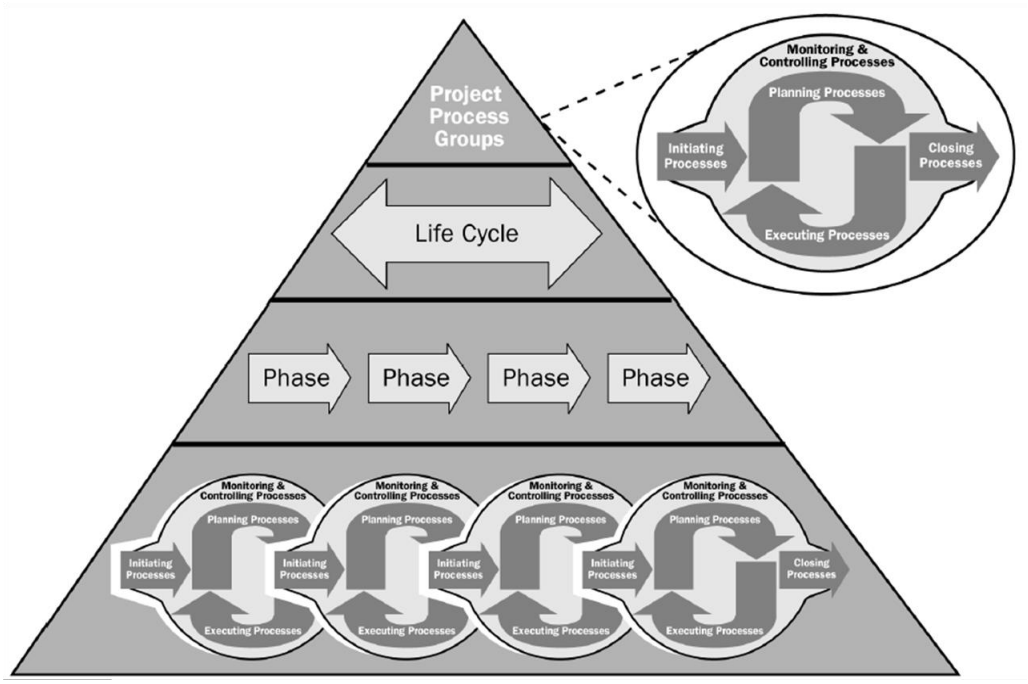

Figure 22: Project Management Process Group for a multi-phased project

It is very important to clarify that the Process Groups are not Project Phases.

Figure 23 shows an overview of the different phases of a project.

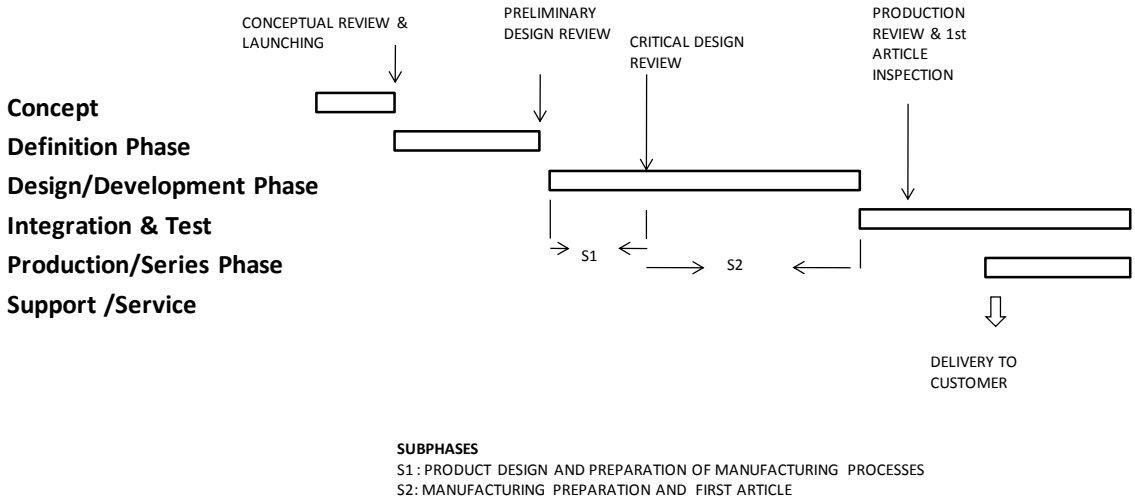

Figure 23: Project Life Cycles. Phases

In most of the projects, distinct phases such as feasibility study, concept development, design, prototype, build, test, in service etc. and all of the Process Group processes would normally be repeated in every phase of the project life cycle.

In figure 24 shows the linkages between different phases of a project during its life cycle with the processes groups.

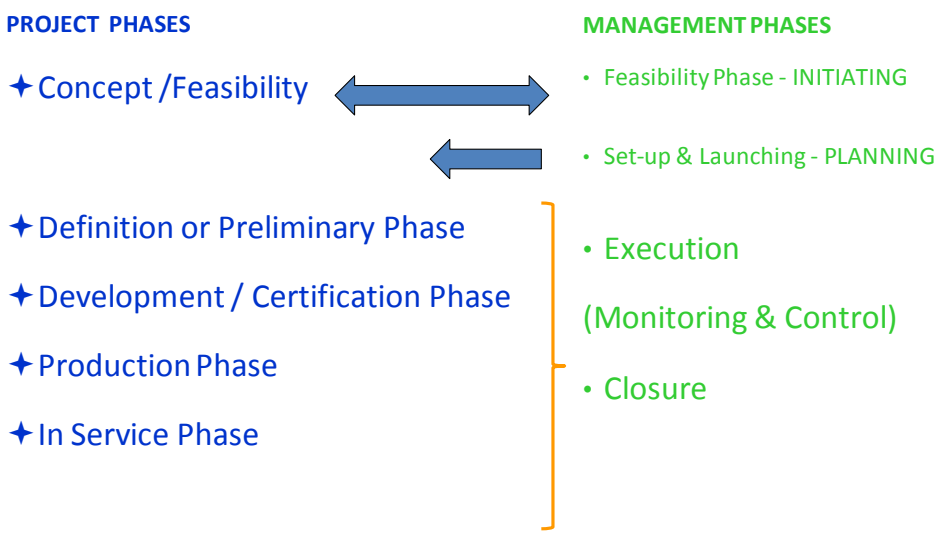

Figure 24: Project Life Cycles. Phases Vs Processes Groups

The project life cycle defines the phases that connect the beginning of a project to its end. When an organization identifies an opportunity to which it would like to respond, it will often authorize a feasibility study to decide whether it should undertake the project.

The project life cycle definition can help the project manager clarify whether to treat the feasibility study as the first project phase or as a separate, stand-alone project. Where the outcome of such a preliminary effort is not clearly identifiable, it is best to treat such efforts as a separate project.

The transition from one phase to another within a project's life cycle generally involves, and is usually defined by, some form of technical transfer or handoff. Deliverables from one phase are usually reviewed for completeness and accuracy and approved before work starts on the next phase. However, it is not uncommon for a phase to begin prior to the approval of the previous phase's deliverables, when the risks involved are deemed acceptable. This practice of overlapping phases, normally done in sequence, is an example of the application of the schedule compression technique called fast tracking. There is no single best way to define an ideal project life cycle.

Some organizations have established policies that standardize all projects with a single life cycle, while others allow the project management team to choose the most appropriate life cycle for the team's project. Further, industry common practices will often lead to the use of a preferred life cycle within that industry.

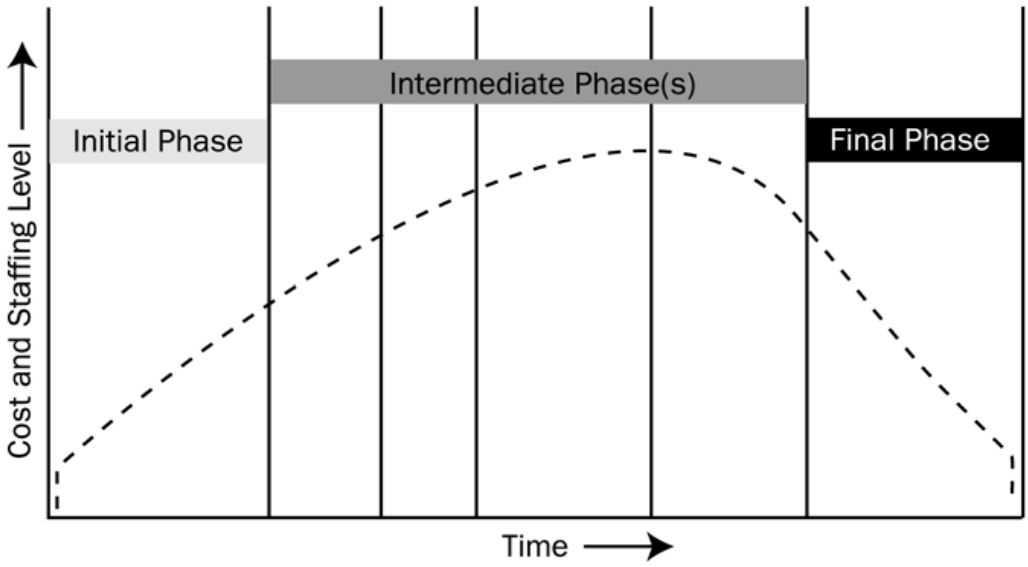

Figure 25: Project Cost and Staffing Level across the Project Life Cycle

Project life cycles generally define:

- What technical work to do in each phase
- When the deliverables are to be generated in each phase and how each deliverable is reviewed, verified, and validated.
- Who is involved in each phase.
- How to control and approve each phase.

The main characteristics are:

- Phases are generally sequential and are usually defined by some form of technical information transfer or technical component handoff.

- Cost and staffing levels are low at the start, peak during the intermediate phases, and drop rapidly as the project/project phase draws to a conclusion.
- The level of uncertainty is highest and, hence, risk of failing to achieve the objectives is greatest at the start of the project/project phase. The certainty of completion generally gets progressively better as the project/phase continues.
- The ability of the stakeholders to influence the final characteristics of the project's/phase' product and the final cost of the project/phase is highest at the start, and gets progressively lower as the project/phase continues. A major contributor to this phenomenon is that the cost of changes and correcting errors generally increases as the project/project phase continues.

5. UAV. PROJECT SET-UP

As it was mentioned before, in chapter 4, project set-up phase comprises all project management activities required for launching a project. The module takes a system life cycle perspective that may reach beyond the boundaries of a particular project.

The Project Set-Up module comprises all activities that are required at the beginning of a project to implement a proper project management process. This includes the definition of the project goals, the definition of the way the project team will operate and share the work amongst the participating groups and the definition of the technical development process to be applied

The aim of Project Set-Up processes are:

- Define project objectives: these objectives shall be established considering the needs to be satisfied, the project scope, and initial assumptions and constraints including technical, time, resource, legal and budget constraints.
- Define resulting work products
- Define work breakdown structure (WBS)

- Define project organization: The responsible person and core members of the project team shall be appointed.
- Define project processes in detail
- Provide project environment including facilities and tools
- Build up project team

Projects normally start with the initiating processes such as opportunity analysis, preparation of bid/product development decisions, preparation and submittal of proposals, contract negotiations and acceptance.

In this way it was launched the Project Charter/Project Directive like the pivotal starting point for the project, formally authorizes a project. It serves as the foundation for project efforts and should be accepted by stakeholders as well as committed by all project team members.

The Project Charter/Project Directive should contain the following aspects, which have been detailed before:

- Project purpose or justification, business needs, high-level project description, or product requirements that the project is undertaken to address.
- Assigned Project Manager and authority level.
- Stakeholder influences & Functional Organizations:
- Summary milestone schedule
- Summary budget.

In case of changed premises and for further Program phases this document will be adjusted. Any changes to the document shall be subject to configuration control.

5.1 UAV Requirements

UAV is the key driver for the future "UAV Center of Excellence in Spain".

The UAV Programme Development Project consists in the development of a complete Tactical UAV system including some equipment and sensors.

UAV Programme is a system Tactical Unmanned Air System (TUAS) defined to support Army battalions and divisions in RSTA (Reconnaissance, Surveillance and Target Acquisition), BDA (Battle Damage Assessment) and artillery fire correction roles.

Figure 26: UAV Programme

UAV programme is based in:

- Launching and supporting one of the key strategic areas included in the National Aeronautic Strategic Plan.
- Development of the National Industry in the UAV business
- Qualify the Spanish Industry in the development and manufacturing of UAV´s, equipment and sensors, not only focused on the system but also on technology acquisition in sensors and equipment
- Development of this technology as "core" for the Spanish Defence

The system will give division level support to the Spanish Army for the following tasks:

- Reconnaissance, Surveillance and Target Acquisition (RSTA)
- Battle Damage Assessment (BDA)
- Artillery Fire Adjustment

- UAV will be integrated into the Spanish Army communications system
- UAV will be integrated into the Spanish Army C4I Tactical Systems (SIMACET and PCGACA)
- UAV will operate without runway. Provision for landing gear required.
- Each air vehicle should carry a 60 kg payload and remain 10 hours flying at 12000 ft
- Each subsystem will be transportable in a C-130 and road transportable

It was elaborated and discussed with the SP Army a System Requirement Document (TLSRD) for the UAV System including also all the applicable certification requirements coming from STANAG 4671 and LTF-1550 aiming to CAT2.

The objective of this Top Level System Requirement Document (TLSRD) is to identify all the applicable requirements the UAV programme has to fulfill. It is meant to be used by system designers, engineers in charge of system integration and flight test, safety experts, documentation writers, simulator designers and in a general way by all people involved in system development and test.

This TLSRD also incorporate the outcomes of discussions with the SP Army gathered in the ad-hoc working group.

Some of UAV Main Contractual Requirements are as following:

- Autonomy 10 hours
- Payload 60kg
- Operational Ceiling 12 kft
- Conventional & Launcher/Parachute Take-off & Landing
- Equipped with EO/IR sensor
- Wide Band communications
- All weather operation (EMC “robust”)
- Autonomous navigation

- Two Data Link systems (different bandwidth)
- Simultaneous control of two AVs from GCS
- VRT (video remote terminal)

5.2 UAV Programme Organization

The company has to lead as Prime Contractor & Technical Responsible a National Industry Team with maximum participation of other Spanish Industries

The National Industry Team has to finance the 25% of the Project Development Costs whereas the CDTI the finance remaining 75%.

- CDTI Policy/Requirements:
  - CDTI, within the Spanish Ministry of Science and Innovation is the responsible Agency to manage and provide funding to the Aeronautical Projects.
  - CDTI has a strong interest in launching and supporting UAV.
  - One of the key strategic areas included in the Aeronautical Strategic Plan.
  - Development of the National Industry in the UAV business.
  - Qualify the Spanish Industry in the development and manufacturing of UAV's, equipment and sensors.
  - Development of this technology as "core" for the Spanish Defence.
- Company participation < 35- 40 %
- Other National Industries > 50 – 55 %
- The Risk Sharing Partners (RSPs)

Major project stakeholders have already been identified and all parties actively involved in the project understand and agree with the defined roles and responsibilities.

The UAV organization inside the company was established as follows (Figure 27).

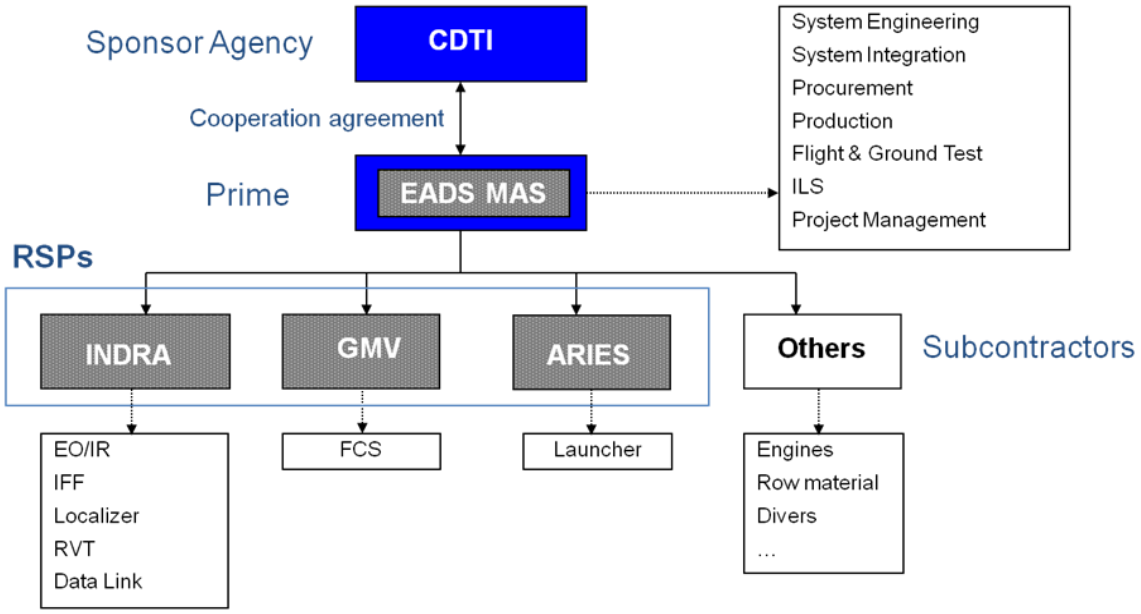

Figure 27: UAV Organization inside the company

Once CDTI & the company have signed the main contract, SP MoD will establish a permanent Program Office for the UAV, to collaborate in the system definition and to monitor the development according with their requirements.

- ✓ PMO (Program Manager Office) will be the responsible to assure the needed interfaces, making easy customer access to the Program information.
- ✓ TMO (Technical Manager Office) will coordinate and manage all technical issues between Company & MoD SP and/or any other potential customer identified by MV.
- ✓ TMO will be responsible of the technical content definition requested by the customer at TMG (Technical Maturity Gate) milestone.

The project manager is the individual empowered to manage the project.

- He is the leader of the project management team.

- He is the main interface of the customer and has authority to define other interfaces.

- He is responsible for the elaboration of the Project Management Plan (PMP), including Organization Breakdown Structure (OBS) and Work Breakdown Structure (WBS).

- He manages the risks and opportunities of the project (risk / opportunity capture, analysis, containment and exploitation respectively).

- He is responsible for the decision on “make or buy” (in close relationship with procurement management).

- He leads the execution of the PMP, reports on work progress, on risks and opportunities status evolution.

- He alerts management on any problem or risk status evolution that could severely affect the project achievements and sets up the appropriate plan of action for problem solving.

Once Project Charter is agreed with key stakeholders and signed-off by project sponsor, a project team will be officially introduced to the project with a joint Kick-off Meeting; it will be explained in section 5.9.

The UAV organization is as follows. (Figure28)

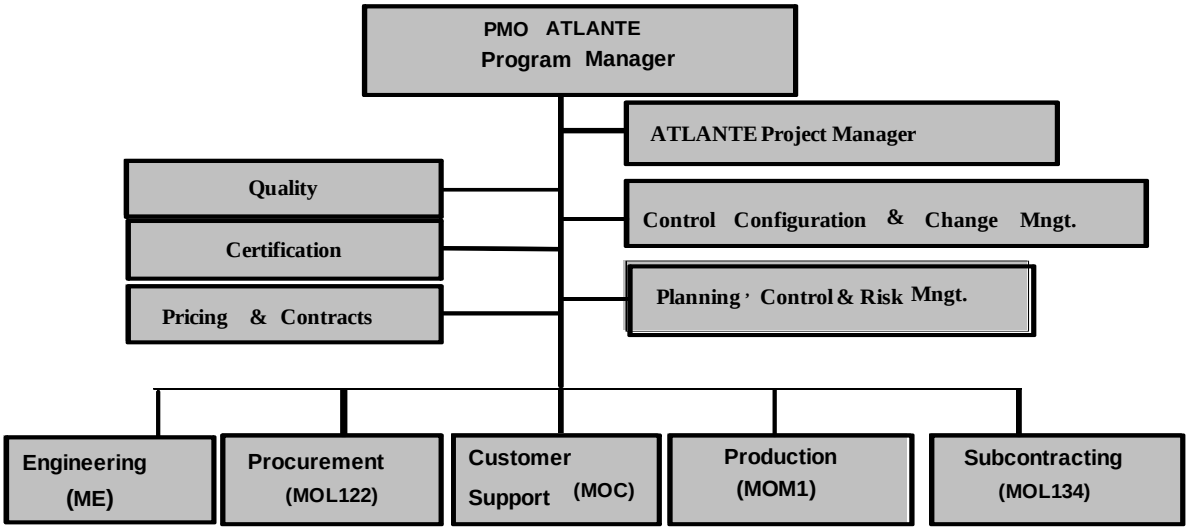

Figure 28: UAV Organization

5.3 UAV Programme Description

In this section the high level UAV overall system architecture will be described (Figure 29):

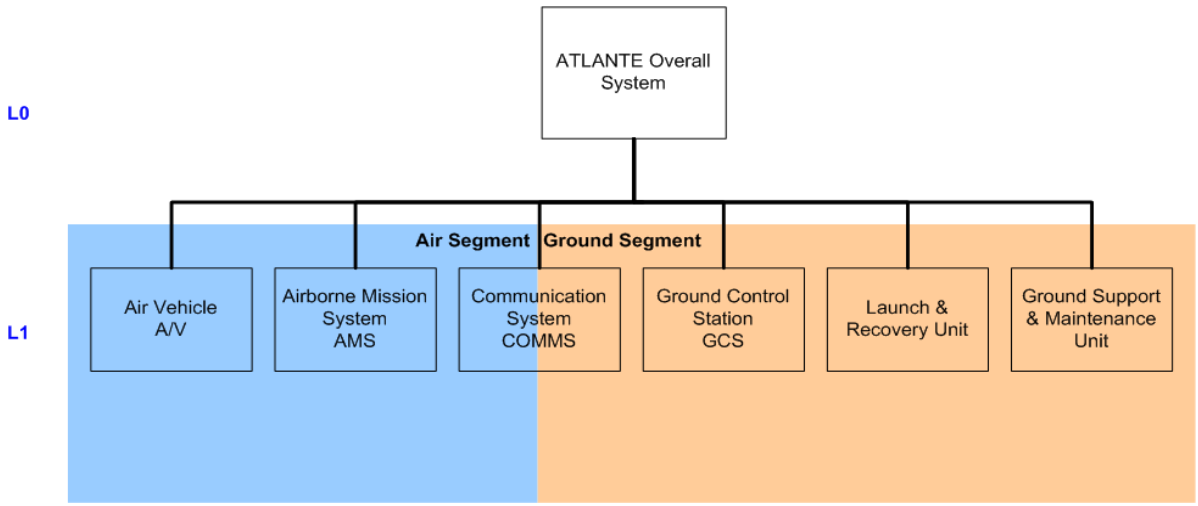

Figure 29: UAV Overall System Architecture

The UAV programme operational system comprises:

- One (1) Ground Control Station (GCS)
- One (1) Ground Data Terminal (GDT): GDT comprises antennas and RF equipment, included in COMMS, and the support equipment (trailer, power, etc.) included in GS&MU.
- Four (4) Air Vehicles
- One (1) Launch and Recovery Unit
- Three (3) Remote Video Terminal (RVT): The RVT is a compact, man-portable, rugged field unit that receives real-time video images directly from a remote platform. RVT equipment is included in COMMS

- Four (4) payload sets (EO/IR sensor+ transponder): Payload sets are included in AMS

- One (1) Maintenance Unit: Maintenance Unit is included in GS&MU

The following air segment items are considered as payload:

- "Mission equipment": Equipment that provide a mission functionality (for example: EO/IR, COMMS relay, etc)

- "Mission support equipment": Equipment only required to support mission equipment (for example mission data recorders, EO/IR extractor & retractor, etc)

- Transponders

In terms of Airworthiness and Certification:

- There is no contractual requirement for System Certification.

- Existing UAS airworthiness requirements) will be considered as an internal design requirement, to ensure that the System could be successfully certified if later required.

- Flight testing will be covered by an Experimental Airworthiness Certificate issued by INTA (SP MoD), in accordance with Spanish Regulations.

- It has been assumed that certification basis for UAV System will be a certification in accordance to CAT 2.

CAT2 (Category 2) means unmanned aerial vehicles can take off and land within specially designated military training areas or restricted areas with flight-restricted airspace above. The flight path in between runs through a flight-restricted area or in airspace restricted for general air traffic also outside of military training/test sites.

5.4 UAV WBS.

To define the UAV is one of the project management activities more important in the success of the project as it was emphasized in section 4.1.1

Following WBS UAV was established to control the advance of the activities to fulfill the contract with the customer.

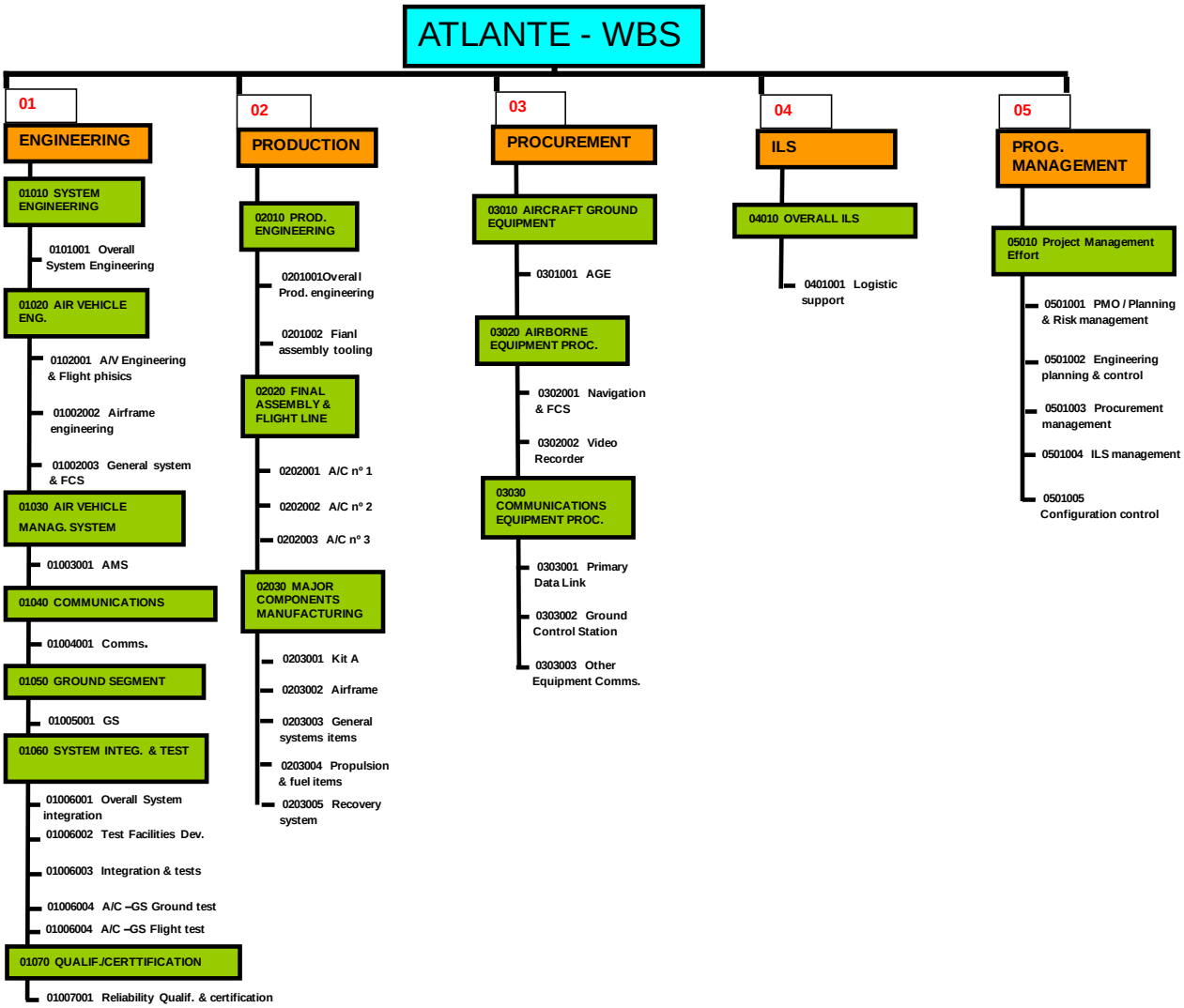

Figure 30: UAV WBS

Each WBS component, including work package and control accounts within a WBS, is generally assigned a unique identifier from a code of accounts (SAP). These identifiers would be used to provide costs, schedule, and resource information.

The code in SAP is as following

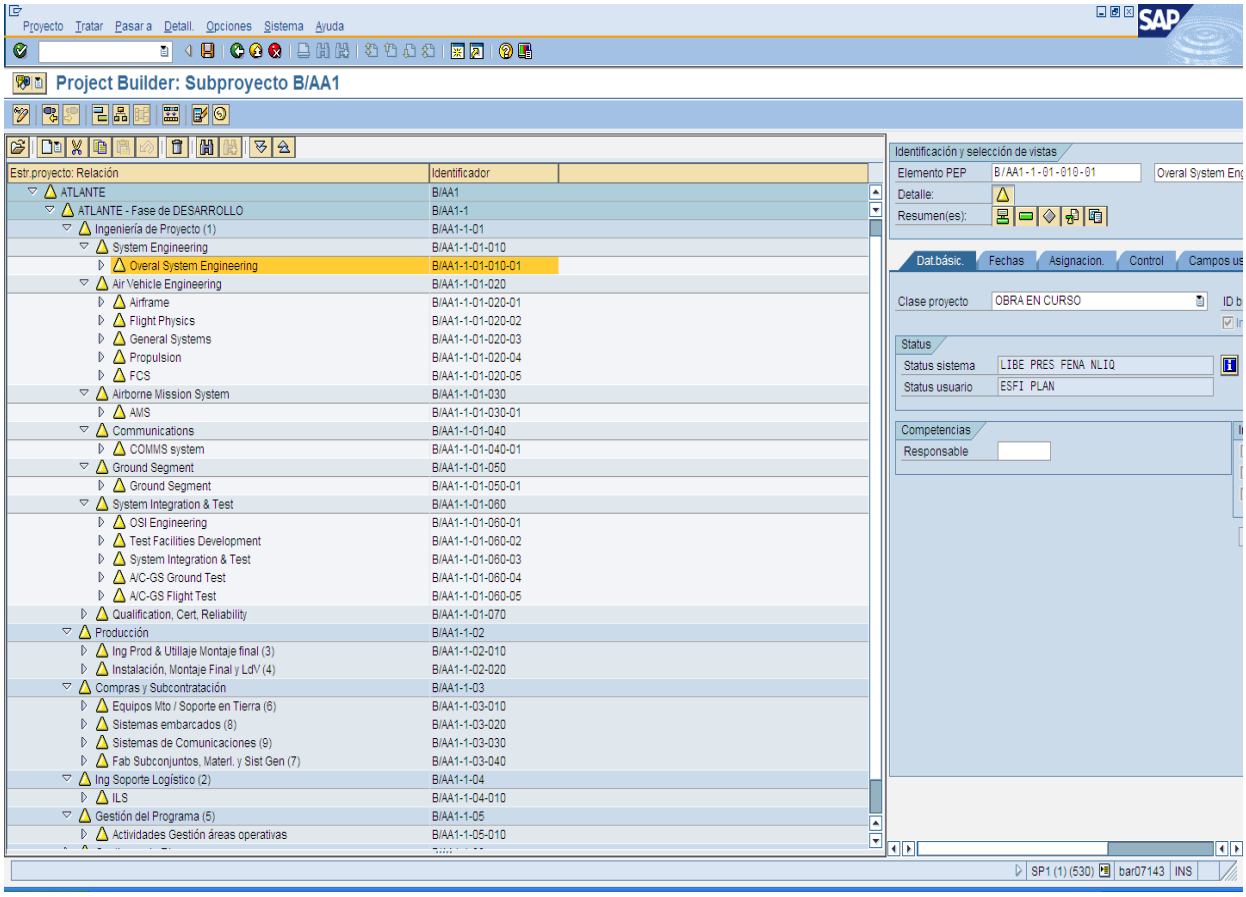

Figure 31: UAV SAP Code

L1 (CC)	L2 (OA)	L3 (OC)	PEP / Grafo
Engineering (1)			B/AA1-1-01
	System Engineering		B/AA1-1-01-010
		Overall System Engineering	B/AA1-1-01-010-01
	Air Vehicle Engineering		B/AA1-1-01-020
		Airframe Eng	B/AA1-1-01-020-01
		Flight Physics	B/AA1-1-01-020-02
		General Systems	B/AA1-1-01-020-03
		Propulsion	B/AA1-1-01-020-04
		FCS	B/AA1-1-01-020-05
	Airborne Mission System		B/AA1-1-01-030
		AMS	B/AA1-1-01-030-01
	Communications		B/AA1-1-01-040
		COMMS	B/AA1-1-01-040-01
	Ground segment		B/AA1-1-01-050
		GS	B/AA1-1-01-050-01
	System Integration & Test		B/AA1-1-01-060
		OSI Engineering	B/AA1-1-01-060-01
		Test Facilities Development	B/AA1-1-01-060-02
		System Integration & Test	B/AA1-1-01-060-03
		A/C-GS Ground Test	B/AA1-1-01-060-04
		A/C-GS Flight Test	B/AA1-1-01-060-05
	Qualification, Cert, Reliability		B/AA1-1-01-070
		Reliability, Qualif & Certification	B/AA1-1-01-070-01
Production			B/AA1-1-02
	Production Eng & F/assy tooling (3)		B/AA1-1-02-010
		Production Eng for F/Assy	B/AA1-1-02-010-01
		F/Assy tooling	B/AA1-1-02-010-02
		Production Eng for Airframe (Incl. Kit A)	B/AA1-1-02-010-03
	Installation, Final Assy & Flight Line (4)		B/AA1-1-02-020
		A/C 1	B/AA1-1-02-020-01
		A/C 2	B/AA1-1-02-020-02
		A/C 3	B/AA1-1-02-020-03
Procurement & Subcontracting			B/AA1-1-03
	Maintenance / Ground Support Equipment (6)		B/AA1-1-03-010
		Ground Support Equipment	B/AA1-1-03-010-01
	On-board equipment (8)		B/AA1-1-03-020
		Navegation & FCS	B/AA1-1-03-020-01
		Video recorder	B/AA1-1-03-020-02
	Communications (9)		B/AA1-1-03-030
		Primary Data Link	B/AA1-1-03-030-01
		Other COMMS equipment	B/AA1-1-03-030-02
		GCS equipment (incl. Shelter)	B/AA1-1-03-030-03
	Manuf of Subassies, installation materials & GenSys (7)		B/AA1-1-03-040
		Kit A	B/AA1-1-03-040-01
		Airframe	B/AA1-1-03-040-02
		General Systems	B/AA1-1-03-040-03
		Fuel & Propulsion	B/AA1-1-03-040-04
		Recovery system	B/AA1-1-03-040-05
Integrated Logistic Support (2)			B/AA1-1-04
	ILS		B/AA1-1-04-010
		ILS	B/AA1-1-04-010-01
Management (5)			B/AA1-1-05
	Management activities of CoCs		B/AA1-1-05-010
		PMO (+ insurances)	B/AA1-1-05-010-01
		Engineering Planning	B/AA1-1-05-010-02
		Procurement/subcontracting management	B/AA1-1-05-010-03
		ILS management	B/AA1-1-05-010-04
		Configuration Control (PMO)	B/AA1-1-05-010-05
Risk Provision			B/AA1-1-99

Figure 32: UAV WBS SAP Codes

The company is the leadership of the project and has the responsibility of such task and works in different work packages in order to integrate all the activity in the overall UAV. High-quality work packages are vitally important for managing projects and should therefore be prepared and maintained with the utmost care.

The Programme organization regarding the overall work spread and allocation is based on a systematic approach.

Each Work Package carries out its tasks, has autonomous control over internal issues and delivers research and development results in accordance with the Project Work Programme and within the allocated budget.

5.5 UAV Work Packages and SoW

A Programme like this, with such a community of entities involved, requires a strong management, a strong coordination within the consortium and with other external bodies and initiatives and a work of dissemination and exploitation of information between internal consortium members and external to user's community.

UAV organization is complex due to the number of participants in the Programme but manageable with the appropriate control mechanisms. This mechanism will be based on a clear definition of work packages, tasks and deliverables where the interfaces, inputs, outputs and milestones will be clearly defined, as explained in the next sections.

Everything produced throughout and by the UAV project corresponds with a work package. Work packages receive inputs in the form of deliverables from related work packages and produces outputs in the same form for other work packages. A work package includes a Statement of Work (SOW), assumptions / exclusions and deliverables, a time schedule including milestones shall be established, the effort shall be estimated and resources shall be allocated for each implementation increment.

Overall overview of Program UAV in terms of work packages:

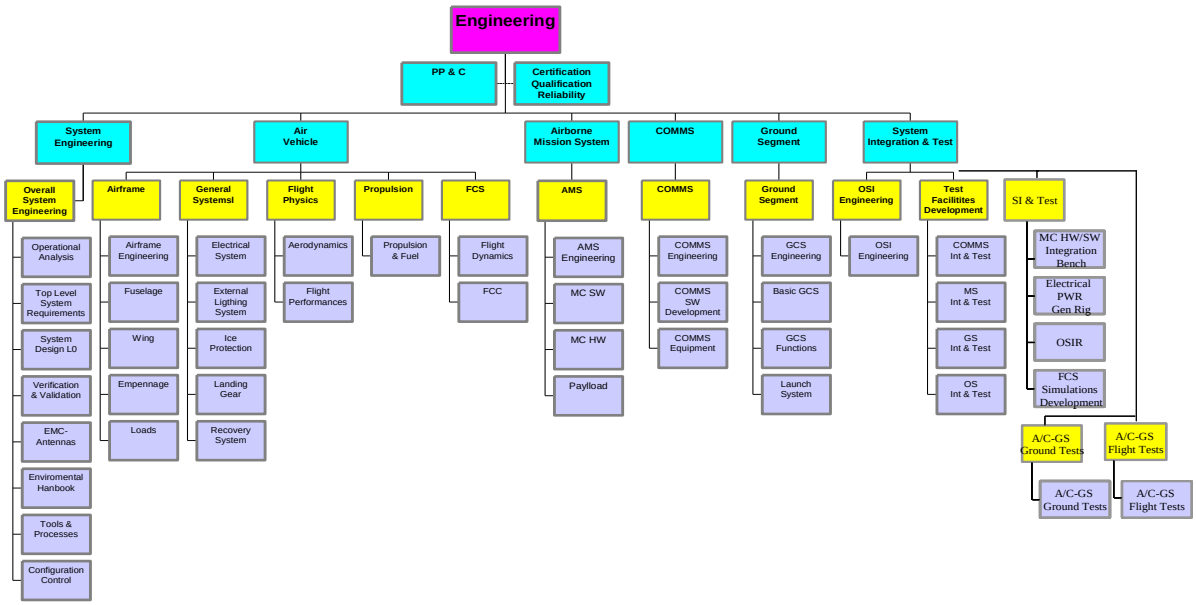

Figure 33: UAV overview of Work Packages

Creation and maintenance of the work package is an integral part of the programme and project management process. The framework for the work package content has to be defined during the set-up phase, and they will have to be review, and if it is necessary to change or detail the content, in following phases.

The work package's activities description was detailed in a set of documents which have been agreed and prepared during a previous phase to Kick-off (feasibility phase). Each one of these documents lists in detail the tasks, responsible, interfaces and deliverables (internal and external) and its budget portion.

The PMO is responsible for the introduction in SAP of the WBS up to work package level. Work packages are responsibility of the Centers of Competence (CoC), and therefore the Planning and Control departments of the CoCs creates the work packages in SAP-PS as a SAP network and stipulates the following: responsible organizational unit, user status, budget (in man-hours) and period can be planned.

Each work package has defined a statement of work (SoW) according to the template attached in section 4.1.2

SoW details the work to be completed within the scope of the project, defines and specifies the necessary tasks and activities for engineering, certification and support related to every Work Package.

For example in the case of Overall System Engineering, six work packages have been defined as individual parts, all the six covering 100% of the activities that have to be performed under Overall System Engineering, and each one of them has a code in SAP system (network).

EPEP - imputación	Network Name	Network
Overall System Engineering B/AA1-1-01-010-01	Operational Analysis	**6011807**
	Top Level System Requirements	**6011808**
	System Design L0	**6011809**
	Verification & Validation	**6011810**
	EMC-ANTENNAS	**6011811**
	Enviromental Handbook	**6011812**
	Tools & Processes	**6011813**
	Configuration Control	**6011814**

Figure 34: Example of UAV Networks

5.6 UAV Master Plan / Detailed Schedules

Master Schedule availability for each one of the phases, where the Major Milestones to fulfill the contract with the customer are identified is essential to perform the set-up of a Project, in this case UAV Programme.

A summary-level project schedule that identifies the major deliverables and work breakdown structure components and key schedule milestones (see also milestone schedule) is necessary for analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule.

- ✓ **Master Time Schedule:**

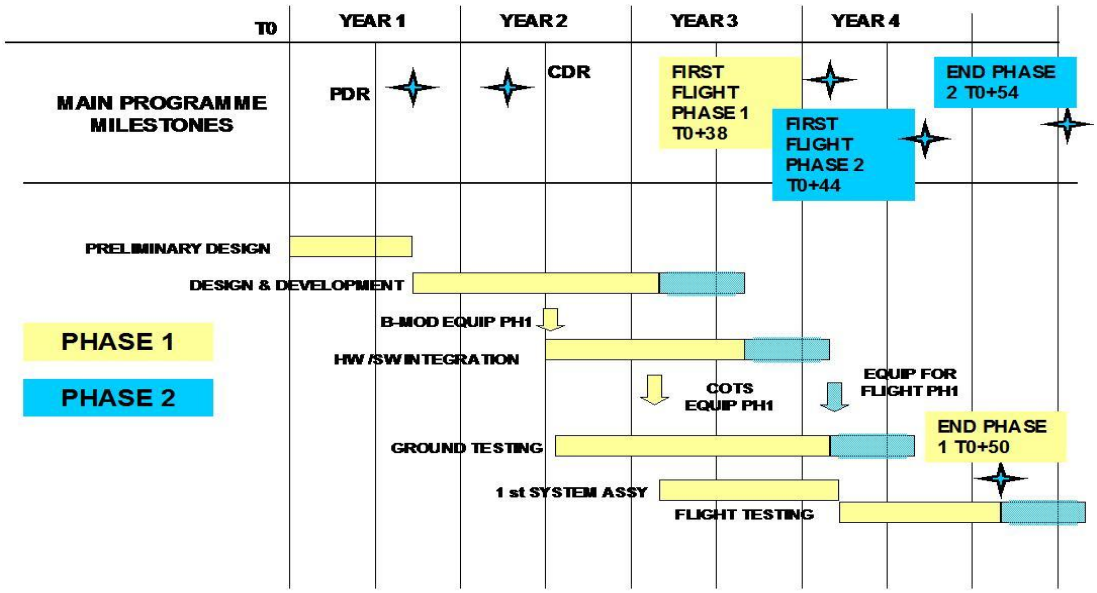

Figure 35: UAV Master Schedule

- Total duration: 54 months.
- Contractual buffer of 30 months.
- Technical Maturity Gate (TMG) in T0+20 to obtain a Minister of Defense (MoD) contract.
- Two simultaneous Phases to reduce risks.

- Phase 1: Full System with Primary Data Link COTS.
- Phase 2: Full System with Primary Data Link INDRA.

✓ **Milestones Schedule.**

Milestones shall be synchronized with higher level milestones and milestones for other projects as far as system interfaces are concerned.

Milestone achievements have to be assessed considering the dimensions time, costs and quality.

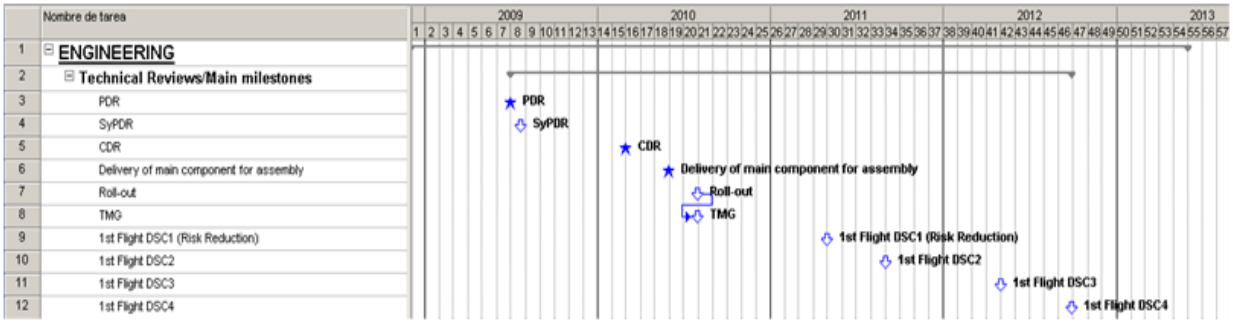

Figure 36: UAV Milestone Schedule

✓ PDR: Preliminary Design Review

✓ CDR: Critical Design Review

✓ Delivery of main component for assembly

✓ Roll Out/TMG (Technical Maturity Gate)

✓ 1st FLIGHT

The centers of competence (those responsible for work packages) were responsible for the detailed planning of their work packages in accordance with the contract initiation documentation. They were supported by Planning & Control departments.

It can see a detailed UAV planning relating to WP Tools and Processes, shown before and used as example:

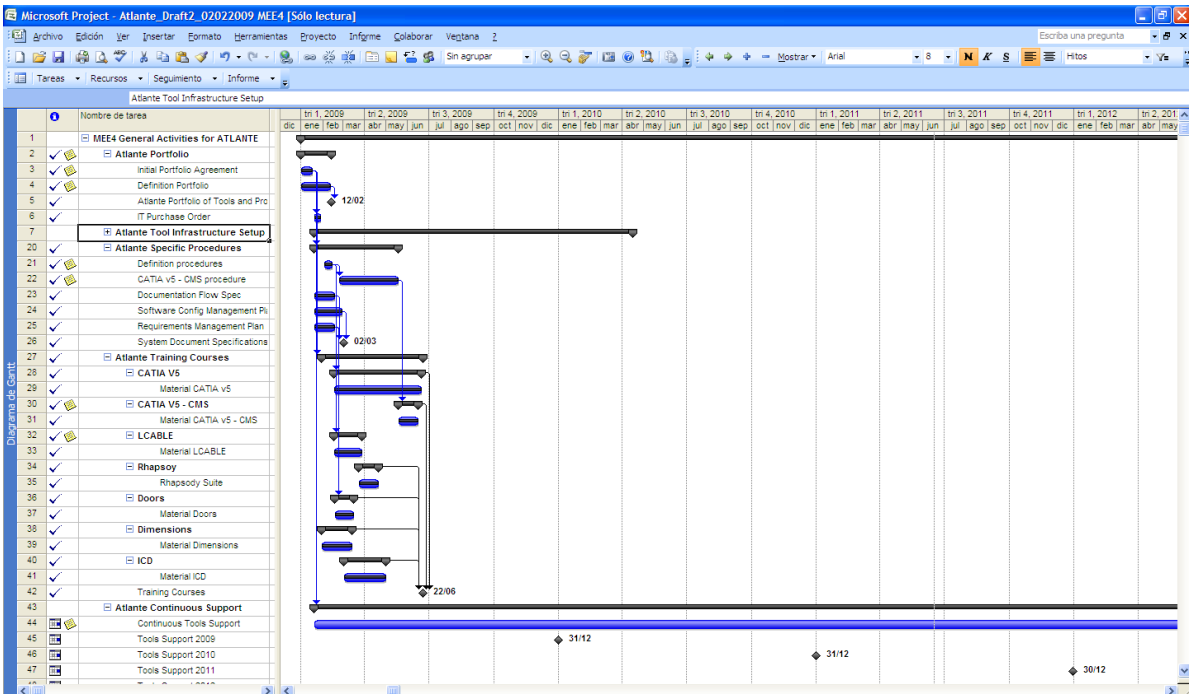

Figure 37: UAV WP Tools and Processes Detailed Plan

Programme planning compiles and distributes all relevant contractual documents regarding performance, costs and schedules subdivided according to the work breakdown structure (WBS).

It could schedule periodic project reviews at specified milestones and update the plan as needed following each review, for example in the PDR or CDR.

Also it must be described mechanisms for placing the baseline version and future revisions of the plan under configuration control, specify the control mechanisms used to measure the progress of the work completed at milestones, specify the methods and tools used to compare actual schedule performance to planned performance and to implement corrective action when actual performance deviates from planned or required performance.

In the company specific company tools coexists with standard tools which are used to control the UAV project performance.

It is important to emphasize in the following aspects:

- Adherence to the overall milestones and the time schedule of each increment shall be monitored.
- Milestone achievements shall be monitored and shall be coordinated with higher level milestone achievements.
- As far as system interfaces are concerned, milestone achievements of other projects shall be monitored and coordinated with own project milestone achievements.
- When delays or under-achievements of milestones become evident corrective actions including risk management activities shall be initiated.

5.7 UAV Budget.

The budget of the project is elaborated, down to the desired level of detail, or at least up to Work packages.

Regarding UAV the budget information, due to the nature of the project, is considered confidential. Therefore it cannot be included in this document.

On the following figure shows the values in terms of percentage Cost sharing with the Risk Sharing Partners (RSPs) involved.

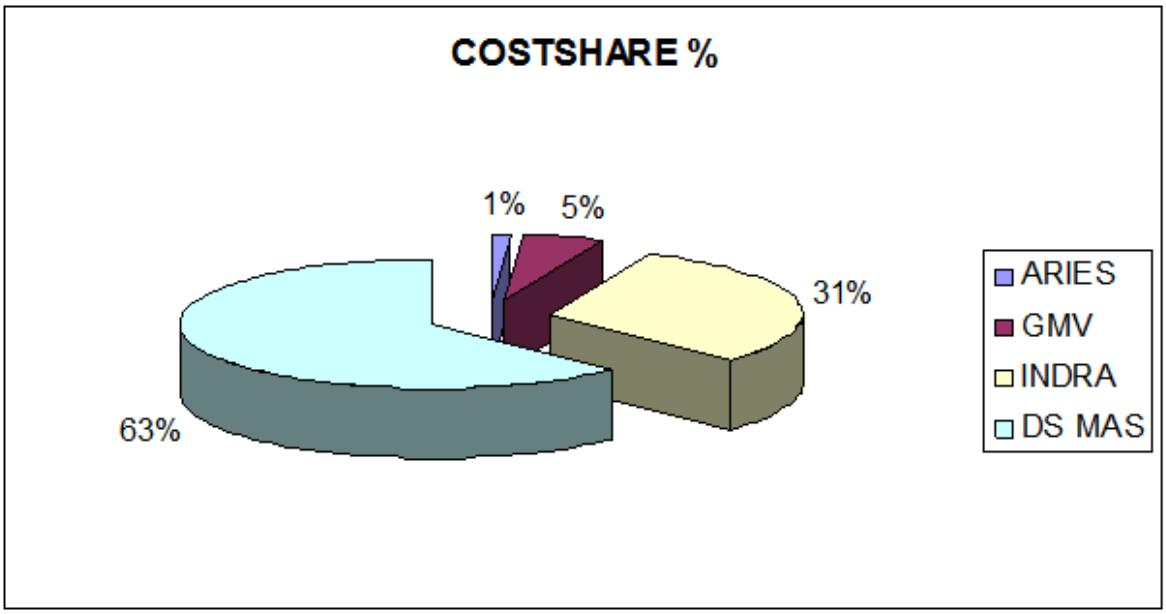

Figure 38: UAV Cost Share %

In UAV Programme the budget was established according to WBS and later decomposed by work packages.

Estimating work package costs involves developing an approximation of the costs of the resources needed to complete each work packages.

Cost estimation method is estimate the cost of individual work packages / activities and then rolls up these estimates to come up with an overall project estimate.

In UAV Programme, actual data is generated by:

- Booking of Mh on work packages (project order) on an individual basis by each employee via the SAP CATS tool. This is done once per week.

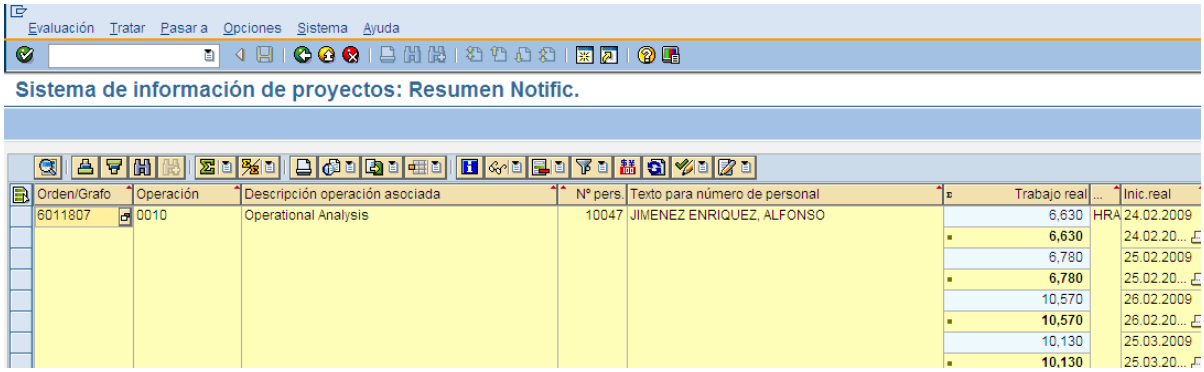

Figure 39: UAV Booking Manhours

- Continuous booking of costs by the accounting dept. e.g. IT costs, external subcontractors, material, travel expenses etc.

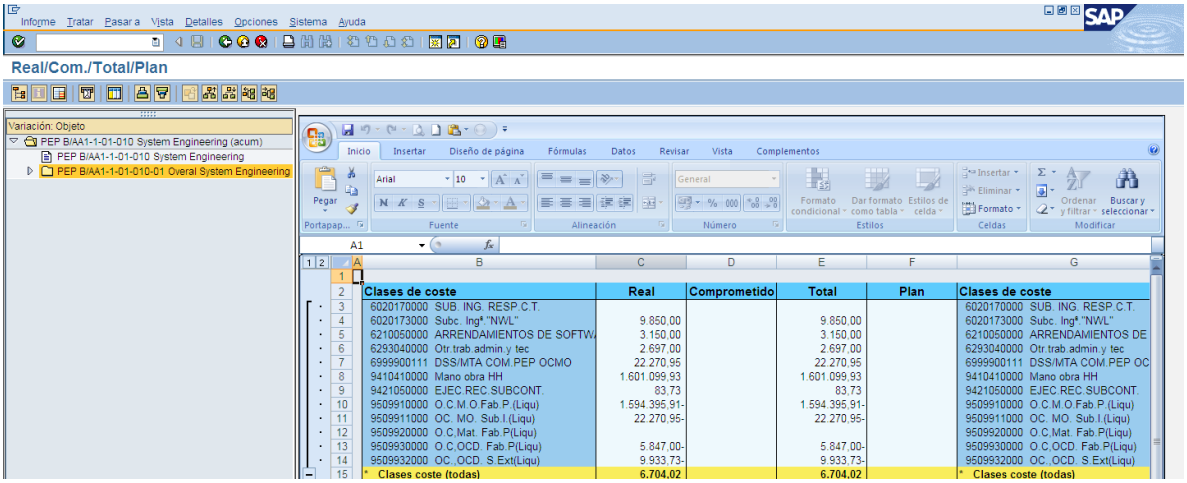

Figure 40: UAV SAP Booking Cost

- WP responsible reporting milestones once per month via the SAP Light tool.

As it was mentioned in section 4.3, KPIs are used to measure project performance, once of the KPIs is Estimated at Completion (EAC). Yearly UAV EAC is reviewed, detailed by Center of Competence and by class of cost, such as own hours, subcontracting hours, travels, equipment, investments…etc.

5.8 UAV Risk

As it was defined in section 4.1.5, Risk or Opportunity is an uncertain event or condition that, should it occur, will have a negative or positive effect on the achievement of objectives. These events could originate from a variety of sources, internal and external, in all areas of the project, e.g. technical, financial, legal, supplier's etc.

The objectives of project risk and opportunity management are to decrease the probability and impact of events and conditions adverse to the projects and to increase the probability and impact of positive events and conditions. It therefore supports the basic project objectives to perform in budget, time and quality / performance, the decision making and planning process in projects and crucial contributes to the overall success in the business.

In UAV a Risk Management Plan (RMP) was created: “UAV Risk and Opportunity Management Plan”. It describes the procedures for contingency planning and the methods used in tracking risks, evaluating changes in individual risk exposures, and responding to those changes. It includes a plan for ongoing risk identification throughout the project’s life cycle. Document the risks in a separate risk register, Risk Database.

RMP identifies the risk management tasks to be performed, who is responsible for each (roles and responsibilities), and the target date for completion of each task.

Risk Management tasks must be incorporated into the project schedule and budget, following what is established in the RMP.

Each operative area will nominate a responsible person/department for risk coordination, which will inform to the PMO UAV about the identified risks during the project development. The UAV Risk Register is created and updated and reviewed continuously (periodically and on request basis).

Stage to follow:

- Continuously monitor risk / opportunity triggers and start, if appropriate, with response actions and fallback actions respectively.

- Review documented risks / opportunities regularly and update the Risk& Opportunity Register, if necessary.
- Identify and document new risks / opportunities as soon as they arise.
- Analyze consequences of risk / opportunity status changes on response plans and adjust.
- Trigger appropriate project change requests.
- Check whether the risk / opportunity response actions are implemented as planned and whether they are effective.
- Perform risk audits, when actual risk status or response effectiveness seems in doubt.
- Escalate immediately when top priority risks have occurred.
- The top project risks and opportunities as well as the overall risk status have to be reported in the division-specific Management Information System.

Regarding UAV the risks information, due to the nature of the project, is considered confidential. Therefore it cannot be included in this document.

5.9 UAV Kick-off Meeting

In UAV program was appointed the necessity to establish a "Red Team" in order to evaluate the adequate processes performed during project initiating. All the processes performed were revised by this Red Team, in order to assess their adequacy and establish project profitability previously to project launch.

The Red Team reviews the project hypothesis and the processes performed until now to substantiate this Development Project. Basically, the objective is to check if the program is mature enough (costs, planning, etc..).

The purpose was:

- Create a shared vision and common understanding of the project objectives and strategy
- Start the team building process.
- Make sure that the team will have the same level of information
- Clarify the contribution of each person/group/department/CoC...
- Build the modus operandi of the team.
- Get the commitment to the decisions made and first planning elements.
- Details of the internal contract implementation and particularly the internal project schedule (including external and internal interfaces) should be agreed upon in a kick-off meeting with all responsible competence centers and the PMO.

Once Red Team approved and checked technical approach, budget, project master plan, main milestones…etc the Programme Directive was launched.

In case of changed premises and for further Program phases this document shall be adjusted. Any changes to the document shall be subject to configuration control.

6. CONCLUSIONS

The methodology V-model provides a useful illustration of the SE activities during the lifecycle stages. This methodology makes a distinction between development sub-processes and integral sub-processes. As it was mentioned Project Management is one of the Integral Sub-Processes and this activity is essential during every project, not only in the preliminary phase.

This Final Project has followed this V&V model to identify and perform the necessary activities to establish and define all project management elements. These activities have covered both sides of the V&V model, firstly establishing Project Management, then executing the activities identified in work packages, and finally monitoring and controlling these activities.

This Final Project provides an in depth look into all project management processes to be considered for development projects in the full project lifecycle, adapting those processes depending on the nature of the project itself.

The main conclusion is that all processes within project management are iterative in the progressive elaboration throughout the project's life cycle; therefore it is essential to be defined correctly following all steps described in this project.

This Final Project has been performed as an academic work, but its structure can be used to perform a real project, UAV programme has functioned as an example.

7. BIBLIOGRAPHY

[1] Internal EADS Documentation.

[2] Master Aircraft System Integration documentation.

[3] Guide to the Project Management Body of Knowledge (PMBOK® Guide) Third Edition 2004 Project Management Institute, Four Campus Boulevard, Newtown Square, PA 19073-3299 USA

[4] Guide for Planning and Managing Through Used of Earned Value Techniques.

[5] Systems Engineering Fundamentals (SEF).