FACULDADE DE ENGENHARIA DA UNIVERSIDADE DO PORTO



Specification of a Space Project Management Handbook

Diana Maria dos Santos Barbosa

Mestrado Integrado em Engenharia Electrotécnica e de Computadores

Supervisor: Américo Lopes de Azevedo (Prof.)

Co-Supervisor: Costa Pinto (Eng.)

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Presidente Professor Doutor Rui Manuel Esteves Araújo
Professor Auxiliar do Departamento de Engenharia Electrotécnica e de Computadores da Faculdade de Engenharia da Universidade do Porto

Professor Doutor José António dos Reis Tavares
Professor Adjunto do Departamento de Informática da Instituto Superior de Engenharia do Instituto Politécnico do Porto

Professor Doutor Américo Lopes de Azevedo
Professor Associado do Departamento de Engenharia Industrial e Gestão da Faculdade de Engenharia da Universidade do Porto

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Autor - Diana Maria dos Santos Barbosa

Faculdade de Engenharia da Universidade do Porto

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Abstract

In this document there is presented a specification of a project management platform for space projects. The main goal for this specification was to include the European Cooperation for Space Standardization standards and normative documents within the platform available for all projects during the entire life cycles. The European Cooperation for Space Standardization (ECSS) provides a set of management standards to be used and respected for all space projects developed by space industry, enterprises or organizations under the guidance of the European Space Agency. These standards intend to define common rules among all space projects to set coherency between them despite the enterprise or organization responsible for the development. Besides the management standards adoption, the specified platform satisfies a series of needs and requirements made by the project manager and project development team of the space department for which this platform was design to. The requirements defined for the platform formed the basis to the definition of the system's architecture. This architecture was translated into groups of packages that combined defined the major areas of the platform's system, each one of these areas have features and functionalities that allow the users to effectively manage their activities during the entire life cycle of a project.

Like in every other system, it was important to define the database structure behind it, including all elements/components and association relationships between these. This database specification is included on the system definition step that is presented in this document. To conclude the project management platform specification the design of all the interfaces is presented at the end of this document, these interfaces illustrate the user-platform interactivity, the system's functionalities and all implemented management features. The last chapter of this document is dedicated to the conclusions drawn from the developed work and to describe the possible work to be developed in the future that could improve even more the specified platform.

Key words: Project management; ECSS standards; Requirements definition; System specification; Interfaces design; Management platform; Use cases.

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To my dog Lucas for teaching me that words are overrated, for being by my side day and night, for showing me that strong bounds are forever and that you will always be a part of me. And finally to those who make my inner light shine brighter everyday, thank you for all the support.

Diana Santos Barbosa

"Be not afraid of greatness:
some are born great, some achieve greatness, and some have greatness thrust upon them."

William Shakespeare

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Abbreviations and Symbols

ESA	European Space Agency
ECSS	European Cooperation for Space Standardization
PMBok	Project Management Body of Knowledge
WBS	Work Breakdown Structure
SEP	Systems Engineering Structure
PRD	Project Requirements Documents
ILS	Integrated Logistic Support
WP	Work Package
OBS	Organization Breakdown Structure
MDR	Mission Definition Review
PRR	Preliminary Requirements Review
SRR	System Requirements Review
PDR	Preliminary Design Review
CDR	Critical Design Review
QR	Qualification Review
AR	Acceptance Review
ORR	Operational Readiness Review
FRR	Flight Readiness Review
LRR	Launch Readiness Review
CRR	Commissioning Result Review
ELR	End-of-Life Review
MCR	Mission Close-out Review
RID	Review Item Discrepancy
DRD	Document Requirements Definition
CM	Configuration Management
DRL	Document Requirements List
TDP	Technical Data Package
ZIP	Compressed file
CIDL	Configuration Item Data List
SCF	Software Configuration File
CBS	Cost Breakdown Structure
CCS	Country/Company Structure
CCN	Contract Change Notice
DCP	Development Cost Plan
OBCP	Original Baseline Cost Plan
CBCP	Current Baseline Cost Plan
EAC	Estimate At Completion
ETC	Estimate To Completion
Baan	Financial platform used within the company
UML	Unified Modeling Language

Chapter 1

Introduction

1.1 Context and Motivation

This thesis presents the work developed for the specification of a management platform for space projects. This specification was made during an internship on the electronic products space department in the EFACEC company [6] and it's execution was born due to the fact that the space was always a personal interest of mine. On a first meeting between me and the engineer responsible for the space department it was discussed what work could be developed that would add value to the projects developed on his department. After this, the idea of a management platform was sketched and its first requirements and performance expectations were defined. The project management area and the space were two areas of personal interest that came together on this dissertation project. In general, projects developed by development teams have a series of processes and activities that need to be manage in an effective and controlled way, due to this fact, it is common the existence of platforms that help projects management and keep track of all the necessary activities to be developed during a project's life cycle.

The idealized platform would be able to help the project manager supervise all of the projects developed by his project development team and keep record of all the important activities to be executed. But these were not the only early requirements for this platform, all space projects must be developed according to the standards defined by ESA (European Space Agency) [7] as so this platform should be able to follow the guidelines defined on those standards. With this, the specification of the Space Project Management Platform was started and its features were defined, the platform should help both project manager and development team members to monitor and execute all of the activities involved during the development of each space project in course.
The platform should give each user, from the project development team, the overall view of all projects and all of its different areas such as the project schedule, documents, meetings, financial data, phases and risk monitoring. Each user would have to have a personal area where all of his activities/tasks nominations were presented and were he could manage his to-do list for each project.

1.2 Main objectives

The main objective traced for this thesis was to specify a platform to manage space projects developed by a project development team within an electronic products space department. This platform would have available for selection all documentation defined by the ECSS standards within each respective area of expertise, it would also serve as a management tool for keeping track of all activities and responsibilities of all team members during a project's life cycle. The platform would also serve as a communication tool between the users. All meetings and risk monitoring tasks would be kept in record within the platform.

Thereby, these objectives defined for the specification of the platform were divided according to categories:

- ECSS standards analysis.
- Needs assessment.
- Requirements definition.
- System definition.
- Interfaces design.

The European Cooperation for Space Standardization (ECSS) [8] standards analysis consisted on the full reading of each one of the standards defined for the management branch, these standards present guidelines to be respected and followed when developing a space project. Each one of these standards was filtered in a way that allowed to highlight all interest aspects to be implemented into the platform.
The needs assessment process was divided into two different tasks: the assessment of the project manager needs in terms of management of all activities and monitoring the project development team, and the project development team needs, which consisted on identifying the difficulties detected during the development of work necessary for every project, such as managing all of the assigned activities, keeping track of all scheduled meetings or documents executions nominations.
After these two initial steps it was possible to move to the requirements definition, these requirements translate the identified needs into features and functionalities that the system should be able to perform. By guaranteeing the implementation of these requirements the system will be able to correspond to the project manager and project development team expectations.
The system definition phase consists on defining the system packages dividing them into the system major areas and specifying the features and functionalities within each one. The last part of this definition is the specification of the database structure which it was made using the UML entities and association relations.
At last, the system interfaces design takes place, this design is based on the system's definition and aims to provide in an easy and simple way the system's screens necessary for the management of all space projects.

The present document will illustrate in detail all of these specification steps.

1.3 Expected results

The expected results defined for this specification are:

- The needs assessment of the project manager and project development team;
- The ECSS standards normative requirements to be implemented into the system;
- The requirements definition that reflect the identified needs;
- The system definition divided into its major packages and functionalities;
- The design of the system interfaces.

For a specification to be consider successful the end result must present a clear, unambiguous, and complete definition of the system. This definition must be solid in a way that if delivered to a software development team it would be possible to build and implement the system. Another important result is the specification of the system's database where all of the system's characteristics would be defined through a software modelling language which would facilitate once again its real implementation.

1.4 Dissertation structure

The dissertation document is divided into six chapters: the first chapter is the current one, the Introduction chapter, the second one is the Literature review (2) chapter where the ECSS standards for space project management are presented and assessed, these standards represent valuable information for the system's definition.
The following chapter is the Needs assessment and Requirements definition chapter (3), here the projects manager needs as well as the project development team needs are assessed, classified and translated into requirements to be implemented in the system's definition.
The fourth chapter is dedicated to the system's definition (4) where the system's packages are defined and organized in a way that allows the interfaces design to be much efficient and simple to organize, it is also in this chapter that the database structure defined for this system is illustrated.
On the fifth chapter, the System design chapter (5), is where the system's interfaces are presented according to the requirements defined to be implemented, and where the features and functionalities necessary to fulfil the users expectations are illustrated. There is also presented some use cases that illustrate some of these features and functionalities defined within the system's interfaces.
The last chapter is the Conclusions and Future work chapter (6), here the conclusions about the developed work are presented and the possible future work to be implemented and improved on the platform is identified.

Chapter 2

Literature Review

In this chapter the literature review used to guide the specification of the system is presented through different management standards. The Project Management Body of Knowledge [1] is a well known and prestiged standard that defines the guidelines and requirements necessary to perform project management throughout a project life cycle. Another important standard for project management is the Systems Engineering Process [2] that defines the guidelines to create systems based on the transformation of the stakeholders needs into requirements that the systems should be capable of fulfilling. Although these two standards represent important guidelines for this specification, the European Cooperation for Space Standardization (ECSS) standards for the management of space projects are the foundation of the specified system. The ECSS standards intend to support all different steps of the development of space projects, indicating all required normative documents on each project phase.

2.1 Project Management Body of Knowledge

The Project Management Body of Knowledge (PMBok) standard [1] defines the knowledge and practices applicable to most projects although these may not be applicable uniformly on all projects, the project team responsible for the management and development of each project must determine which practices are more suitable for the project in question.
Each project can be defined by its distinctive characteristics and for its final goal, creating a unique product or service, it also haves a definite start and end and its product or service can be distinguished from other products or services. Projects may also involve a single unit of one organization (such as department) or may involve various organizations joining expertise or partnering. An organization's business strategy is performed by projects, they represent the means by which the strategy is implemented, for a project to reach its end it is necessary that the project's objectives have been considered achieved, or that those objectives cannot or will not be met, or the need for the project no longer exists.

2.1.1 Project management

Project management is the application of knowledge, skills, tools and techniques to project activities to meet project requirements. A successful project management is accomplished through processes such as: initiating, planning, executing, controlling, and closing that are common among all projects. Projects are divided into crucial phases, each phase is marked by the completion of one or more deliverables and reviews that aim to determine if the project should continue to the next phase and to detect and correct errors cost effectively.

A project's life cycle can be described using forms, charts and checklists to provide structure and consistency, but most of these descriptions share common characteristics like cost and staffing levels are low at the start of the project, higher at the end and decrease rapidly as the project draws to a conclusion. The probability of completing a project is lowest at the start of the project thereby the risk and uncertainty levels are highest, this probability gets progressively higher as the project continues its development.

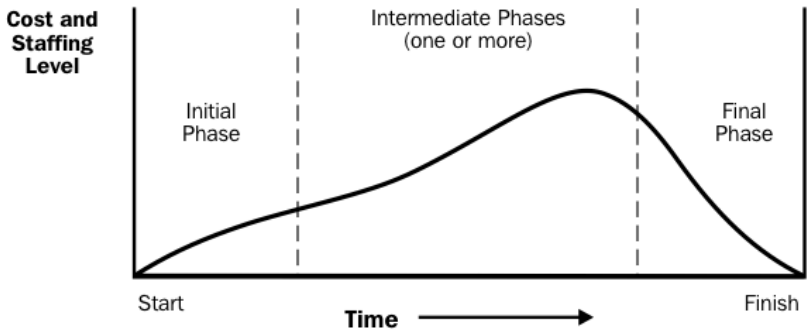


Figure 2.1: Generic life cycle - figure available in [1]

An essential tool on a successful project management is the right communication level, communicating involves the exchange of information, this exchange implies the choice of the sender-receiver models such as the choice of media: when to communicate in writing, orally, informal memo, formal report, the writing style, presentation techniques and meeting management techniques. Project communications management is the application of these concepts to the specific need of the project.

An important aspect when managing a project is the problem solving process, this involves a combination of problem definition and decision-making, the problem definition requires distinguishing between causes and symptoms, these problems may be internal, external, technical, managerial or interpersonal. Decision-making includes analysing the problem to identify viable solutions and then make a choice; once this choice has been made it must be implemented.
As said, projects are composed of processes, a process, by definition, is a series of actions bringing about a result, so the project management processes are essential within a project and can be organized into five groups:

- Initiating processes;

- Planning processes;
- Executing processes;
- Controlling processes;
- Closing processes.

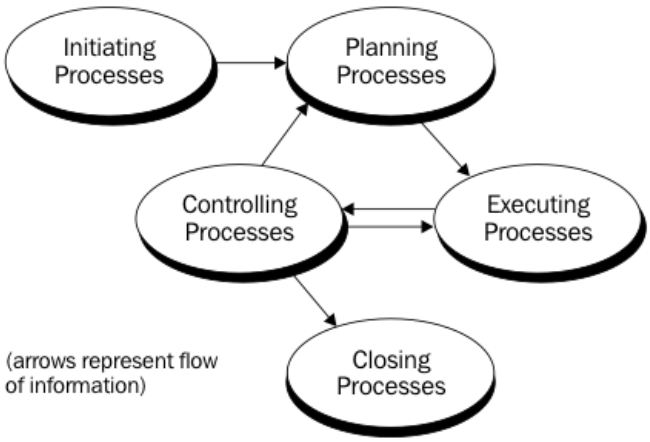


Figure 2.2: Links between process groups in a phase - figure available in [1]

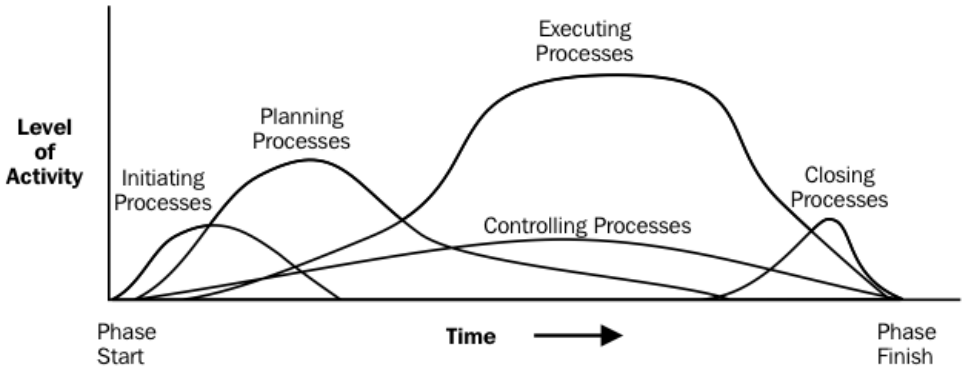


Figure 2.3: Overlap of process groups in a phase - figure available in [1]

The project scope of work is an important and iterative process usually done by the project team with the use of a Work Breakdown Structure (WBS), allowing the team to organize and decompose all of the work to be developed in the project, simplifying the management and control of the work packages. The project plan execution is the primary process for carrying out the project plan, in this process, the project manager and team must coordinate and direct all of the technical and organizational interfaces present in the project.

Another important tool for a project's success is the project time management, this process includes the processes required to ensure timely completion of the project and are the:

- Activity definition;
- Activity sequencing;
- Activity duration estimating;
- Schedule development;
- Schedule control.

The project cost management process includes the processes required to ensure that the project is completed within the approved budget, those processes imply the resource planning, cost estimating, cost budgeting and cost control. The primary concern of the project cost management is to control the costs associated to the resources needed to complete project activities.

Also the project quality management aims to ensure that the project will satisfy the needs for which it was undertaken, it involves quality planning, quality assurance and quality control and it must address both the management of the project and the product/service of the project. Failure to meet quality requirements can have serious negative consequences on the project's development.

Another important branch of project management is the project human resource management that is responsible for assuring that all people involved with the project is used in the most effective way. It includes all the project stakeholders such as sponsors, customers or partners. The main processes involved in this management are the organizational planning, staff acquisition and team development processes.

At last the risk management is a systematic process that identifies, analyses, and responds to a project risk, it includes maximizing the probability and consequences of positive events to a project and minimizing the probability and consequences of negative or adverse events that can affect the project's objectives. The risk management is implemented through the execution of six main processes:

- Risk management planning;
- Risk identification;
- Qualitative risk analysis;
- Quantitative risk analysis;
- Risk response planning;
- Risk monitoring and control.

Risk conditions can include aspects of the project environment that may contribute to project risk such as poor management practices or dependency on external participants that cannot be controlled. Project risk includes both threats to the project's objectives and opportunities to improve those objectives. Identified and analysed risks are the ones that it may be possible to plan for them; these risks are defined as known risks.

2.2 Systems Engineering Process

During a system's life cycle it is essential to transform stakeholders needs, requirements, and constraints into a system solution. This standard [2] defines the guidelines to the development of systems for commercial, government, military, and space applications. All of the information applies to a project within an enterprise that is responsible for developing a product/service. This standard also specifies the requirements for the Systems Engineering Process (SEP) and its application throughout the product life cycle.

Each project has a series of tasks to perform during the different phases on the project's life cycle, these tasks shall be performed for the requirements analysis for the purpose of establishing what the system will be capable of accomplishing, the environments in which system products operate, the requirements of the human/system interfaces, and the physical characteristics and constraints that affect design solutions. It is important to define and quantify the stakeholder expectations for the system; they may come from a recognized market opportunity, direct communications from users, or the requirements from a higher-level system. These expectations include what the stakeholder wants the system to accomplish (functional requirements), how well each function is to be accomplished (performance requirements), the environment in which the product of the system operates or may be used, and at last the system constraints such as cost or price objectives, schedule, technology, etc.

The enterprise is responsible for identifying and defining the project and enterprise constraints that impact design solutions, these project constraints can be approved specifications and baselines developed before the SEP application, engineering and technical plans, control mechanisms, etc. The enterprise constraints may include:

- Management decisions;
- Enterprise general specifications, standards, or guidelines;
- Policies and procedures;

The project must also identify and define external constraints that impact design solutions or the implementation of SEP activities, such as the technology base, international standards, public and international laws.

All of the operational scenarios in the project must be identified and for each one the project defines expected interactions with the environment and other systems, human tasks and sequences, or platforms. With this, it is important to define system effectiveness measures that can reflect the stakeholder expectations. These measures can include the performance, safety, or usability levels. The functional and design interfaces to external and/or interacting systems, platforms, or products must also be defined, it is important to define the utilization environments and factors, being natural or induced, for each of the operational scenarios.

As known, the human factor is essential for a project's success; thereby, the project must evaluate and determine the human experiences, aptitudes, knowledge, skills and abilities required to

perform the tasks that are associated with the humans who support the system life cycle processes. To define what the system should be able to do (functional requirements) the project performs functional context analysis, the identified functions are decomposed during functional decomposition to provide a basis for identifying and assessing design alternatives. All required design characteristics for the product under development must be identified and organized into the ones that represent constraints or characteristics that can be changed based on trade-off analyses.

2.2.1 Requirements validation

The requirements analysis represents an important part of the system engineering process, figure 2.4, this analysis is composed by a series of tasks such as the comparison between the established requirements baseline and the stakeholder expectations to ensure that the technical requirements represent the stakeholder needs, requirements, and constraints for the system product and life cycle concept.

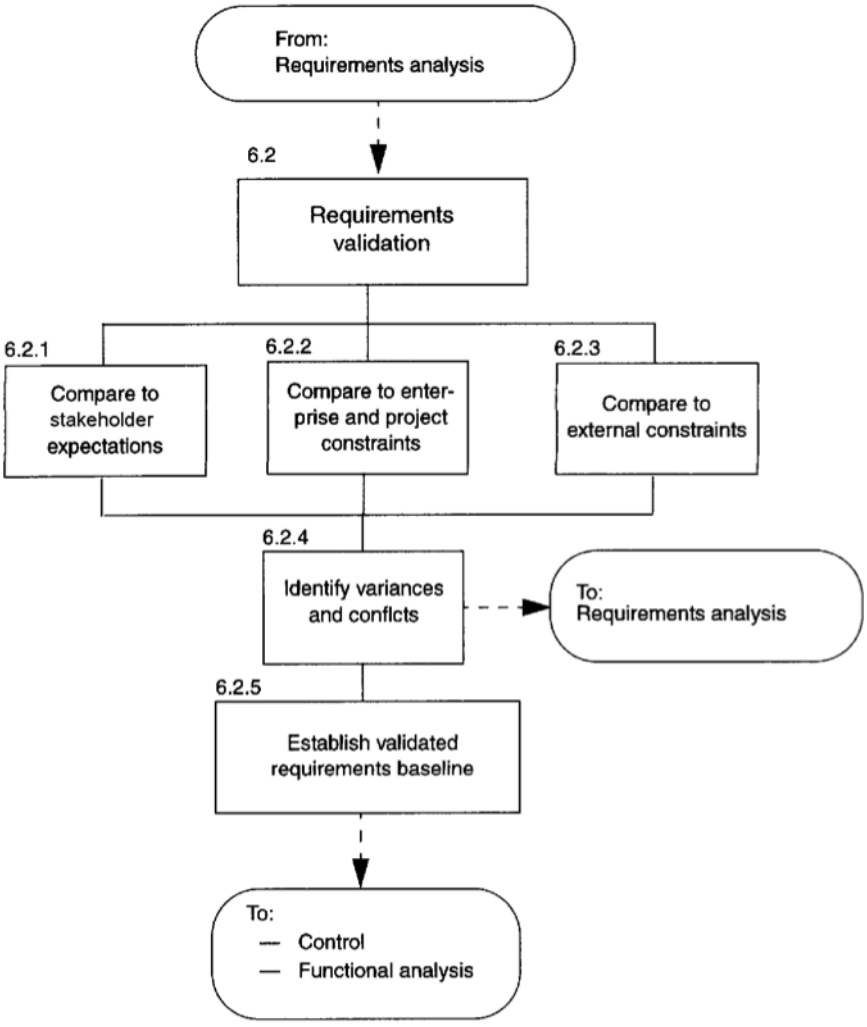


Figure 2.4: Requirements validation - figure available in [2]

To ensure that the technical requirements are correctly represented and that these stay within the enterprise and project policies and procedures, acceptable risk levels and resources, the project analyses and compares the established requirements baseline against enterprise and project constraints. It is also important that the project identifies and defines variances and conflicts that arise out of the validation tasks defined in the diagram of the figure 2.4, each variance or conflict is resolved by refining the requirements baseline.

Once the established requirements baseline variations and conflicts are resolved the final requirements baseline is considered valid, this baseline is then used as input to functional analysis. The functional analysis process decomposes the system functions to lower-level functions that should be executed by elements of the system design such as subsystems, components, or parts. This is accomplished by translating the validated requirements baseline into a functional architecture; this architecture describes the functional arrangements and sequencing of subfunctions resulting from breaking down the set of system functions.

2.2.2 Functional analysis process

The functional analysis process, as shown in the figure 2.5, decomposes the system functions to lower-level functions that should be executed by elements of the system design such as subsystems, components, or parts. This is accomplished by translating the validated requirements baseline into a functional architecture.

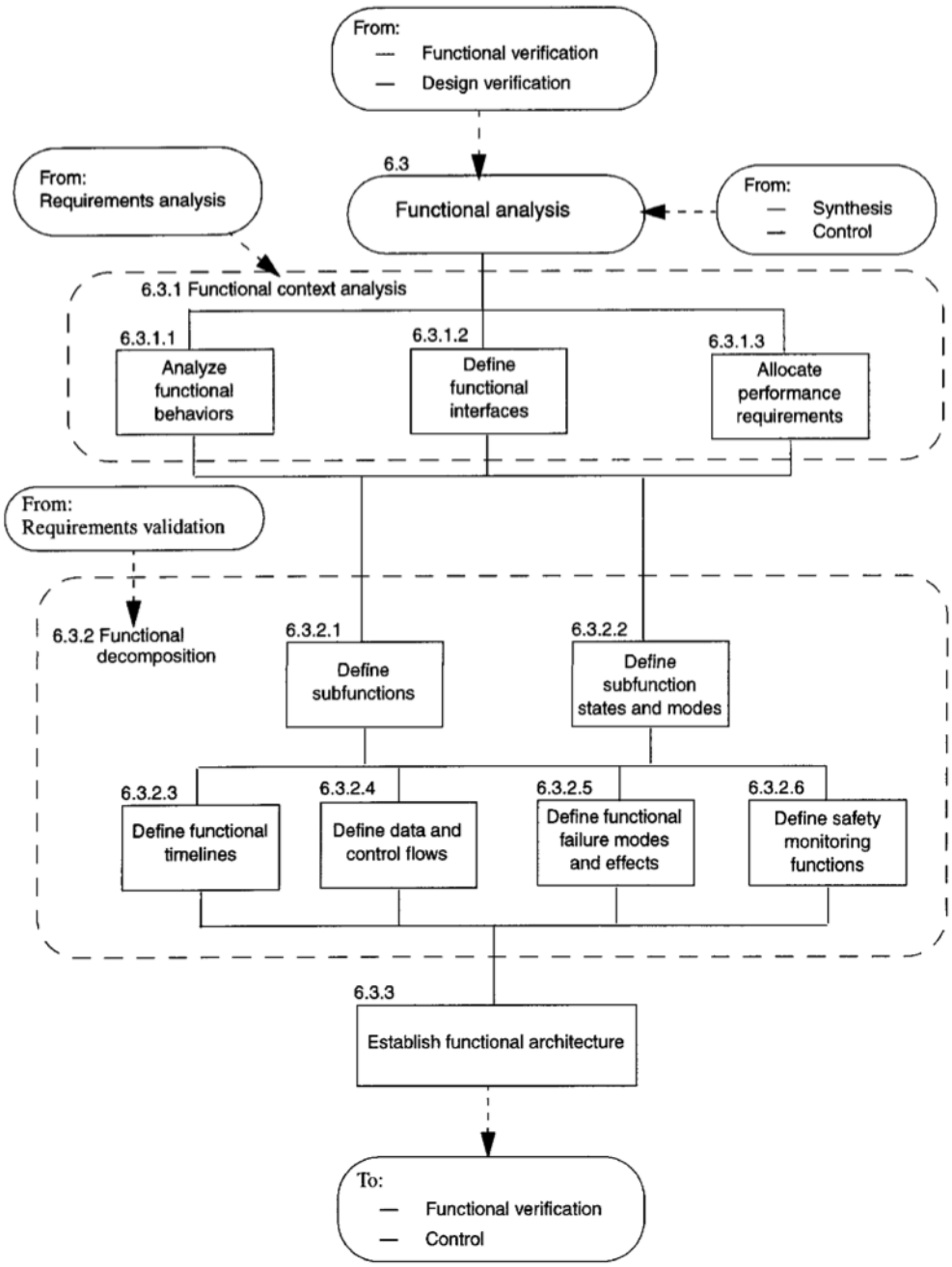


Figure 2.5: Functional analysis process - figure available in [2]

2.3 Introduction of the ECSS standards

The ECSS (European Cooperation for Space Standardization) standards are a result of a cooperative effort between the European Space Agency (ESA), national space agencies and European industry associations for the purpose of developing and maintaining common standards for all space projects. The requirements in all standards are presented in terms of what shall be accomplished, rather than in terms of how to organize and perform the necessary work, this one is done by the criteria of every company or association responsible for its development.

2.4 Project planning and implementation

The Project planning and implementation standard [3] presents, in a coherent way, the set of processes for all aspects of the project management and control, this is accomplished by doing an establishment of the project requirements and constraints derived from the mission statement, defining phases and formal milestones enabling the progress of the project to be controlled, defining project breakdown structures, which makes easier to identify the tasks and responsibilities of each actor, facilitate the coherence between all activities and perform scheduling and cost activities. This standard presents the principles of project planning and implementation that consists on the project planning, organization, breakdown structures and phasing principles.

2.4.1 Principles

Project planning and implementation include all of processes carried out in order to plan and execute a space project from initiation to completion at all levels in the costumer-supplier chain in a coordinated, efficient and structured way. It is important to the project initiator to define the purpose and objectives of the project in the mission statement which identifies the key performance parameters and technical/programmatic constraints to be applied to the project. All space projects have project requirements documents (PRD) that typically comprise the statement of work, technical requirements, management requirements, engineering requirements, product assurance requirements and programmatic requirements. The management branch of the ECSS standards is identified by the M standards.

The top level project plan is the project management plan which defines the project management approach and methodology to be used throughout the life cycle of the project. It includes the definition of the system engineering and product assurance management approach or provides references to separate the two plans which together make up the total planning documentation used to implement a project.

For the project organization the establishment of a well structured and coherent organization structure for implementing a project at all levels in the customer-supplier chain is essential for ensuring an effective and efficient management approach. The organizational structure is arranged

to include all disciplines [1] essential to implement the project with well defined functions [2] as well as clear reporting lines. The organizational structure provides a clear and unambiguous definition of individual roles and responsibilities together with the necessary authority to implement these within the internal project set-up as well towards project external interfaces.

Another important aspect of the project organization structure is the insurance of effective means of communications by using the right tools for interaction between all project actors, as well as between the project team and its external interfaces. The information technology is the primary means for the exchange of information within a project. Communication serves initially to provide clarity about the project's goals and objectives and to support the day to day work of the project team. Regular reporting is an important tool for exchanging information concerning the progress of the project. Throughout the project development there must be audits that represent independent examinations to determine whether processes and procedures achieve the specified objectives. They are an essential tool to identify problem areas.

Project breakdown structures provide the basis for creating a common understanding between all actors, they break the project down into manageable elements. One element of the project breakdown structure is the product tree which breaks down the system performances into functions, each one is decomposed into sub-functions independent of the type of products involved. This "function" approach is applied during project start-up or during the system definition phase. Another important element is the specification tree which defines the hierarchical relationship of all technical requirements specifications for the different elements of a system or product. The product tree is the breakdown of the project into successive levels of hardware and software products or elements, articulated to perform the functions identified in the function tree. The product tree includes the development models, the integration tools and test equipment, and external items necessary to validate the end product and integrated logistic support (ILS) items. The product tree forms the basis for the elaboration of the work breakdown structure.

The work breakdown structure (WBS) is the principal structure used in managing a project and provides a framework for managing cost, schedule and technical content. It divides the project into manageable work packages, organized according to the nature of the work by breaking down the total work to be performed into increasing levels of detail.

[1] discipline - specific area of expertise within a general subject

[2] function - combination and interaction of a number of operations or processes, which together achieve a defined objective

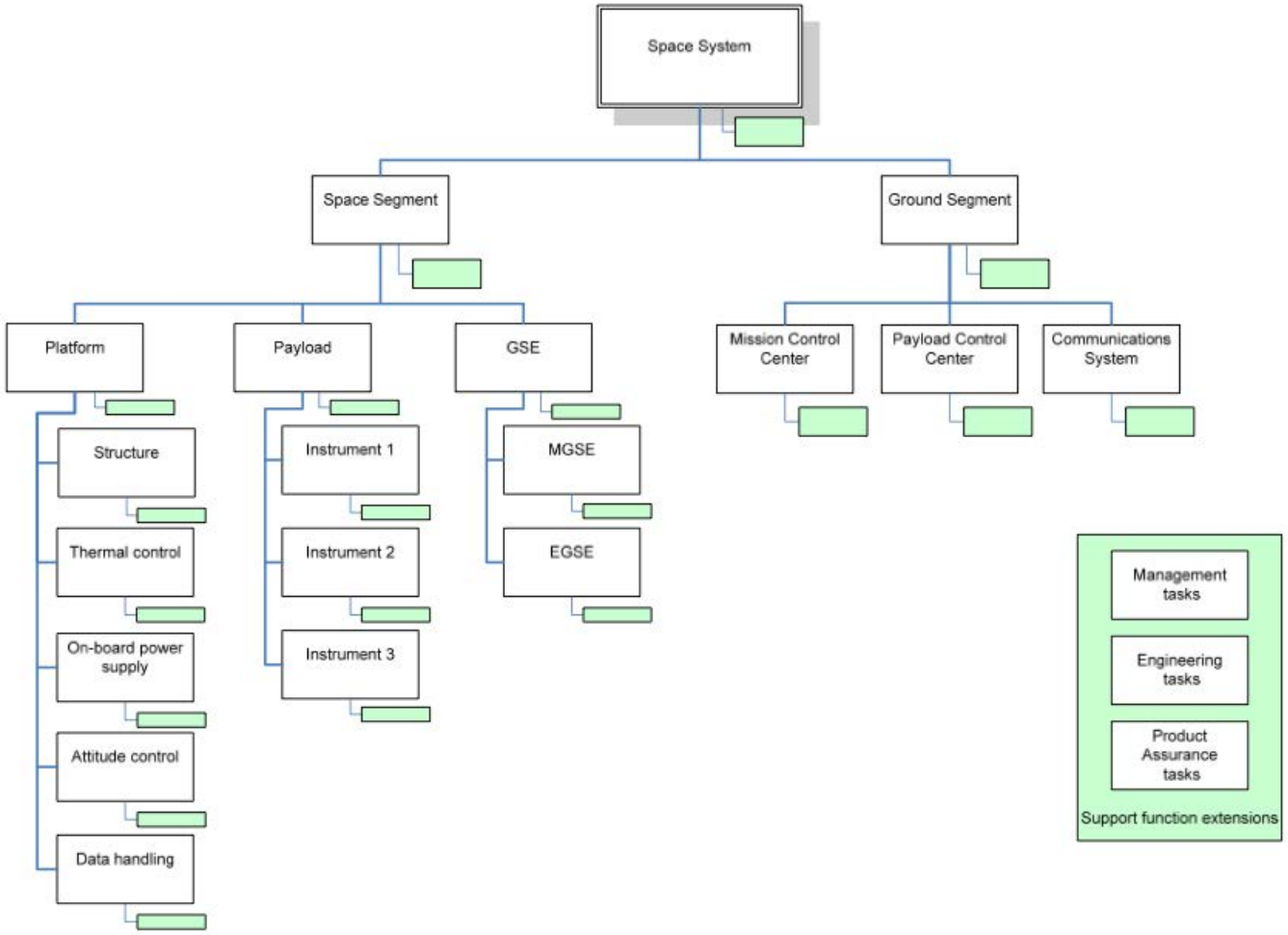


Figure 2.6: WBS example available in [3]

A work package (WP) can be any element of the WBS down to the lowest level that can be measured and managed for planning, monitoring, and control. The organization breakdown structure (OBS) is also an important tool for the identification of the key personnel and assigned responsible parties for each work package in the WBS.

This standard defines that all space projects can be divided into common phases, these are the:

- Phase 0 - Mission analysis/needs identification
- Phase A - Feasibility
- Phase B - Preliminary Definition
- Phase C - Detailed Definition
- Phase D - Qualification and Production
- Phase E - Utilization
- Phase F - Disposal

Project phases are closely linked to activities on system and product level. Depending on the specific circumstances of a project and the acceptance of involved risk, activities can overlap project phases.

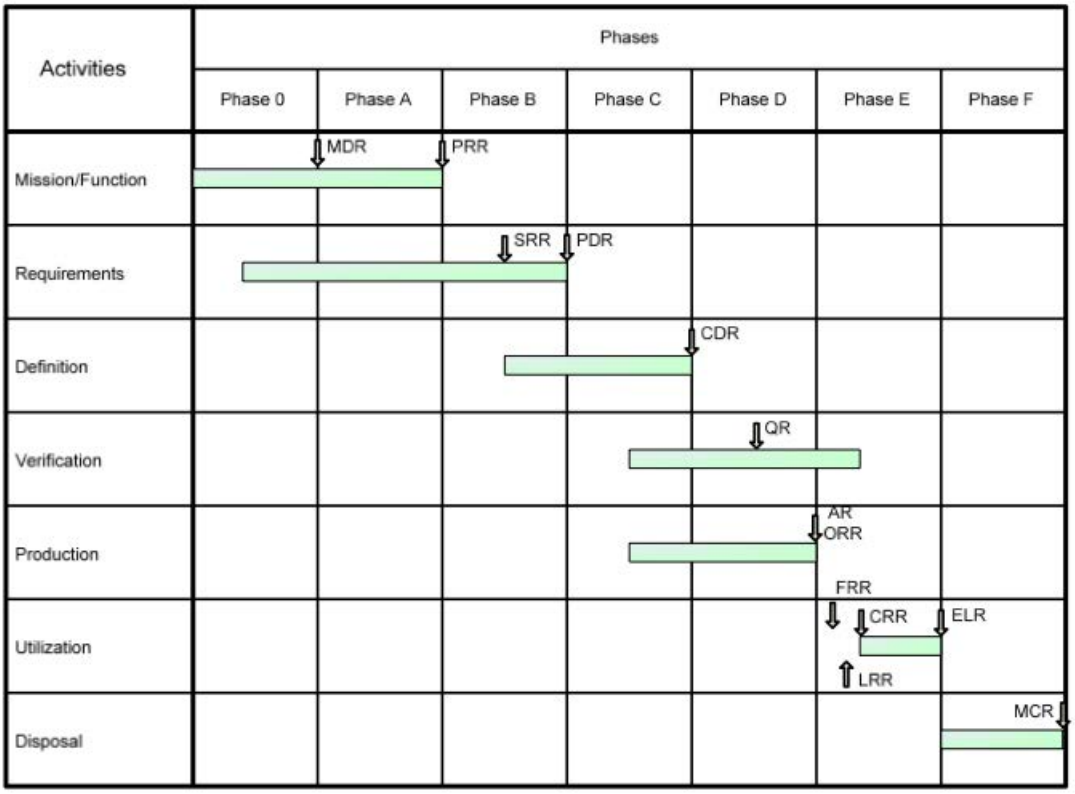


Figure 2.7: Project Life Cycle example available in [3]

The 0, A and B phases are focused mainly on:

- the elaboration of system functional and technical requirements and identification of system concepts to comply with the mission statement;
- the identification of all activities and resources to be used to develop the space and ground segments of the project;
- the initial assessments of technical and programmatic risk;
- initiation of pre-development activities.

Phases C and D comprise all activities to be performed in order to develop and qualify the space and ground segments and their products. Phase E includes all activities to be performed in order to launch, commission, utilize, and maintain the orbital elements of the space segment and utilize and maintain the associated ground segment. Finally Phase F comprises all activities to be performed in order to safely dispose all products launched into space as well as ground segment.

Each of the above project phases includes end milestones in the form of project reviews, the outcome of which determines readiness of the project to move forward to the next phase.

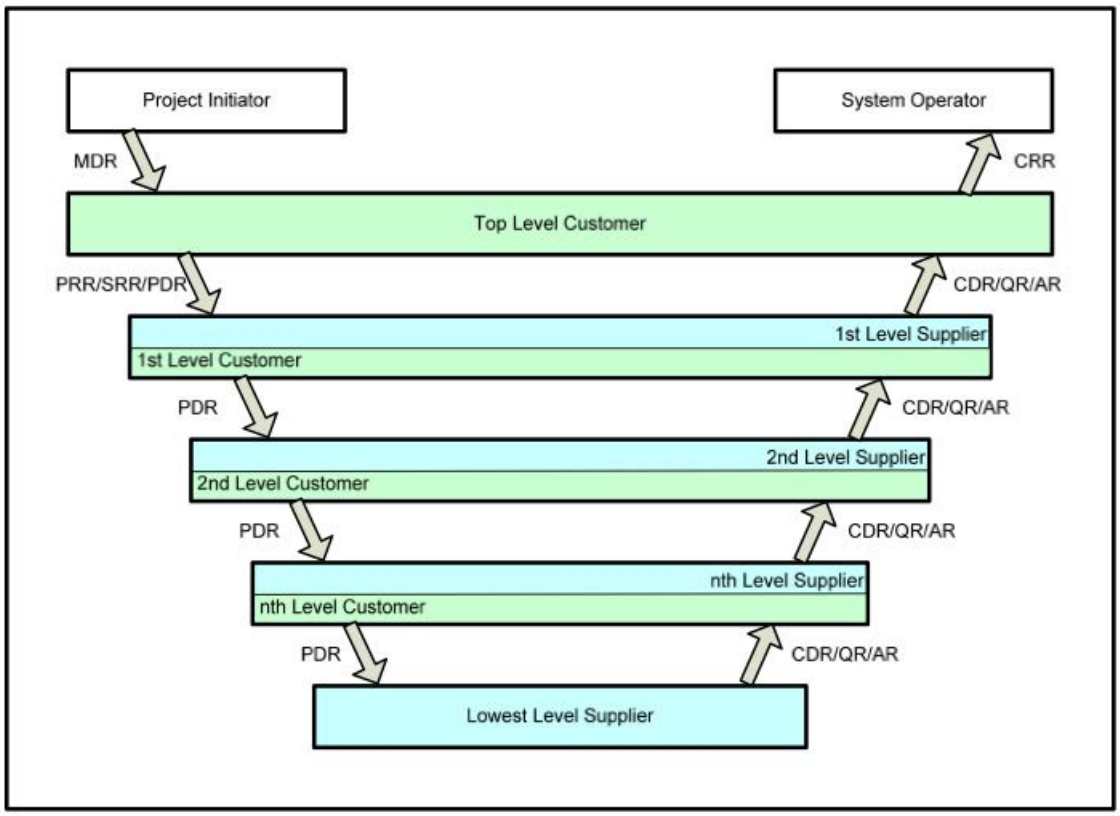


Figure 2.8: Review Life Cycle example available in [3]

2.4.2 Project phases

All project phases are provided with typical major tasks, associated reviews milestones, and review objectives which are presented below:

- **Phase 0 - Mission analysis/needs identification**
  - Overview

    This is mainly an activity conducted by the project initiator, the top level customer and representatives of the end users.
  - Major tasks
    - Elaborate the mission statement in terms of identification and characterization of the mission needs, expected performance, dependability and safety goals and mission operating constraints with respect to the physical and operational environment;
    - Develop the preliminary technical requirements specification;
    - Identify possible mission concepts;
    - Perform preliminary risk assessment.
  - Associated review
    - The mission definition review (MDR) is held at the end of Phase 0.
  - Main review objective(s)
    - The primary objective of this review is to release the mission statement and assess the preliminary technical requirements specification and programmatic aspects.
- **Phase A - Feasibility**
  - Overview

    This is mainly an activity conducted by the top level customer and one or several first level suppliers with the outcome being reported to the project initiator, and representatives of the end users for consideration.
  - Major tasks
    - Establish the preliminary management plan, system engineering plan and product assurance plan for the project;
    - Elaborate possible system and operations concepts and system architectures and compare these against the identified needs, to determine levels of uncertainty and risks;
    - Establish the function tree;
    - Assess the technical and programmatic feasibility of the possible concepts by identifying constraints relating to implementation, costs, schedules, organization, operations, maintenance, production and disposal;

    - Propose the system and operations concept(s) and technical solutions, including model philosophy and verification approach, to be further elaborated during Phase B;
    - Elaborate the risk assessment.
  - Associated review
    - The preliminary requirements review (PRR) is held at the end of Phase A.
  - Main review objective(s)
    - Release of preliminary management, engineering, and product assurance plans;
    - Release of the technical requirements specification;
    - Confirmation of the technical and programmatic feasibility of the system concept(s);
    - Selection of system and concept(s) and technical solutions, including model philosophy and verification approach, to be carried into Phase B.

- **Phase B - Preliminary definition**
  - Major tasks
    - Finalize the project management, engineering and product assurance plans;
    - Establish the baseline cost at completion;
    - Elaborate the baseline master schedule;
    - Elaborate the preliminary organization breakdown structure (OBS);
    - Identify and define external interfaces;
    - Prepare the next level specification and related business agreement documents;
    - Conduct reliability and safety assessment;
    - Finalize the product tree, the work breakdown structure and the specification tree.
  - Associated reviews
    - The system requirements review (SRR) held during the course of Phase B;
    - The preliminary design review (PDR) held at the end of Phase B.
  - Main review objective(s) - PDR
    - Verification of the preliminary design of the selected concept and technical solutions against project and system requirements;
    - Release of final management, engineering and product assurance plans;
    - Release of product tree, work breakdown structure and specification tree;
    - Release of the verification plan (including model philosophy).

- **Phase C - Detailed definition**
  - Major tasks
    - Completion of the detailed design definition of the system;
    - Production, development testing and pre-qualification of selected critical elements and components;
    - Completion of assembly, integration and test planning for the system and its constituent parts;
    - Detailed definition of internal and external interfaces;
    - Issue of preliminary user manual;
    - Update of the risk assessment.
  - Associated review
    - The critical design review (CDR) is held at the end of the Phase C.
  - Main review objectives
    - Assess the qualification and validation status of the critical processes and their readiness for development for phase D;
    - Confirm compatibility with external interfaces;
    - Release the final design;
    - Release assembly, integration and test planning;
    - Release flight hardware/software manufacturing, assembly and testing;
    - Release of user manual.
- **Phase D - Qualification and production**
  - Major tasks
    - Complete qualification testing and associated verification activities;
    - Complete manufacturing, assembly and testing of flight hardware/software and associated ground support hardware/software;
    - Complete the interoperability testing between the space and ground segment;
    - Prepare acceptance data package;
  - Associated reviews
    - The qualification review (QR) held during the course of the phase;
    - The acceptance review (AR) held at the end of the phase;
    - The operational readiness review (ORR), held at the end of the phase;
  - Main review objectives - QR
    - To confirm that the verification process has demonstrated that the design, including margins, meets the applicable requirements;

    - To verify that the verification record is complete;
    - To verify the acceptability of all waivers and deviations;
  - Main review objectives - AR
    - To confirm that the verification process has demonstrated that the product is free of workmanship errors and is ready for subsequent operational use;
    - To verify the "as-built" product and its constituent components against the required "as designed" product and its constituent components;
    - To verify the acceptability of all waivers and deviations;
    - To verify that the Acceptance Data Package is complete;
    - To authorize delivery of the product;
    - To release the certificate of acceptance;
  - Main review objectives - ORR
    - To verify readiness of the operational procedures and their compatibility with the flight system;
    - To verify readiness of the operations teams;
    - To accept and release the ground segment for operations;

- **Phase E - Operations/utilization**
  - Major tasks
    - Perform all activities at space and ground segment level in order to prepare launch;
    - Conduct all launch and early orbital operations;
    - Perform on-orbit verification and operations in order to achieve the mission objectives;
    - Perform all ground segment activities in order to support the mission;
    - Finalize the disposal plan;
    - Perform all activities at space and ground control segment level in order to prepare the launch;
  - Associated reviews
    - The flight readiness review (FRR) is held prior to launch;
    - The launch readiness review (LRR), held immediately prior to launch;
    - The commissioning result review (CRR), held after completion of the on-orbit commissioning activities;
    - The end-of-life review (ELR) held at the completion of the mission;
  - Main review objectives - FRR
    - This review is conducted prior to launch, its objective is to verify that the flight and ground segments including all supporting systems such as tracking systems, communication systems and safety systems are ready for launch.

  - Main review objectives - LRR
    - The objective of this review is to declare readiness for launch of the launch vehicle, the space and ground segments including all supporting systems.
  - Main review objectives - CRR
    - It allows declaring readiness for routine operations/utilization. The review is conducted following completion of a series of on-orbit tests designed to verify that all elements of the system are performing within the specified performance parameters.
  - Main review objectives - ELR
    - To verify that the mission has completed its useful operation or service;
    - To ensure that all on-orbit elements are configured to allow safe disposal.

- **Phase F - Disposal**
  - Major tasks
    - Implement the disposal plan.
  - Associated review
    - The mission close-out review (MCR) is held at the end of this phase.
  - Main review objectives
    - To ensure that all mission disposal activities are adequately completed.

2.4.3 Concepts for the system specification

From this standard, there are important aspects to be implemented on the system's specification. As first main goal, the system must be capable of allowing the phasing process to be applied to a project according to the defined phases presented on this standard summary. Each one of these phases will have a brief description containing the major tasks and respective normative documents as well as the associated reviews presented above. Each project should have available for selection all phases, reviews and associated normative documents.

2.5 Organization and conduct of reviews

The Organization and conduct of reviews standard [9] identifies all of the activities, outputs and information needed to complete the process of a review.

2.5.1 Principles

The definition of a project review is an examination of the project status and associated issues in a certain period of time. Their primary purpose is to provide an assessment of the project status against targets and requirements. The technical progress is measured through the crucial stages in a responsible and controlled way.

2.5.2 Review tasks

There are four major review tasks:

- Initiation of the review

  This task comprises the assignment of reviews members to the review bodies, the preparation and release of the review procedure and the assessment of prerequisites.

- Preparation and distribution of the review data-package

  This task comprises the preparation and distribution of the documentation as defined in the review procedure.

- Review of the documentation

  This task comprises the detailed review of the review data-package. Any identified problems, questions and solutions arising from the examination of the documentation are recorded on review item discrepancy (RID) forms. Collocation meetings between the review team and the customer/supplier serve to solve issues raised in RIDs, to consolidate findings and to provide recommendations for RID closure.

  Finally, the review team issues a report synthesizing the results of the review and identifying major issues for attention of the review authority.

- Review findings and conclusions

  Finally this task comprises the examination of the review findings, confirmation of the recommendations, decisions for follow-up activities and confirmation of the achievement of the review objectives.

Also in this standard there are five types of review meetings to take into consideration:

- Kick-off meeting

  The kick-off meeting shall:

  - Present the review procedure and organization;
  - Provide information on the product to be reviewed;
  - Provide a presentation of the documentation submitted for review;
  - Formally authorize the start of the review.

- Coordination meeting

  The coordination meeting shall:

  - Review all inputs from the review team;
  - Agree with the customer issues to be resolved with the supplier;
  - Release all RIDs to the supplier.

- Collocation meeting

  The collocation meeting shall:

  - Review the RID responses provided by the supplier;
  - Agree the final RID disposition with the customer and supplier;
  - Identify action items and due dates;
  - Identify disagreements to be reported to the review authority.

- Review team close-out meeting

  The review team close-out meeting shall:

  - Synthesize the results of the collocation meeting;
  - Provide inputs for the review team report;
  - Agree on major issues requiring the attention of the review authority.

- Review authority meeting

  The review authority meeting shall:

  - Confirm that the review has been performed according the approved procedure;
  - Examine the findings of the review team;
  - Confirm the achievement of the review objectives;
  - Issue a review authority report conforming to the DRD provided by this standard.

Lastly on this standard, the RID processing is defined through the Review Item Discrepancy (RID) form which shall be the mechanism used to record questions or identified problems. The RIDs shall be categorized as Major or Minor if the issue impacts an objective of the review or if the issue is considered part of normal work. All RIDs shall be considered as closed when the disposition and any associated actions have been agreed by all parties.

2.5.3 Concepts for the system specification

From this standard the system must include all types of review meetings as well as all documentation necessary to ensure the correct management. The review procedure, review item discrepancy (RID), review team report and review authority report shall be available to the project manager and project team on the system's platform. This standard also provides the logic diagram for RID processing which helps the project team understand the process and supports the correct filling of the RID form which shall also be available on the platform with all the other filling guidelines for all documents present on this standard.

2.6 Configuration and information management

The configuration and information management standard [10] aims to describe the processes and provide the requirements for managing the information/documentation and configuration of products within a space programme or project.

2.6.1 Principles

The configuration and information/documentation management are interrelated processes for managing any kind of projects. The configuration management is the process for establishing and maintaining a consistent record of a product's functional and physical characteristics compared to its design and operational requirements. The configuration management allows one to:

- know at any time the technical description of the product using approved documentation;
- record and control the evolution in the technical description of a product;
- identify and record all discrepancies detected during production, delivery or operation.

The information/documentation management is the process for ensuring timely and effective creation, collection, review, delivery, storage, and archiving of all the project information. To achieve this objective, all recorded information must be managed electronically. Information/documentation management is applied throughout the entire life cycle of the project and allows to:

- ensure the coherence of the overall project information, thus facilitating effective and efficient use of the information;
- ensure the access to information by all the actors who need it and are aware of its availability, related methods and procedures;
- support the project reporting.

2.6.2 Management and planning

The customer defines the configuration management requirements for the project, these requirements are applicable to all the actors of the project as defined by the customer at each level towards his supplier(s). Each one of the suppliers produces a configuration management plan (CM plan) responding to his customer's configuration management requirements. The purpose of the CM plan is to define the process and resources for managing the configuration of the product in a controlled and traceable way. It also describes the means for an efficient comparison between the predicted and the actual configuration of the delivered product.

Another important aspect of this standard is the definition of the configuration identification which establishes and releases controlled documentation for the purpose of identifying configuration characteristics of a product until is fully defined with respect to its intended functional, performance and physical characteristics, thereby ensuring the continuous integrity of the product configuration. By applying product item identifiers to the product, configuration identification enables traceability from the product to its defining documents.

2.6.3 Implementation of information/documentation management

The implementation of the information/documentation management comprises the activities described in the following topics:

- Creation and revision

  During this phase the content of a document is established and the documentation reference is assigned. This activity is performed under the responsibility of the organization assigned in the DRL.

- Review

  - Review activity
    When the document is complete, it is submitted for review and approval as required. The review process is then initiated as specified within the CM plan.
  - Approval and release

    Approval can be given either by electronic signature or by process as defined in the CM plan. Although the electronic signature or approval by process ensures that the document has not been modified after its approval and the author cannot deny his responsibility for the content of the document.

- Delivery

  Documents are delivered using Technical Data Package (TDP) format which defines the way to exchange content files and their related metadata and to structure them within folders. The TDP is a ZIP file containing document file(s) and metadata describing these documents.

- Storage and retrieval

  Storage and retrieval overlaps with the other phases. The information system is in order to handle metadata and static and dynamic content.

- Archiving and retrieval

  Archiving is the last phase of the information process. It ensures that the project information/documentation is preserved from damage or loss, accessible and retrievable for use, and access controlled to authorized personnel.

2.6.4 Concepts for the system specification

From this standard the system shall be able to execute the information/documentation management according to the orientations here presented. All of the normative documents must be included on the system according to the respective project phases. These documents are the configuration management plan (CM plan), configuration item list, configuration item data list (CIDL), as-built configuration list, software configuration file (SCF), configuration status accounting reports, and as said on the previous standard, the guidelines defined for the filling of these documents must be present in the system to help users to execute them in the correct way.

The change request, change proposal, request for deviation and request for waiver documents must be also present in the system. All documentation should be stored in a digital way and be available to authorized users at any time during the project's development.

2.7 Cost and schedule management

The cost and schedule management [4] is defined in this standard as a collective system of organized processes and actions in support of project management. This processes allow optimal use of human resources, facilities, materials and funds, thereby achieving a successful completion of the space project referring to cost targets, timely completion, and technical performance. It is important to plan and control costs and activities with special care being given to the identification of critical situations that can impact in an adverse way the project's success.

2.7.1 Principles

Cost and schedule management provides a common working baseline for the planning and expenses across the participants of the project. It ensures a uniform basis and common understanding of the project planning, cost and manpower targets for use by all participants. The main objectives of cost and schedule management are to plan accurately the phasing of procurements, expenses and resources for the project as well as highlight any deviations and propose remedial actions. The schedule management includes the activities to accomplish timely completion of the project:

- Schedule definition, including activities, sequencing and duration;

- Schedule control, including the comparison between the current work scheduling and the baseline establishment;
- Schedule reporting.

Cost management includes activities to complete the project within the approved budget:

- Cost estimating and planning;
- Cost control;
- Cost reporting.

2.7.2 Project structure

- **Work breakdown structure - WBS**
  The WBS, presented in the 2.4 standard is an important structure to the cost and schedule management by providing a network of events and activities. The logic relationships between the activities allow the producing and completing of the WBS deliverables by identifying the necessary resources and the responsible organizations.
  An estimate based on the WBS elements helps to plan, coordinate, and control the various project activities that both the customer and the suppliers are conducting. The WBS also provides a common framework for tracking the evolution of estimates and forecasting the total cost of the project more accurately.

- **Cost breakdown structure - CBS**
  The CBS defines a set of cost categories used to break down all the costs of the project. The total cost planned for each work package is broken down per cost category. For each cost category, the distinction between direct and indirect costs is identified by each supplier to the customer.

- **Business agreement structure**
  A business agreement structure is a specific type of organization chart, the purpose of which is to identify the project reporting relationships between the customers and the suppliers. It shows which suppliers are responsible for which work packages.
  By relating work packages in the WBS to business agreements in the business agreement structure, contractual responsibilities can be traced.

- **Country/Company structure - CCS**
  The CCS shows the relationships between each company's business agreement for a project and the countries in which the corresponding work is performed. This allows to illustrate how each supplier's work is distributed per country, for geographical return purposes.

2.7.3 Business agreement types

The way to manage cost and schedule aspects of a project depends on the business agreement type. There are two basic types: **Fixed Price** and **Cost Reimbursement** that must be present on the specified system. These agreements or contracts are used between customers and suppliers and represent important documents for keeping track of all payment responsibilities .

2.7.4 Risk management

Risk management is a systematic process of identifying, analysing, and responding to risks of a project during its entire life cycle. It allows maximising the probability and consequences of positive events and minimizing the probability and consequences of adverse events for project objectives as said before in the [1] and [2] standards. The cost and schedule management of a project is supported by an appropriate risk assessment, in order to allow the relevant decisions to be taken early enough in the course of the project development.

2.7.5 Schedule management principles

Developing a network of activities, milestones and relationships between the two allows for effective schedule analysis, risk evaluation and mitigation. The identification of critical paths helps to anticipate the definition of corrective measures on such critical activities so as to avoid schedule drift. Once the activity identification, network logic and durations have been performed and the customer requirements taken into account, the resulting network is analysed using an agreed project calendar taking into account working hours, working days and company holidays, and available critical resources such as personnel, machines, tools and facilities.

- **Schedule control**
  - **Baseline schedule**

    The baseline schedule describes the activities and their sequences that meet the project objectives for timely completion of the project or project phase. The baseline schedule is coherent with the agreed product tree and describes the flow of the work as defined in the WBS, therefore the level of detail of the baseline schedule depends on the level of detail of the WBS. However it is defined as a minimum that the baseline schedule contains:

    * key milestones;
    * descriptions of activities;
    * duration of activities;
    * identification of the critical path activities.

    The baseline schedule is included in the project business agreement.
  - **Current working schedule**

The current working schedule identifies the most realistic view of the project status given by the supplier to the customer, and reflects the following information:

* up-to-date status of activities;
* up-to-date status of key milestones;
* supplier's procurement status.

The comparison between the current working schedule an the baseline schedule forms the basis for the overall project progress assessment.

- **Performance evaluation**

  The commonly used project schedule presentation is the Gantt chart, in this type of bar chart each activity is represented by a bar, the length of which corresponds to the duration of the activity. The links between the bars are shown with arrows as illustrated below. The critical path is typically highlighted.

ID	Task Name	Duration	Start	Finish	% Complete	Predecessors
1	**Solar Array Project (5 panels per wing)**	**414 days**	**Mon 03-11-03**	**Mon 30-05-05**	**67%**	
2						
3	**ENGINEERING**	**190 days**	**Mon 03-11-03**	**Tue 20-07-04**	**100%**	
4	**MS#01 Kick-Off Meeting Completion**	**2 days**	**Mon 03-11-03**	**Tue 04-11-03**	100%	
5	**DVT activities**	**75 days**	**Wed 05-11-03**	**Mon 16-02-04**	**100%**	**4**
6	Prelimin. DVT lay-out def. + Drawing Substrate	75 days	Wed 05-11-03	Mon 16-02-04	100%	4
7	DVT Interface Drawing Cells & Wiring	5 wks	Tue 13-01-04	Mon 16-02-04	100%	6FS-5 wks
8	Cup/Cone for DVT Sample	3 wks	Wed 24-12-03	Tue 13-01-04	100%	6FS-2 wks
9	**PDR Phase**	**124 days**	**Wed 05-11-03**	**Thu 22-04-04**	**100%**	
10	Prel.Design & Analyses + PDR Datapackage	17 wks	Wed 05-11-03	Mon 01-03-04	100%	4
11	Substrate production drawings	69 days	Tue 20-01-04	Thu 22-04-04	100%	6FS-4 wks
12	**MS#04 Preliminary Design Review (PDR)**	**2 days**	**Thu 18-03-04**	**Fri 19-03-04**	100%	52FS+3 days;10FS+2 wks
13	**CDR Phase**	**89 days**	**Mon 22-03-04**	**Tue 20-07-04**	**100%**	
14	Detailed Design & Analyses + CDR Datapackage	82 days	Mon 22-03-04	Fri 09-07-04	100%	12
15	Review Datapackage CDR	2 wks	Mon 28-06-04	Fri 09-07-04	100%	14FS-10 days
16	**MS#09 Critical Design Review (CDR)**	**2 days**	**Mon 19-07-04**	**Tue 20-07-04**	100%	15FS+5 days;55FS+5 days
17						

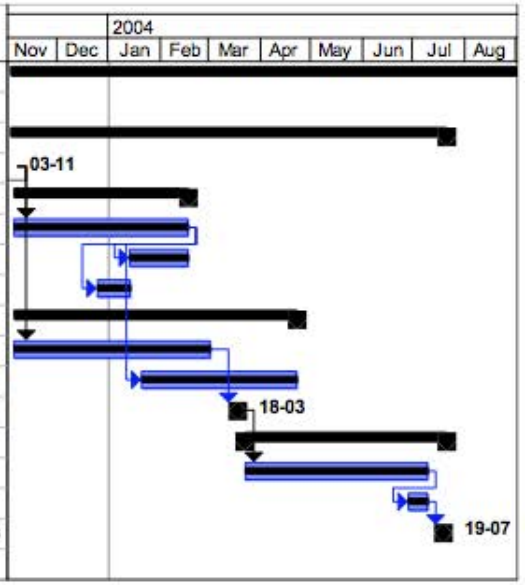


Figure 2.9: Gantt Chart example available in [4]

Also a concise overview of the project is obtained through a "traffic light" presentation by comparing the baseline and current working schedule for each identified milestone. The green color representing an activity on schedule with more than 10 days margin, the yellow color representing an activity with the current date within +/- 10 days of baseline date, and the red color representing an activity with the current date more than 10 days later than baseline.

Milestone	Baseline	Current	
Finish of development	1/ Jun 04	8/ Jun 04	
Design review	1/ Nov 04	10/ Oct 04	
Start manufacturing	1/ Feb 05	25/ Jan 05	
Delivery	1/ Jul 05	20/ Aug 05	

Figure 2.10: Milestone list example available in [4]

- **Schedule reporting**

  Schedule reporting helps to satisfy the information requirements for schedule control and performance measurement. It provides clarity regarding the project status and progress, also supports the work of achieving the project objectives and the decision making process. Schedule reporting is implemented within the supplier's organization and between the supplier and customer.

  - **Schedule progress information**
    - Activities started, together with their actual start date;
    - Activities completed, together with their actual finish date;
    - Forecast completion dates for activities in progress;
    - Validity assessment of the defined sequences, relationships and constraints of planned activities.

    Any reported schedule information is accompanied with a description of assumptions and resulting effects. Causes of deviations from baseline schedule are explained, and remedy actions proposed.

- **Reporting system and tools**

  There are different schedule reporting means to ensure effective communication between supplier and customer:

  - Progress meetings, including minutes of meetings and action item lists;
  - Progress reports;
  - Reviews;
  - Problem notification report;

- Comparison of planned and actual data;
- Gantt charts;
- Traffic light representation of the milestones status.

2.7.6 Cost management principles

The objective of cost management is to ensure a rapid assessment of proposed payment profiles, of actual expenditures, and of risks and deviations. It also provides the forecasting of future incomes and expenses that support budget and cash flow planning and ensures visibility on the current project commitments.

- **Contractual and financial interfaces**
  - **Contract change notice**
    A contract change notice (CCN) is the means by which changes to the business agreement are made, any change with a financial or schedule impact on the project is submitted by the supplier to the customer.
- **Cost estimating and planning**
  - **Cost estimating**
    Cost estimating is the process of determining the expected costs of a project. This activity is of high importance at project management level because an accurate and reliable cost estimate has a positive impact on the total project cost.
  - **Development cost plan**
    The development cost plan (DCP) shows how the anticipated cumulative expenses of the project are developing over time.
- **Cost control**
  - **Baseline cost plan**
    The set of financial data on which the customer and the supplier have reached an agreement constitutes the baseline cost plan. The initial business agreement includes the **Original Baseline Cost Plan (OBCP)**. The OBCP, together with the financial impact of changes contractually agreed thereafter, constitutes the **Current Baseline Cost Plan - (CBCP)**.
    Original Baseline Cost Plan (OBCP) + Approved changes = Current Baseline Cost Plan (CBCP)
- **Cost reporting**
  - **Reports applicable to all contract types**
    They are submitted by the supplier to the customer with a periodicity defined in the business agreement, regardless of the type of contract:

* OBCP;
* CBCP;
* Estimate at completion - EAC
  The EAC gives an estimate of the total expenses of the project upon its completion;
* Financial elements enabling the customer to establish the project geographical distribution;
* Price variation mechanism relevant elements;
* Inventory Records.

– **Reports specific to cost reimbursement contracts**

  The reports are submitted by the supplier to the customer with a periodicity defined in the business agreement:

  * Actual versus planned costs of the applicable CBCP, including analysis of deviations;
  * Cost Sharing scheme status;
  * Estimate to completion - ETC
    The ETC is a part of the EAC. The ETC is the total expenses estimated for work to be performed from the defined cut-off date until the work is completed.
  * Financial statement of cost incurred, to be updated after finalization of the corresponding financial audit.

2.7.7 Concepts for the system specification

The specification of the system's platform must include the necessary documentation associated to the cost and planning management. On the planning side, the schedule and schedule progress report must be included on the system, on respect to the activities/tasks planning, as well as the activities Gantt chart developed by the project manager. This chart will be analysed and classified according to the traffic-light system defined on this standard. On the cost management, the system must include the following documents: Cost Breakdown Structure, Company price breakdown forms, Geographical distribution report, Cost estimating plan, Cost estimating report, Milestone Payment Plan, Inventory record, Cost and manpower report, OBCP and CBCP for cost reimbursement, OBCP and CBCP for fixed price, EAC and ETC for cost reimbursement, EAC for fixed price, and Contract change notice.
Note that, not all of the documents defined by this standard are applicable to all space projects, this way, it is up to the project manager to decide the ones he wants to see executed.

2.8 Risk management

The Risk management standard [5] defines risks as threats to project success due to the fact that they represent negative effects on the project cost, schedule, and technical performance, but appropriate practices of controlling risks can also present new opportunities with positive impact. The primary objective of project risk management is to identify, assess, reduce, accept, and control space project risks in a systematic, proactive, comprehensive and cost effective manner, taking into account the project's technical and programmatic constraints.

2.8.1 Principles

- **Risk management concept**

  Risk management is a systematic and iterative process for optimizing resources in accordance with the project's risk management policy. It is integrated through defined roles and responsibilities into the day-to-day activities in all project domains and at all projects levels.

- **Risk management process**

  Undesired events are assessed for their severity and likelihood of occurrence. Within the risk management process, available risk information is produced and structured, facilitating risk communication and management decision making. The results of risk assessment and reduction and the residual risks are communicated to the project team for information and follow-up.

- **Risk management implementation in a project**

  Project management has the overall responsibility for the for the implementation of risk management, ensuring an integrated, coherent approach for all project domains. Risk management is a continuous, iterative process. It constitutes an integral part of normal project activity and is embedded within the existing management processes.

- **Risk management documentation**

  The risk management process is documented to ensure that the risk management policies are well established, understood, implemented and maintained, and that they are traceable to the origin and rationale of all risk-related decisions throughout the project life cycle. The risk management documentation includes the risk management policy, which:

  – defines the organization's attitude towards risk management and the categorization of risk management;

  – provides a high-level outline for the implementation of the risk management process.

  In addiction to the risk management policy document there are two key documents established on this standard:

– **Risk management plan**

  Describing the implementation of the risk management process.

– **Risk assessment report**

  For communicating the identified and assessed risks as well as the subsequent follow-up actions and their results.

2.8.2 The risk management process

The risk management process is defined by a set of cycles and steps implemented throughout all the project phases as described in the figure:

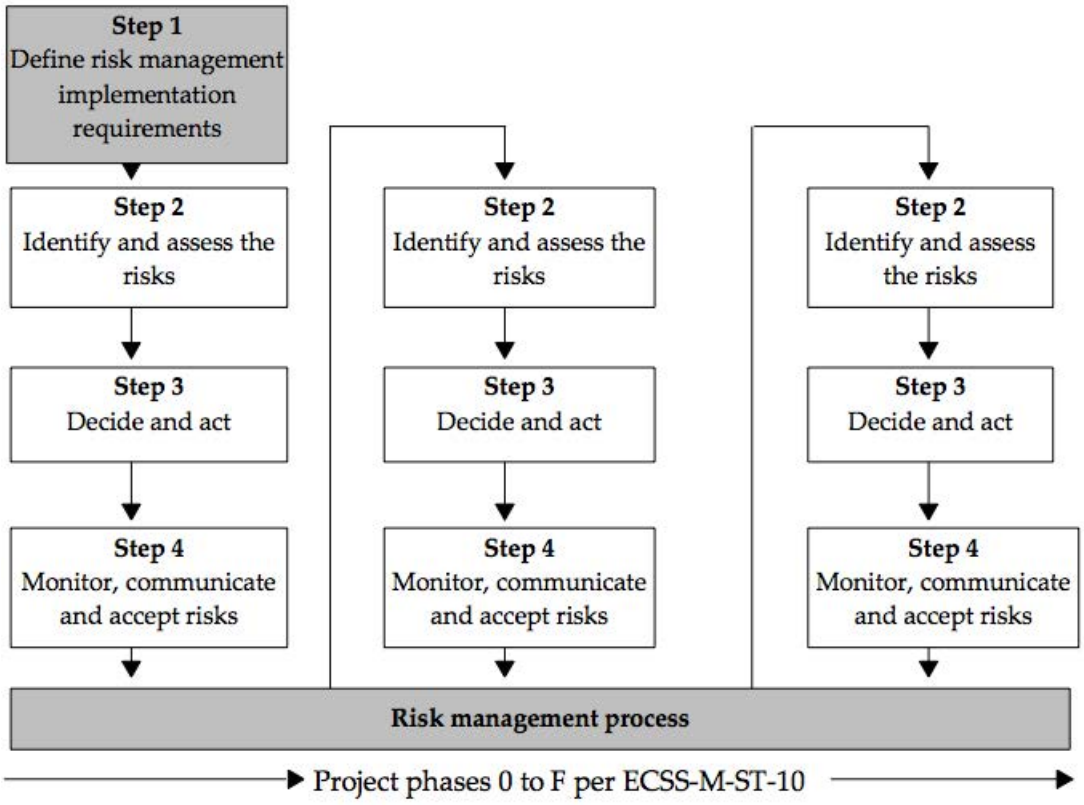


Figure 2.11: The steps and cycles in the risk management process available in [5]

Each of these steps involve a series of tasks to be performed within the risk management cycle. Each of the steps are described below:

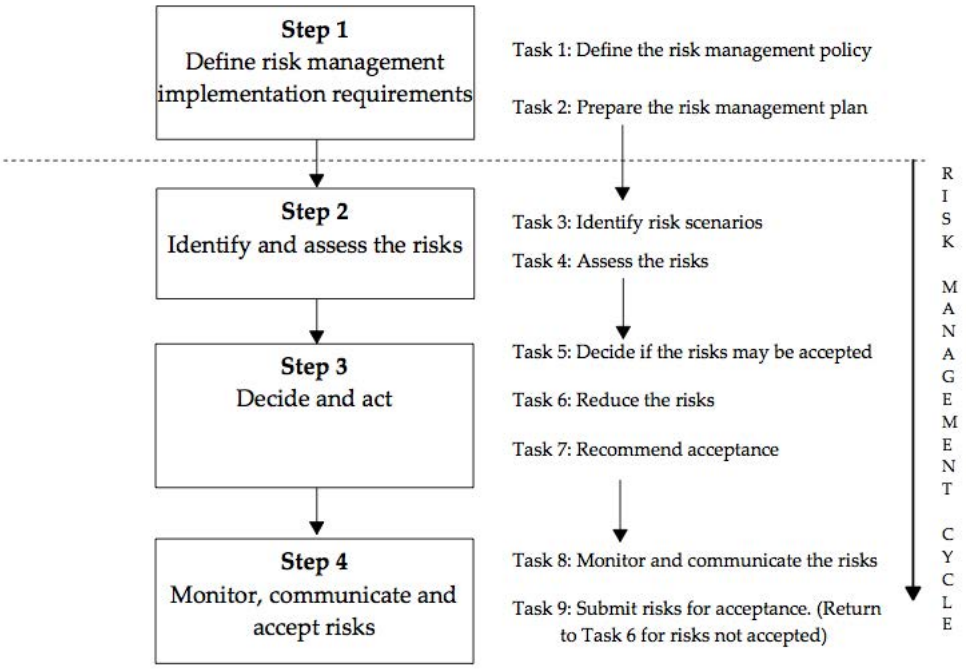


Figure 2.12: The tasks associated with the steps of the risk management process within the risk management cycle available in [5]

- **Risk management steps and tasks**
  - **Step 1: Define risk management implementation requirements**
    - **Task 1: Define the risk management policy**
      - Identification of the set of resources with impact on risks;
      - Identification of the project goals and resource constraints;
      - Description of the project strategy for dealing with risks;
      - Definition of scheme for ranking the risk goals according to the requirements of the project;
      - Establishment of scoring schemes for the severity of consequences and likelihood of occurrence;

Score	Severity	Severity of consequence: impact on (for example) cost
5	Catastrophic	Leads to termination of the project
4	Critical	Project cost increase > tbd %
3	Major	Project cost increase > tbd %
2	Significant	Project cost increase < tbd %
1	Negligible	Minimal or no impact

Figure 2.13: Example of a severity–of–consequence scoring scheme available in [5]

Score	Likelihood	Likelihood of occurrence
E	Maximum	Certain to occur, will occur one or more times per project
D	High	Will occur **frequently**, about 1 in 10 projects
C	Medium	Will occur **sometimes**, about 1 in 100 projects
B	Low	Will **seldom** occur, about 1 in 1000 projects
A	Minimum	Will **almost never** occur, 1 of 10 000 or more projects

Figure 2.14: Example of a likelihood scoring scheme available in [5]

· Establishment of a risk index scheme to denote the magnitudes of the risks of the various scenarios;

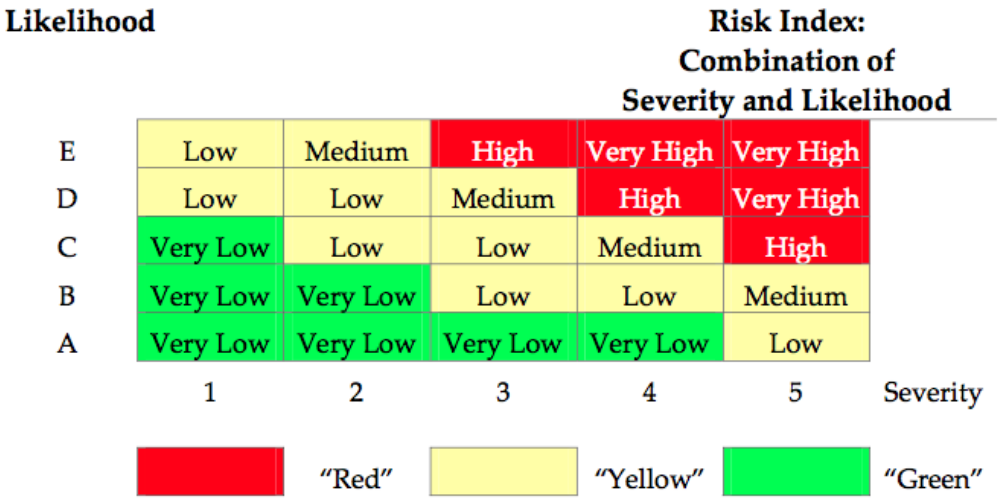


Figure 2.15: Example of risk index and magnitude scheme available in [5]

· Establishment the criteria to determine the actions to be taken on risks of various risks magnitudes and the associated risk decision levels in the project structure;

Risk index	Risk magnitude	Proposed actions
E4, E5, D5	Very High risk	Unacceptable risk: implement new team process or change baseline – seek project management attention at appropriate high management level as defined in the risk management plan.
E3, D4, C5	High risk	Unacceptable risk: see above.
E2, D3, C4, B5	Medium risk	Unacceptable risk: aggressively manage, consider alternative team process or baseline – seek attention at appropriate management level as defined in the risk management plan.
E1, D1, D2, C2, C3, B3, B4, A5	Low risk	Acceptable risk: control, monitor – seek responsible work package management attention.
C1, B1, A1, B2, A2, A3, A4	Very Low risk	Acceptable risk: see above.

Figure 2.16: Example of risk magnitude designations and proposed actions for individual risks available in [5]

- Definition of risk acceptance criteria for individual risks;
- Establishment of acceptance criteria for the overall risk.

* **Task 2: Prepare the risk management plan**
  - Summary of the risk management policy;
  - The risk management-related documentation and follow-up concept.

– **Step 2: Identify and assess the risks**

* **Task 3: Identify risk scenarios**
  - Identification of risk scenarios, including causes and consequences;
  - Identification of the means of early warning for the occurrence of an undesirable event.
* **Task 4: Assess the risks**
  - Determination of the severity of consequences of each risk scenario;
  - Determination of the likelihood and risk index of each risk scenario;
  - Determination of the magnitude of each risk scenario.

– **Step 3: Decide and act**

* **Task 5: Decide if the risks may be accepted**
  - Application of the risk acceptance criteria to the risks;
  - Identification of acceptable risks and risks subjected to risk reduction;
  - For accepted risks proceed to Step 4.
* **Task 6: Reduce the risks**
  - Determination of preventive and mitigation measures/options for each unacceptable risk;

        - Determination of risk reduction success, failure, and verification criteria;
        - Selection of the risk reduction measures and decision on priorities for implementation;
        - Verification of risk reduction;
        - Documentation of the successfully reduced risks in a resolved risks list; and the unsuccessfully reduced risks in an unresolved risks list.
    - **Task 7: Recommend acceptance**
        - Decision options for acceptance of risks;
        - Approval of acceptable and resolved risks;
        - Presentation of unresolved risks for further action.
- **Step 4: Monitor, communicate, and accept risks**
    - **Task 8: Monitor and communicate the risks**
        - Periodical assessment and review of all identified risks;
        - Verification of the performance and effect of corresponding risk reduction;
        - Illustration of the risk trend over the project evolution;
        - Implementation of an alert system for new risks.
    - **Task 9: Submit risks for acceptance**
        - Submission of the risks for formal risk acceptance by the appropriate level of management;
        - Return to Task 6 for risks not accepted.

2.8.3 Risk management implementation

Risk management is implemented as a team effort, with tasks and responsibilities being assigned to the functions and individuals within the project organization. The results of risk management are considered in the routine project management process and in the decisions relative to the baseline evolution.

- **Responsibilities**

  The project manager has overall responsibility for integrate risk management within a project and reports the results of the risk management task to the next higher level in the customer/supplier chain. The project manager defines who is responsible for the control of the risks in their respective domains. The lines for communicating, information and reporting are also defined by the project manager.

- **Risk visibility and decision making**

  Management processes and information flow within the project organization ensure a high visibility of the prevailing risk. Risk information is presented to support management decision making, including an alert system for new risks. Action plans are prepared covering

all outstanding risk items whose magnitudes are above the level specified in the project risk management policy to increase their visibility. The information about all identified risks and their disposition is kept in a record.

- **Documentation of risk management**

  The risk management process includes information on project-specific risk management policy, the risk management plan, the identified scenarios, likelihood of events, risk results, risk decisions, records of risk reduction and verification actions, risk trend data, and risk acceptance data.

2.8.4 Concepts for the system specification

The risk management to be implemented on the system will be composed of an alert system that must alert the user when a new risk is registered within a project, a risk registration area where the users must be able to register and classify the risks on their likelihood and severity scores, and an area where all the documents related to the risk management process defined on this standard will be available for user nomination and execution. All risk management information must be kept in record as defined on the standard.

2.9 Integrated Logistic Support

The Integrated Logistic Support (ILS) approach, defined in this standard [11], is justified in the space context by improvement of current practices in terms of development of material resources and services essential to support operation, maintenance and control of associated operational risks, particularly in terms of utilization cost and availability.
Logistic support is not a new activity: its integration into the project aims at coordinating, throughout the life cycle, the activities and resources involved in the preparation and optimization of the support system, aiming at minimum overall life cycle cost, according to the requirements and operational risks.

2.9.1 Principles

Logistic support shall be provided throughout the utilisation phase and requires the management of specific activities of design and development, in close relation with the other activities such as dependability and safety. The management of logistic activities is therefore integrated into the project management requirements and shall demonstrate:

- that the dependability and safety criteria are taken into account within the product operational environment of use;

- the suitability, coherence and continuity of the support system;

- the ability to control the risks specific to the performance of operation and maintenance tasks.

The purpose of a Support System is to maintain the technical and availability performances levels while respecting safety constraints and optimising overall life cycle cost. The ILS ensures the operational availability and the project should apply the life cycle cost concept when trading off development costs versus later utilisation phase support costs and disposal costs.

2.9.2 ILS main concepts

- **Integration Concept**

  Integrating the logistic support into a project is achieved by considering four aspects:

  - The integration of logistic support in the consumer's needs and his environment;
  - The integration of logistic activities in the project management;
  - The integration of the support system design in the supported system design;
  - The integration of the support elements together.

- **Availability, Support Ability and Human factors**

  The operational availability concept addresses the fact that required external resources to be provided for the availability (performance) shall be, and are provided in the operational conditions of use. External resources are provided by the support system in order to maintain the supported system in an operational state. This ability to provide the external resources is defined as "support ability". Human factors influence both support ability and the supported system characteristics directly.

- **Life Cycle Cost and Operational Risk**

  The life cycle cost concept addresses both the acquisition costs of the supported system and support system and the operation and maintenance costs, and disposal costs. From the life cycle cost analysis, the ILS assists the trade-off between the dependability and safety analyses and the selection of an optimised solution for the support system.

2.9.3 Concepts for the system specification

In fact the ILS standard will not be included on the system specification due to the fact that it does not require any normative documents or organizational structure implementation, serving only as support for space projects.

2.10 Conclusions

From this chapter, it was gathered all the information considered relevant within each presented standard, which should be included in the definition of the specified system. At the end of each standard there were defined all concepts derived from each one of the standards to be included within the system's platform. As expected, the standards regarding project management advocate various aspects that are common to both projects considered normal or space projects. Each abstract of the standards presented here has as main objective to summarize the most relevant aspects and does not constitute in any way a substitute for each of these, by definition a standard presents its content as objectively as possible thereby it becomes difficult to summarize or suppress its information.

Chapter 3

Needs assessment and Requirements definition

This chapter is dedicated to the needs assessment which can be either normative needs defined by the standards, the project manager needs or the project development team needs. These needs will be identified and organized to be translated afterwards into specified requirements.

3.1 Needs assessment

The first step to take when specifying a system for managing projects is to assess all the needs identified for the creation of the system. The system's main purpose is to satisfy those needs and achieve the performance levels that the users expect to see. The needs assessment section is divided into three subsections:

- Normative needs - needs raised by the analysis of the ECSS standards for space projects management;
- Project manager needs - needs defined by the project manager;
- Project development team needs - needs defined by the project's development team members.

3.1.1 Normative needs

For the system to be able to perform all the functionalities necessary to cover all the requirements present on the ECSS standards it is essential to define the needs associated to each one of them. The table 3.1 presents, for each ECSS management standard, the identified need and its correspondent type. The defined types of needs are Organizational, associated to the organization of information, and Documentary, associated to the availability of the necessary documentation.

ECSS Standard	Need	Type
Project planning and implementation	Project phasing	Organizational
	Phasing identification	Organizational
	Major tasks identification	Organizational
	Types of reviews	Organizational
	Standard associated documents	Documentary
	Documents guidelines	Documentary
Organization and conduct of reviews	Identification of review meetings types	Organizational
	Standard associated documents	Documentary
	Documents guidelines	Documentary
Configuration and information management	Standard associated documents	Documentary
	Documentation classification	Documentary
	Information/data record	Organizational
Cost and schedule management	Schedule management associated documents	Documentary
	Schedule management control	Organizational
	Schedule management reporting	Documentary
	Cost management associated documents	Documentary
	Cost management control	Organizational
	Cost management reporting	Documentary
Risk management	Standard associated documentation	Documentary
	Risk management record	Organizational
	Risk management control	Organizational
	Risk management reporting	Documentary
	Risk management alert system	Organizational

Table 3.1: Normative needs assessment

3.1.2 Project manager needs

It is expected that the system will be able to serve as a supportive tool to the project manager in all developed space projects, therefore it is important to assess his needs to define which requirements should the system be able to fulfil. The management of any kind of project is, by common knowledge, difficult, however space projects can become even more complex to manage. All the ECSS management standards and guidelines must be respected and used on the projects as well as the normal management processes.
In the table 3.2 the needs presented by the project manager are defined and categorized by type, Organizational and Documentary as defined above, and Integration which is defined as being part

of the integration with existing platforms already being used by the company. Also, the project manager needs were divided into areas of action facilitating the structuring of the system, these areas can be related to meetings, projects, or alerts.

Area	**Need**	**Type**
Meetings	Meetings schedule record available to all users	Organizational
	Meetings documentation organization and record	Documentary
Projects	Project documentation organized by area of interest	Documentary
	Project phasing according to ECSS standards	Organizational
	Project relevant information imported from the Baan platform	Integration
	Project financial data organization and record	Organization
	Project activities planning imported from Excel file	Integration
	Project activities management	Organizational
	Risk monitoring record	Organizational
	Risk documentation record	Documentary
Alerts	Activity alert reminder	Organizational
	Meeting alert reminder	Organizational
	Documentation alert reminder	Organizational
	Risk registration alert	Organizational

Table 3.2: Project manager needs assessment

3.1.3 Project team needs

Also the project development team, responsible for the development of the space projects, has needs that can be satisfied by the system by helping to perform the project work in a more efficient way. The table 3.3 below shows the needs presented by the project development team, this table follows the same logic as the project manager needs table presented above.

Area	Need	Type
Meetings	Meetings schedule organization and record	Organizational
	Meetings documentation identification and record	Documentary
Projects	Project documentation identification and record	Documentary
	Project phasing identification and record	Organizational
	Project financial documents organization and record	Documentary
	Project activities identification, organization and record	Organizational
	Risk registration organization	Organizational
	Risk documentation record	Documentary
Alerts	Activity alert reminder	Organizational
	Meeting alert reminder	Organizational
	Documentation alert reminder	Organizational
	Risk registration alert	Organizational

Table 3.3: Project team needs assessment

Note that both project development team and project manager have similar needs, this is due to the fact that all projects are developed within a team effort thereby the detected difficulties and needs are the same. The project development team performs the necessary work to assure the project's progress so it is essential to guarantee that the activities performed by the team are well defined and organized as well as the responsibilities attribution. The system to be specified on this document aims to fulfil the team's expectations in a way to facilitate the work and the organizational structure of the projects.

3.1.4 Needs assessment conclusion

It is concluded that the system to be set should satisfy all the presented needs defined by the ECSS standards, project manager and project development team. The needs identified by the project development team meet the needs of the project manager regarding the organization of projects in terms of documentation or activities development, meetings and alerts. The needs assessment is in fact the starting point for the correct definition of the system requirements.

3.2 Requirements definition

The definition of the system's requirements is made by dividing the system into areas using tables. The tables are constituted by two columns, the first only contains the requirement identification code and the second column contains the requirement specification. All requirements are divided into areas, these areas will form the basis for the system structuring and definition in the next chapter.
Although all needs presented in the previous section were translated into requirements, they do not represent all requirements described below. When a system is imagined there can be always new ideas to be implemented that were not identified by the project manager or project development team but that could represent added value to the system performance.

3.2.1 Alerts requirements

The alerts, defined for the system, can be of different types:

- Meeting alerts
  These alerts will be responsible for alerting the users when a meeting is created or when they were nominated to attend to a meeting.
- Note alerts
  The note alert is linked to the note system that was imagined for the platform, this system will allow the user to create notes on different areas within a project, this alert will inform the users when a note has been created.
- Integration alerts
  The two integration aspects of this platform reside on the integration with the Baan platform used by the company and where the system will be importing the projects relevant informations from, and with the Microsoft Project Excel file where the system will import the activities schedule made by the project manager.
- Phasing alerts
  When the phases of a project are selected the system must alert the users about this selection.
- Document alerts
  The document alert is a very important type of alert, this alert occurs whenever a document is selected to be executed and when a user has been nominated to execute it.
- Users alerts
  The user alert represents all alerts directed specifically to the user.
- Risks alerts
  The risks alerts represent the alerts that are responsible for alerting the user about the registration of a new risk or when a user has been nominated to assess a risk and perform the purposed corrective actions.

- Messages alerts
  These alerts will inform the user that a private message has been sent to him.

The 3.4 table represents the requirements defined for the alerts system:

Code	Requirement
A1	All users nominated for an activity/ meeting/ risk monitoring or document must receive an alert
A2	All alerts must be within the types of alerts defined for the system
A3	Each alert shall indicate which activity, meeting, risk monitoring or document is associated to the alert
A4	Each time a user is held responsible for a document the system must send an alert
A5	Each user nominated to participate in a meeting must receive an alert upon the time of which the meeting is created
A6	Every time a new project is imported into the system, there must be an alert sent to all users
A7	The system must send an alert to all users when the phasing selection for a project is executed
A8	A note alert must be sent to all users upon the time the note is created
A9	When a change is detected on a document, activity, note, phasing selection, meeting, or risk, an alert must be sent indicating the changed fields
A10	When a risk is registered on the system, all users must receive an alert
A11	The system alerts must be organized by day and time of occurrence
A12	The system alerts must send an alert when an activity finalization date is imminent
A13	Every time a schedule is imported into the system, there must be an alert sent to all users within the associated project
A14	If a user has been sent a private message, the system must send an alert to the user

Table 3.4: Alerts requirements

3.2.2 Planning requirements

A project's planning is composed by a Gantt chart [12], with activities and their respective descriptions, initiation and finalization dates as well as the duration of each activity. For each project the project manager creates a schedule on a Excel file to keep track of all the activities and timeline within the project, this file is the most important tool for the organization of the work to be developed during a project life cycle.

The 3.5 table presents the planning requirements defined for the system:

Code	Requirement
P1	The system must be able to import the Excel file containing the project's schedule
P2	The system must take the initiation, finalization and current dates and classify the activity according to the traffic-light score defined in the ECSS standards
P3	The system must allow to nominate users to be responsible for the development of an activity present on the schedule
P4	Every activity must be defined by its description
P5	All users must have permission to nominate other users to an activity
P6	The ECSS standards documents must be available in the system for the activity reporting
P7	Any user can nominate other user to execute a document, however the system must keep the nomination logs in record

Table 3.5: Planning requirements

3.2.3 Phasing requirements

The 3.6 table presents the requirements for the phasing of the space projects in the system:

Code	Requirement
PH1	All projects must have the phases defined in the ECSS standards
PH2	Each phase identified within a project must contain the description of all major tasks and reviews defined in the ECSS standards
PH3	For each review, the system shall allow the project manager to select from all phase documents the ones he wants to see executed by the project development team members
PH4	The project phasing must be presented automatically for each project in the system

Table 3.6: Phasing requirements

3.2.4 Notes requirements

The notes system will allow the users to add any relevant information to an area on the project, these notes can be seen/replied by all users.

The 3.7 table represents the requirements defined for the notes system:

Code	Requirement
N1	Each major area in a project must have a note creation button if considered useful
N2	All users must be allowed to create a note
N3	All users can erase their own notes
N4	Each note must have an associated date and time of occurrence
N5	The notes system must allow to create a note to be presented on a future date
N6	All notes are visible to all users

Table 3.7: Notes requirements

3.2.5 Financial requirements

The financial data in a project within the system consists on two major aspects: the contracts made during the project life cycle and the financial documents defined by the ECSS standards for cost management control in space projects.

The 3.8 table defines the requirements for the financial area on the system:

Code	Requirement
F1	All projects shall have a project financial data area
F2	All contracts associated to a project must be available for consult
F3	The financial documents defined in the ECSS standards must be on the system for selection
F4	All users must have access to the financial area
F5	The system must allow to nominate users for executing financial documents
F6	The system must allow external users to consult the financial contracts within a project

Table 3.8: Financial requirements

3.2.6 Integration requirements

The 3.9 table defines the requirements for the integration needed for the system:

Code	Requirement
I1	The system must import, for each project, the schedule plan from Microsoft Project Excel file
I2	For each project, the system must import from the Baan platform, the project number, description and status
I3	The system must allow to select the projects from the Baan platform to be imported into the system
I4	There must only be one schedule per project
I5	Only the project manager can select the projects he wants to import into the system
I6	Only the project manager can submit the project schedule for each project

Table 3.9: Integration requirements

3.2.7 Documentation requirements

The 3.10 table presents the requirements defined to the documents area on the system:

Code	Requirement
D1	All users in a project can be nominated to be responsible for the execution of a document
D2	All ECSS standards documents must be available to be selected by the users
D3	Each user has to be able to classify his respective document status
D4	The system must allow the user to upload/change the document file for which he has been nominated to execute
D5	There must be a documents area where all document nominations are registered according to their respective areas within the system
D6	All standards documents must have the respective execution guidelines available for the nominated users to consult

Table 3.10: Documentation requirements

3.2.8 Meetings requirements

Meetings can be considered one of the most important tools for the activities management during the development of a project, is therefore essential that the system has integrated an area dedicated to keep the record of all meetings within a project.

The 3.11 table defines the requirements related to the meetings area on the system:

Code	Requirement
M1	All meetings must have a date, time, main objectives, type of meeting and nominated users
M2	The system must have available all types of meetings to be chosen
M3	All users must be allowed to create a meeting on the system
M4	The system must allow to nominate users for a meeting
M5	The system must show the user who created the meeting
M6	All documents defined in the ECSS standards relating to the meetings within a project must be present on the system for selection
M7	The system must allow to associate documents to a meeting
M8	The system must keep record, for each project, of all created meetings

Table 3.11: Meetings requirements

3.2.9 Users requirements

The 3.12 table defines the requirements for the users in the system:

Code	Requirement
U1	Each new user on the system must fill a register form
U2	The register form must contain the user's name, number, e-mail, security question and security answer
U3	All registration requests must be sent to the project manager for approval
U4	All approved users must be able to log in into the system
U5	Each user must have a personal area on the system
U6	The personal area must have the user's definitions, to-do list, projects and messages board
U7	Every user must be able to change his definitions
U8	The to-do list must allow the user to have a overall view on his activities and nominations within a project
U9	All users must be able to see all projects within the system
U10	The messages board must allow the user to send direct messages to other users on the system
U11	The system must keep the messages logs of all conversations

Table 3.12: Users requirements

3.2.10 Projects requirements

The 3.13 table defines all the requirements for the projects in the system:

Code	Requirement
PR1	Each project shall have an identification number provided by the Baan platform
PR2	Each project must have an associated description provided by the Baan platform
PR3	Each project must have an associated status provided by the Baan platform
PR4	The system must organize all project data within the respective areas
PR5	Each project must have the following areas: meetings, planning, phasing, risks, documents and financial
PR6	All project areas must be available to all users with exception to the external users

Table 3.13: Projects requirements

3.2.11 Risks requirements

The risk detection and registration is an important tool for keeping track and controlling all of the elements that can represent delays or impact in a negative way the performance, progress and development of a project.

The 3.14 table presents the requirements for the risks area on the system:

Code	Requirement
R1	The system must provide an area to perform risk assessment
R2	On the risks area there must be scoring schemes for risk severity and likelihood as defined in the ECSS standards
R3	The risk index must be generated automatically by the system based on the scoring scheme defined in the ECSS standards
R4	The system must provide the normative proposed actions for each risk index
R5	The system must allow to define the type of action to be taken for the risk control actions
R6	The system must allow to describe the actions to be performed and to nominate responsible users
R7	All of the risks documents defined in the ECSS standards must be available on the system for selection
R8	All risks status must be defined by the responsible users

Table 3.14: Risks requirements

3.3 Conclusions

The set of requirements defined on this chapter form the basis for the system's specification, each of the identified areas will be essential parts to be implemented on the system. Although the majority of the requirements will be implemented within the identified areas, others will be implemented as subsystems within the main system due to the fact that they are not static elements but dynamic, like the notes system, the meeting creation and risk registration processes.

Chapter 4

System definition

To define a system's architecture [13],[14] it essential to study all important aspects and characteristics that must be present on the system. To do this the system was divided into packages that represent the system's major areas using UML language [15],[16],[17],[18] and package diagrams [19]. On this chapter there will be presented three sections that together compose the system's structure: the System packages section decomposes the system into its major areas using illustrative packages, the Permissions section which defines the permission levels for each one of the identified actors for the system, and the last section, the Database structure, illustrates the database entities and attributes, and association relations between them.

For each package there is an associated description and presentation of all its elements.

4.1 System overview

It was defined, taking into account the presented requirements, that the system would be divided into six main packages, as shown in the figure 4.1:

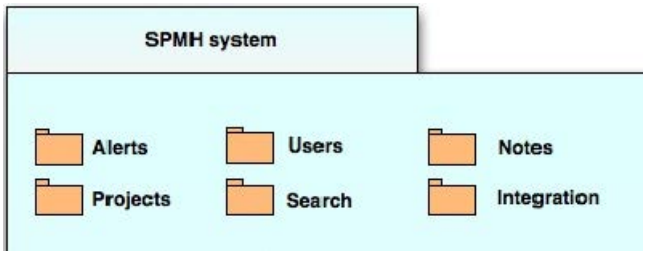


Figure 4.1: Space Project Management Handbook system

Each package is defined by its major characteristics that are presented below:

1. **Integration package**

   The Integration package can be considered the most important package on the system, this package is responsible for the integration with the external platforms used by the project

manager. Without this package the system would not be able to register all space projects and their activities plans.

2. **Projects package**

   The Projects package stores all data related to projects on development, there the project manager and his team can find all information, documentation, activity planning, project phasing, meeting schedules and risks monitoring within the registered projects.

3. **Users package**

   The Users package is responsible for the users personal area where the personal system definitions are stored and where the users can manage all activities/ meetings/ documents nominations and risks associations.

4. **Notes package**

   The Notes package is responsible for an interesting feature in the system. All users can use this tool to leave notes within certain areas of the platform for other users to see. This package allows the information exchange to be very easy and efficient since it register relevant information for all users to see at any time.

5. **Alerts package**

   The Alerts package is a very important package because it's responsible for all the alerts sent by the system to remind the users about their nominated activities, documents and meetings as well as projects importations/ removals, phasing and notes/messages creations. Almost all recorded activity on the system is sent to the users using the alert system.

6. **Search package**

   Finally the Search package allows the users to perform searches within the areas in which they are located. Searches can be performed on almost every area of the platform as it's shown ahead. This tool facilitates the finding of information with interest to the user.

4.2 System packages

4.2.1 Alerts

The Alerts package is composed by seven inner packages, each one of these inner packages is specified as shown in the figure 4.2. The meeting alert package represents two alerts within the meetings area, the system must send a meeting creation alert upon the time of the creation showing the meeting's main objectives, type (review meeting, progress evaluation or other), nominated users, date and time of the meeting and the location being the associated project number and description. If a meeting is changed, the system must send an alert indicating the changed fields, as well as the type, location, date and time of the meeting.

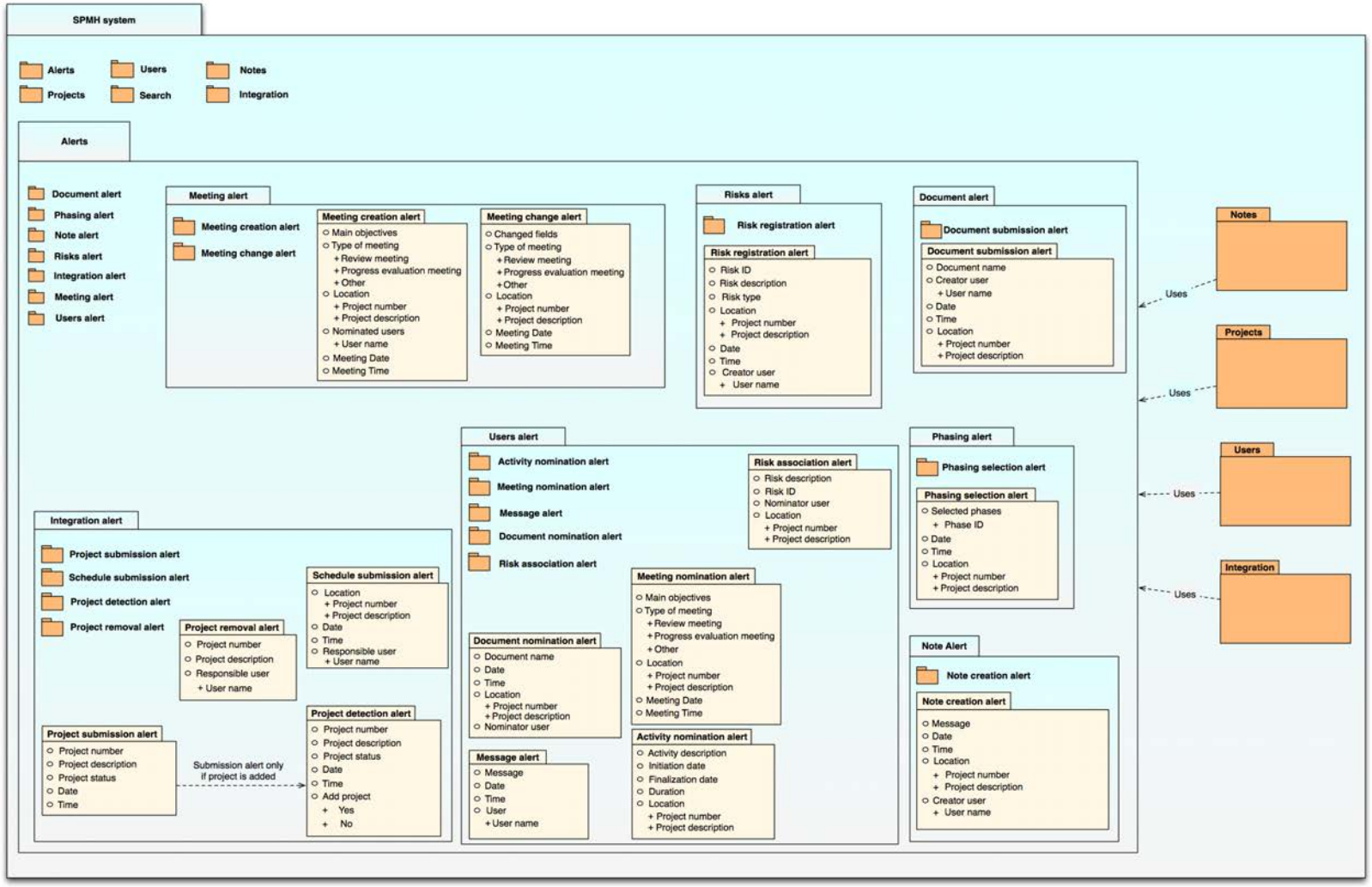


Figure 4.2: Alerts package

The integration alert package is responsible for the alerts of the project's submission indicating the project number, description, status, date and time of the submission, and the project's removal alert where the project number and description is indicated as well as the user responsible for the removal. However, the system must send a project detection alert every time a new project is inserted on the Baan platform and ask the project manager if he wants to add this one to the system. At last, the schedule submission alert is sent whenever a schedule is added to a project, indicating the project number and description, date and time and the user responsible for the submission, this one being always the project manager since he is the only one with permission to submit a project's schedule.

For the risks alert package, the system must send an alert every time a new risk is registered on the system, this alert contains the risk ID given by the system, the risk description and type, the location, being the project number and description, date and time of the registration and finally the user responsible for its registration.

The document alert package represents the alert sent whenever a document is uploaded to the system, this alert indicates the document's name, the user responsible for the submission, date and time of occurrence and the respective project number and description.

For the phasing alert package, is defined that every time a phase selection is made within a project, the system must indicate which phases were selected, the date and time of the selection, and the respective project number and description.

The note alert package defines the alert sent upon the creation of a note within a project, this alert must indicate the message, date and time of the creation, the project number and description, and the name of the user who created the note.

At last, for the users alert package, there are presented five packages, the activity nomination alert responsible for the alert sent whenever a user is nominated to perform an activity, this alert must indicate the activity's description, initiation and finalization dates, the respective duration and the respective project number and description. The meeting nomination package defines the alert sent when a user is nominated to attend to a meeting, this alert must contain the meeting's main objectives, type, the respective project number and description and of course the meeting's date and time. The document nomination alert occurs whenever a user is nominated to execute a document, this alert indicates the document's name, date and time of the nomination, the associated project number and description and finally the name of the nominated user. The message alert package represents the alert that occurs when a message is sent to a user, this alert shows the message, date and time of the occurrence and the name of the user who sent the message. At last, the risk association alert is responsible for alerting the user whenever this one has been nominated to perform the actions associated to a risk assessment, this alert contains the risk description, ID, type of action, associated project, nominator user, and the type of action to be taken.

The Alerts package uses the notes, projects, users and integration packages for retrieving information for the alerts described above.

4.2.2 Integration

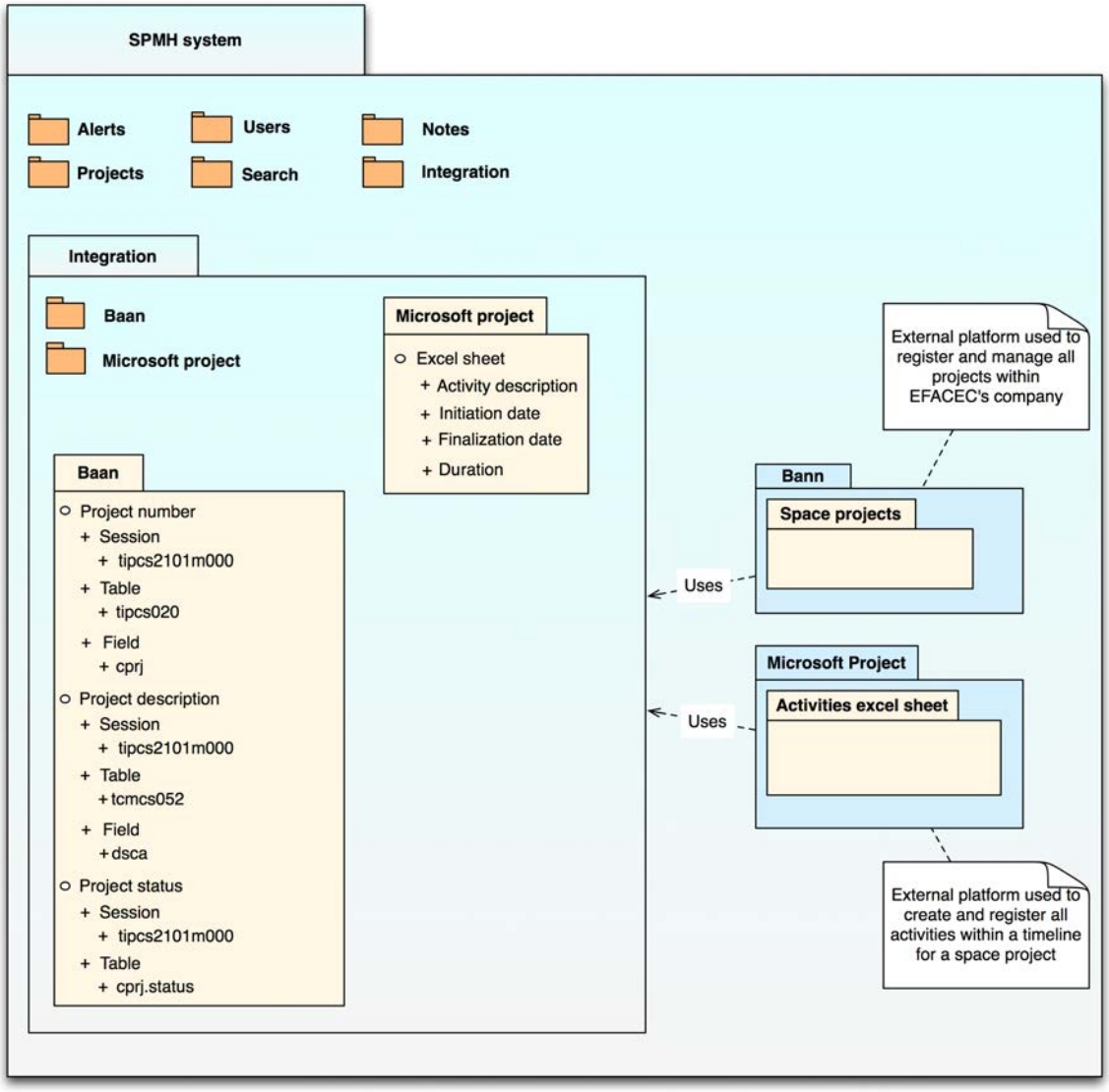


Figure 4.3: Integration package

The Integration package, as shown in the figure 4.3, presents the two major integrations with external platforms needed to ensure the system's correct performance. The integration with the Baan platform is , as said, important for the importation of the projects numbers, descriptions and status, for this package it is necessary to define the session, table and field to retrieve the information for the project number and description, and the session and table for the status. As explain before, the system must also be able to import from an Excel sheet the activities descriptions, initiation and finalization dates and the respective duration, therefore, the system has to have an integration with the Microsoft Project platform.

4.2.3 Projects

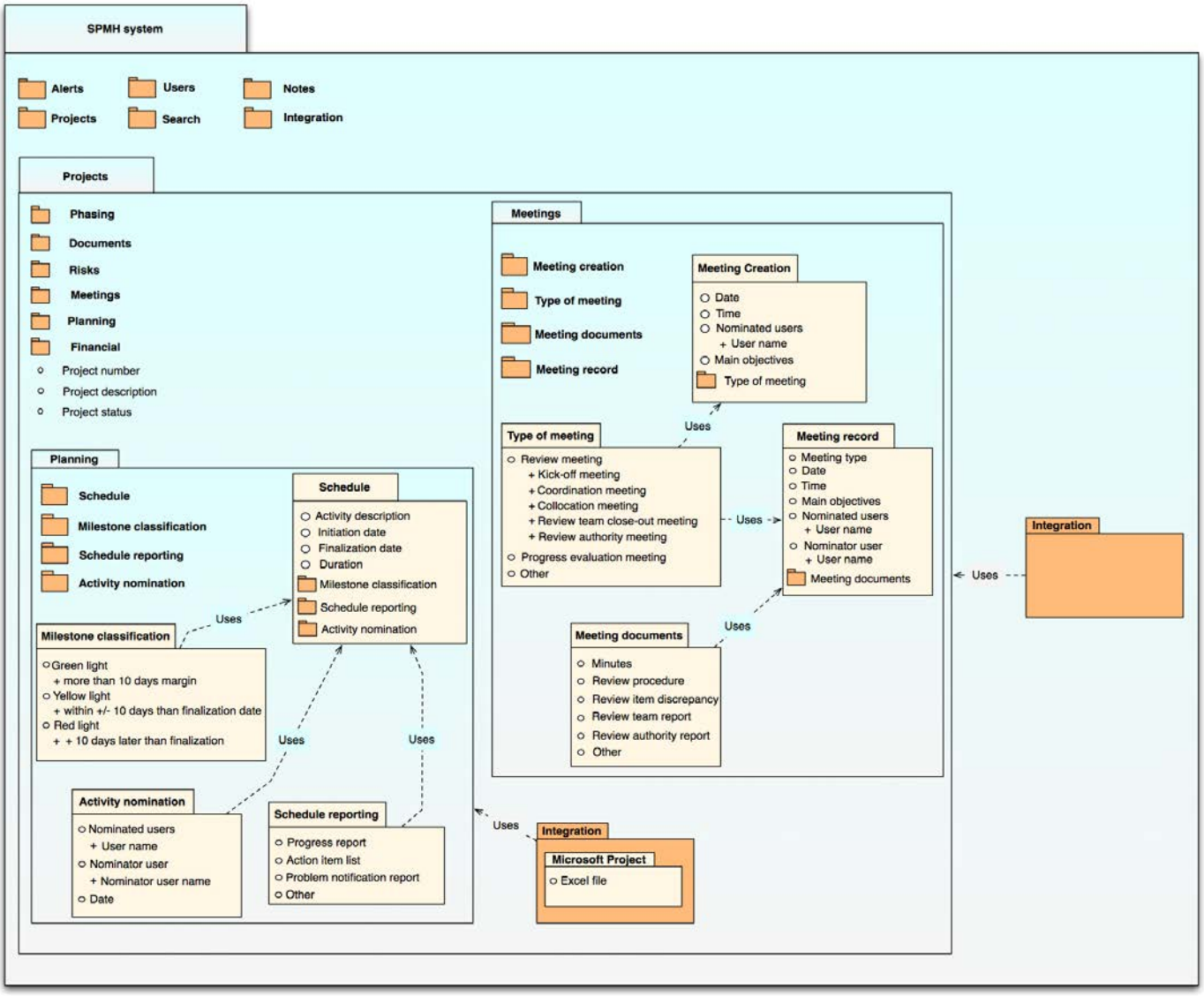


Figure 4.4: Projects package - Meetings and Planning

The Projects package, figure 4.4, is divided into six inner packages representing the six major areas of a project within the system. Every project is represented by its project number, project description and project status, received by the Baan platform integration. This figure presents two of the six inner packages, the planning and the meetings packages.

On the planning package we have the schedule imported trough the Excel sheet defined on the Integration package above, which contains, as said, the activity description, initiation and finalization dates as well as the respective duration, with this information, the system must classify each activity milestone using the traffic-light score defined in the ECSS standards. This milestone

classification consists on giving the activity a color light according to the remaining time left until its termination. The green color is given if the activity has more than ten days of margin to the finalization date, the yellow color is given if the activity is within +/- ten days of the finalization date, and the red color is given if the activity is more than ten days later than the finalization date. For each activity the system allows to nominate users for its execution, indicating the nominated names and nominator name, date and time of the nomination. For the schedule reporting, the system gives the users the option to choose from the documents defined by the standards for activity reporting or the option to add a different document that is not included on the standards documents list.

On the meetings package, there are presented two major features of the system, the creation of a meeting is composed by the setting of the meeting's date and time, the nomination of users to participate in it, the main objectives and the meeting's type. The meeting's type is defined by the ECSS standards and it can be either a review meeting as described in the figure, progress evaluation meeting or other type that the user would like to add.

As required, the system must keep the record of all created meetings within a project, this record consists on the meeting's date and time, type, main objectives, nominated users, nominator user, and on the meeting's documents, these documents are, once again, the ones defined by the ECSS standards although the users can add other documents as well.

The Project package uses the integration packages for retrieving the project number, description and status on each project.

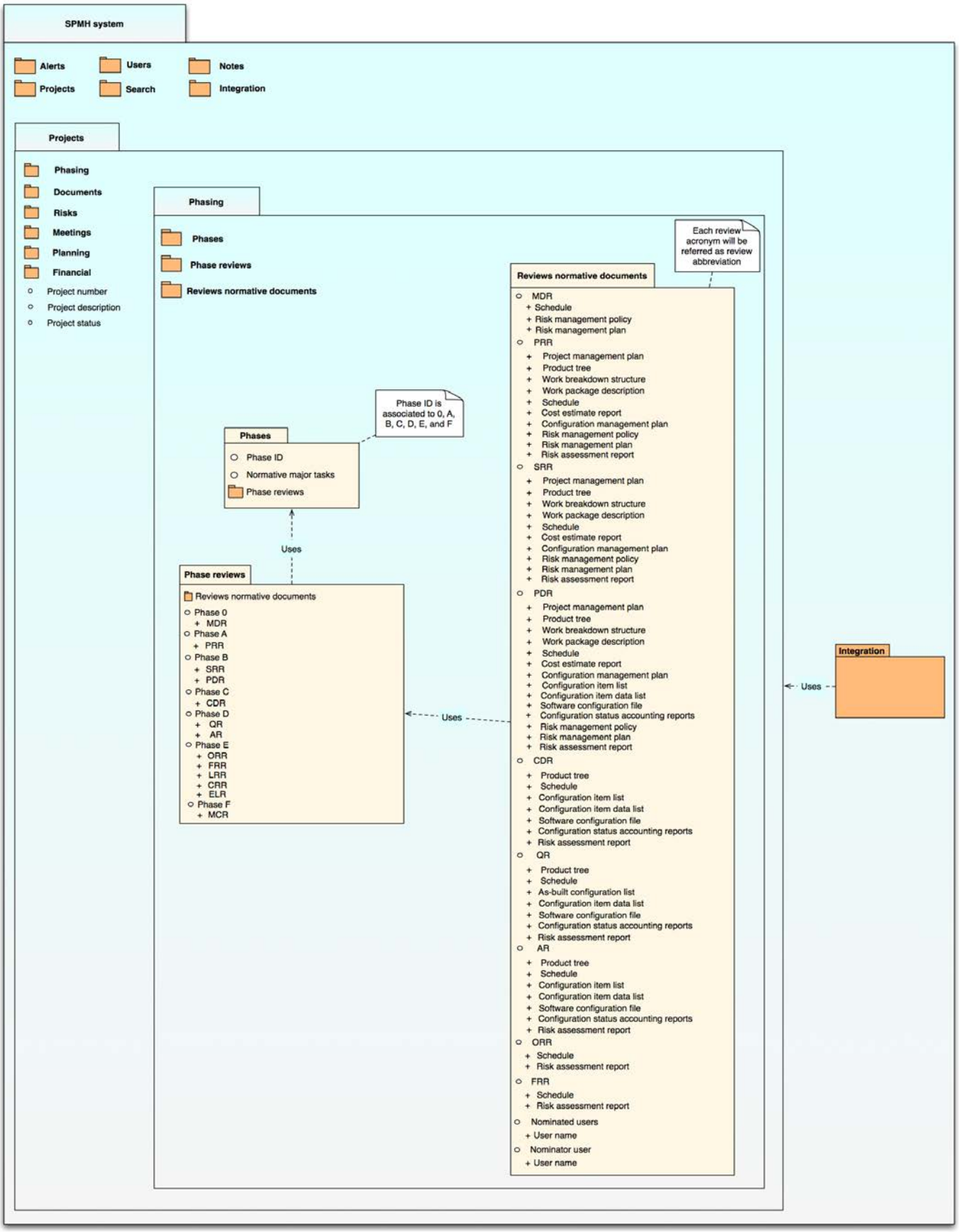


Figure 4.5: Projects package -Phasing

In the figure 4.5 there are present the packages referring to the phases of a project. These phases are defined in the ECSS standards by their IDs, these IDs consist on the number zero for the first phase, and the letters A to F for the following phases. Each phase has an associated review/s on which the standards define a series of documents to be presented. In the figure it's possible to see all the reviews abbreviations and their respective documents. On each phase, the system allows the users to see the major tasks defined by the standards and to select the phases to be implemented on the project as well as to choose the reviews and respective documents to be executed. The figure 4.6 shows the documents defined by the ECSS standards for each review within each project phase.

Document Title	**Phase**													**DRD ref.**
	0	A	B		C	D		E					F	
	MDR	PRR	SRR	PDR	CDR	QR	AR	ORR	FRR	LRR	CRR	ELR	MCR	
Project management plan		X	X	X										ECSS-M-ST-10, Annex A
Product tree		X	X	X	X	X	X							ECSS-M-ST-10, Annex B
Work breakdown structure		X	X	X										ECSS-M-ST-10, Annex C
Work package description		X	X	X										ECSS-M-ST-10, Annex D
Schedule	X	X	X	X	X	X	X	X	X					ECSS-M-ST-60, Annex B
Cost estimate report		X	X	X										ECSS-M-ST-60, Annex G
Configuration management plan		X	X	X										ECSS-M-ST-40, Annex A
Configuration item list				X	X									ECSS-M-ST-40, Annex B
Configuration item data list				X	X	X	X							ECSS-M-ST-40, Annex C
As-built configuration list						X	X							ECSS-M-ST-40, Annex D
Software configuration file				X	X	X	X							ECSS-M-ST-40, Annex E
Configuration status accounting reports				X	X	X	X							ECSS-M-ST-40, Annex F
Risk management policy document	X	X	X	X										ECSS-M-ST-80, Annex A
Risk management plan	X	X	X	X										ECSS-M-ST-80, Annex B
Risk assessment report		X	X	X	X	X	X	X	X					ECSS-M-ST-80, Annex C

Figure 4.6: Management Documents per Delivery per Review - available in [3]

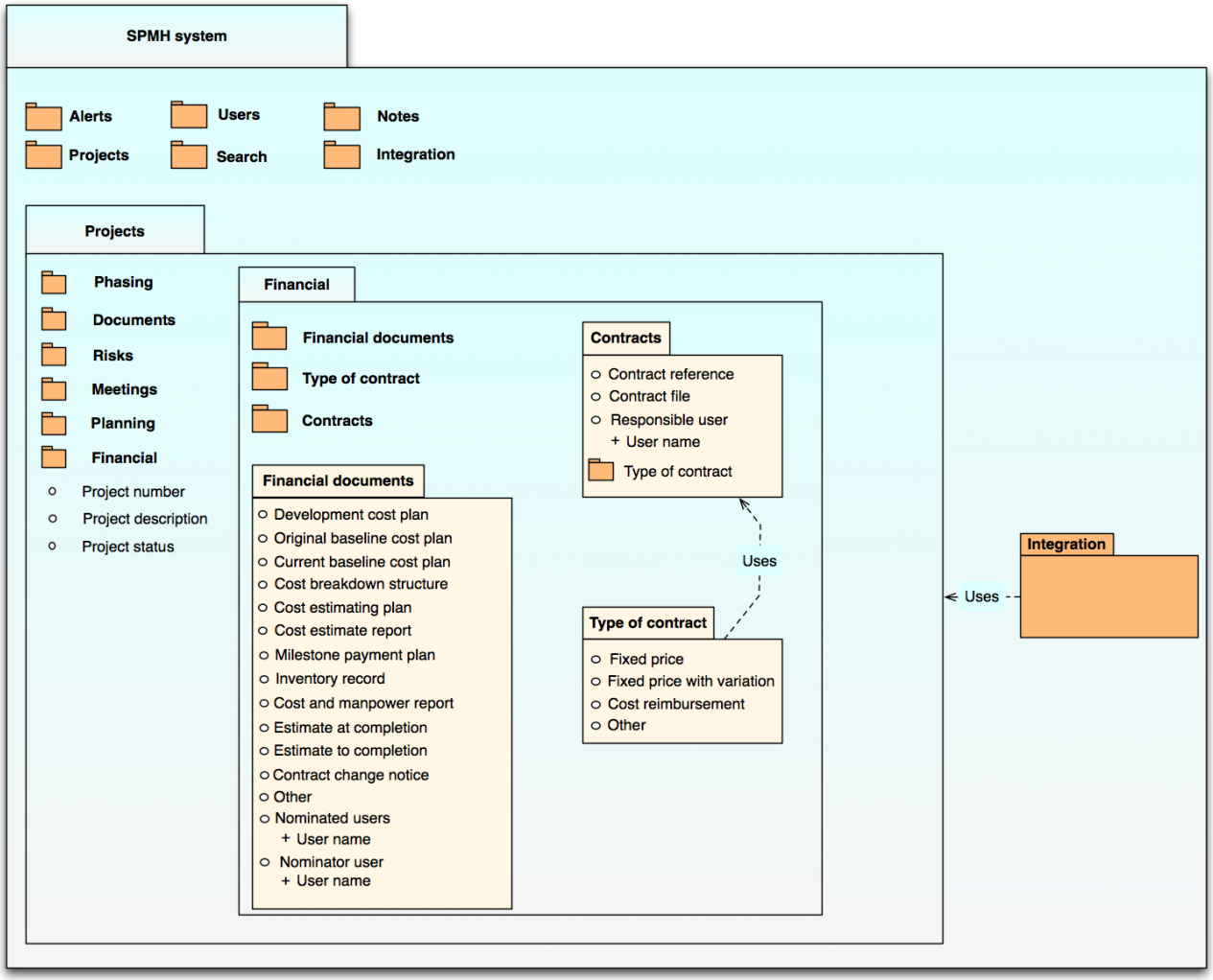


Figure 4.7: Projects package -Financial

For the financial area of any project, figure 4.7, the system divides it into two major inner packages the contracts and the financial documents. The contracts are composed by a contract reference (entered by the user), the contract file, the type of contract and the user responsible for the submission. The type of contract is, once again, defined in the ECSS standards but the system also allows the users to add other types to the system. Note that almost all contracts within a project are prior to the project registration on the Baan platform, thereby this area acts like a storage for all contracts made to be uploaded and associated to the respective project since all projects are imported from the Baan platform. The financial documents for space projects are defined in the ECSS standards, the system allows the users to nominate and be nominated to execute them and also add other documents considered relevant as well.

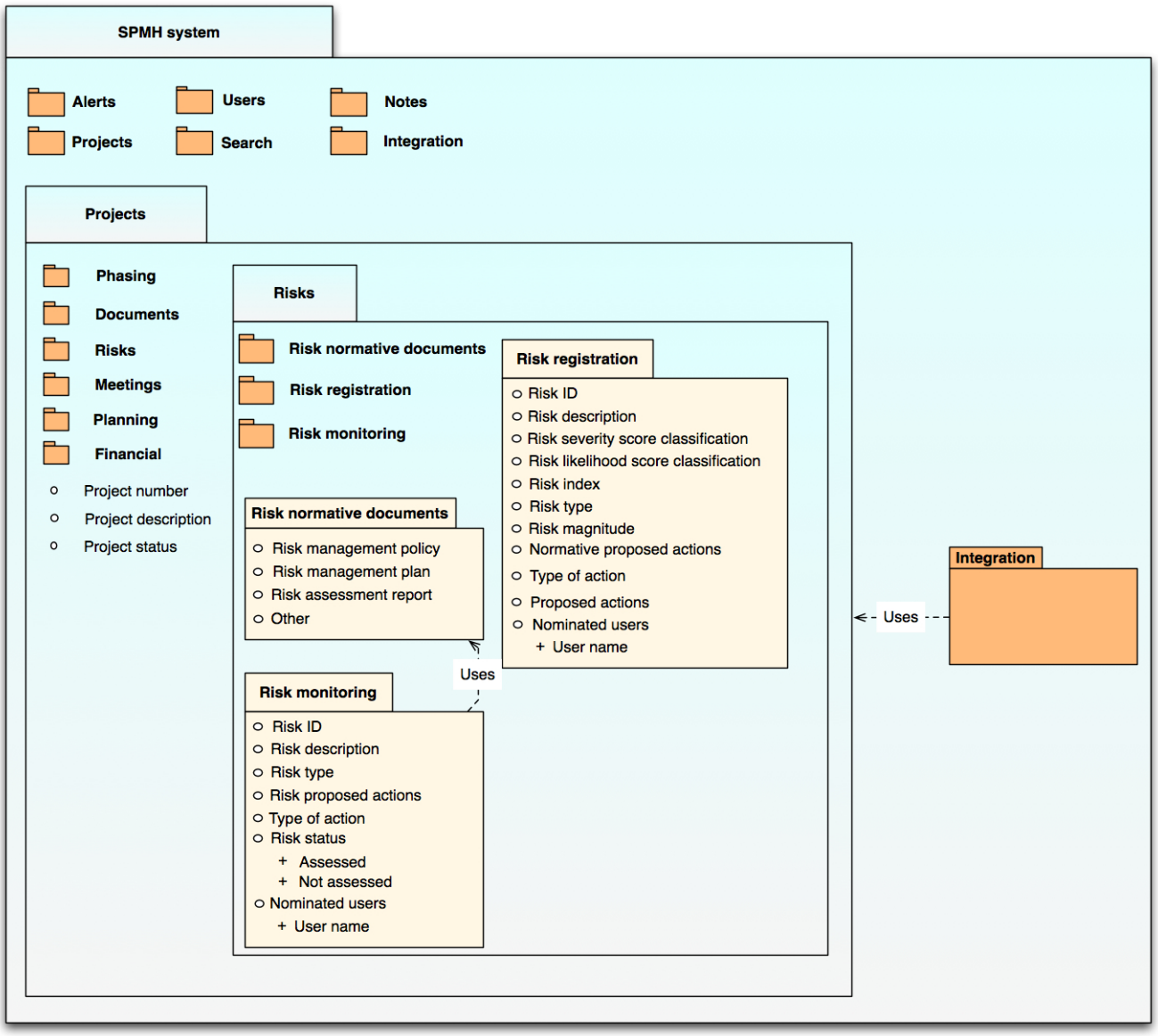


Figure 4.8: Projects package -Risks

The risks package is presented in the figure 4.8 and it's divided into three inner packages, the risk registration package which allows the users to register the a risk detected during the development of their work by describing the risk, classifying the risk severity and likelihood, choose the type of action to execute and finally nominate users for its execution. However, the risk registration process does not depend only on the user, the system must generate the risk ID automatically as well as the risk index, type and magnitude according to the ECSS standards scoring schemes presented on the chapter 2. The normative proposed actions for each type of risk must also be available for consult.

Like on the meetings package, the system must keep record of all the registered risks on the system, thereby the risk monitoring package is an important one, there the users can view, for each registered risk, the risk ID, description, type, proposed actions, nominated users and status.

The status is given by the nominated user and it can be assessed or not assessed. As in almost all other packages, the risks package has also present all documents, for risk management, defined in the ECSS standards and once again, allows the users to add any other they may find important to execute, this feature is defined by the risk normative documents package which is associated to the risk monitoring package because it is possible to associate a registered risk to a document.

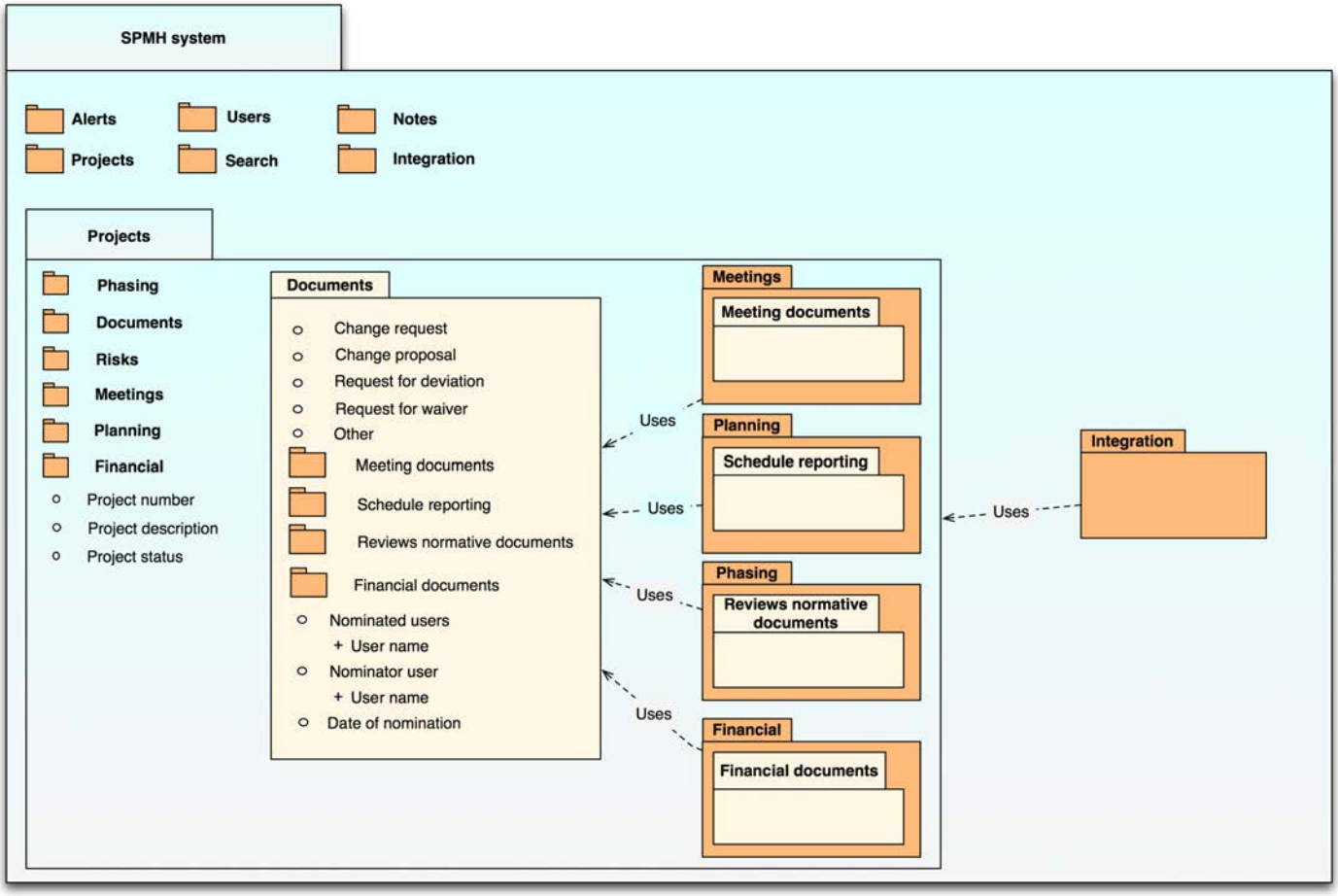


Figure 4.9: Projects package -Documents

At last, the figure 4.9 defines the packages relating to the documents area on a project. This package is a simple one, the documents area is an area where all documents within a project are stored, indicating the respective areas, facilitating the documentation management by giving an overview of all documents selected during the project's life cycle. This package is nothing more than a collector of all documentary information. In the ECSS standards the documents are presented according to their areas of interest but four of them are not linked to a specific area so it was decided that the users could have access to these in this package classifying them as general documents. For each document it is presented the nominated and nominator user/s and date of nomination. As on the other packages, the users can add, if necessary, other documents to the general documents list that are not defined on the standards.

4.2.4 Users

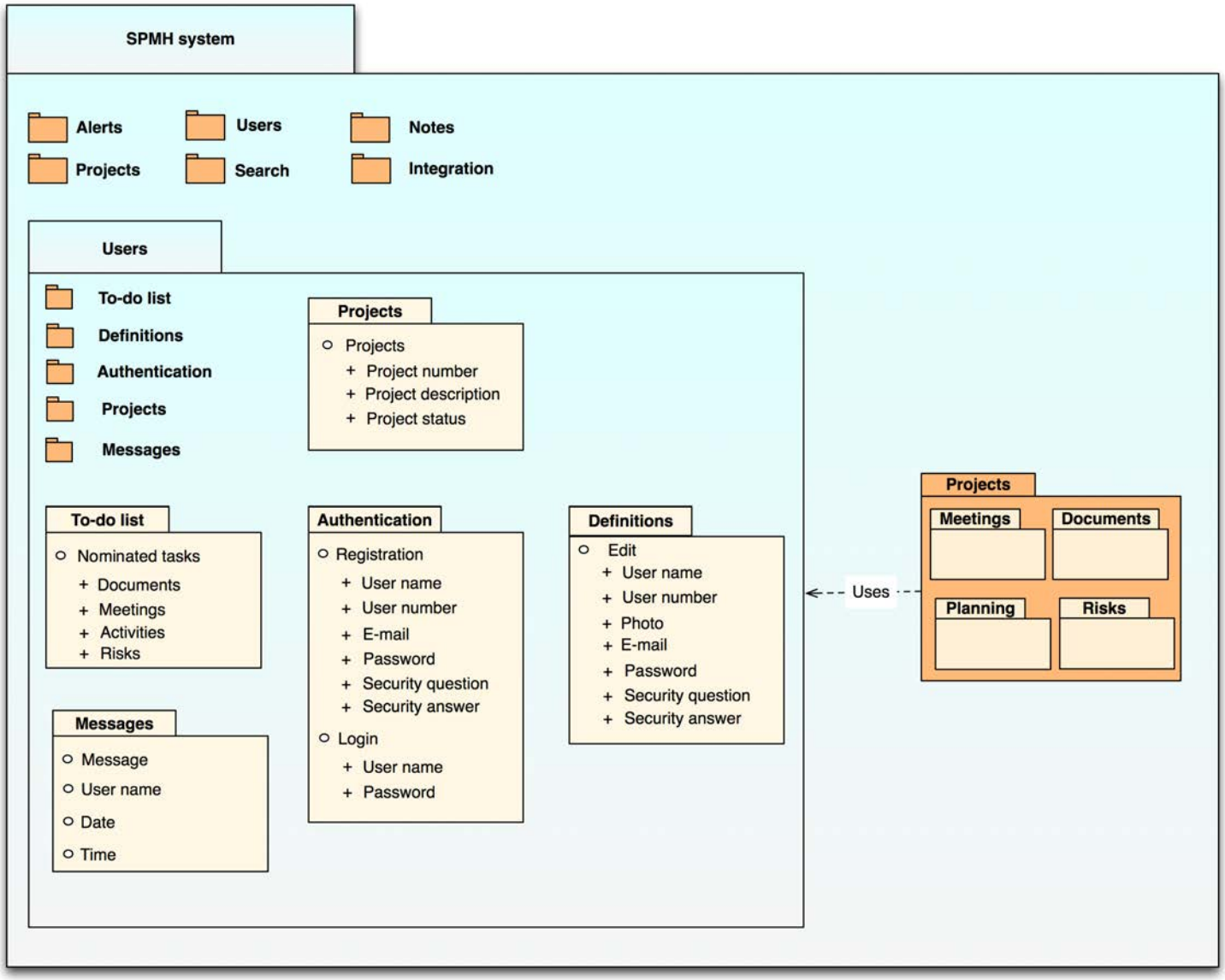


Figure 4.10: Users package

The Users package defined in the figure 4.10 consists on five inner packages: The Authentication package is responsible for the registration and login of all users within the system. For the registration process, the user must fill the user name, number (the code used on EFACEC's systems), e-mail, password, security question and security answer fields, after this, the registration request is sent to the project manager for approval. After approval has been given, the user must log in into the system by using his name and password.

The Definitions package gives the users the possibility to edit their registration definitions.

For each user, the system provides the To-do list package where the user can manage his nominated tasks, such as documents, meetings, activities and risks, and an area where all of the projects

where the user is considered an active member are presented. Active members are the ones that have been nominated or associated to an activity/meeting/document or risk at least one time within the project.
The Projects package is responsible for giving the users an overview of all their projects in development.
At last the Messages package defines for each message sent to the user the message, associated user, date and time of the message. Each user must have an area where he can send and receive private messages with other users.

The Users package uses the Projects package for retrieving all informations on nominated tasks for each user.

4.2.5 Notes

The Notes package is presented in the figure 4.11 where there are defined five inner packages representing the areas within a project where the users can add notes to be visible to all. The first area is the phasing area, defined by the phasing notes package, there the users can add a note by filling the message field. The note will automatically present the message, date, time and the creator's user name. The same process occurs in the planning and documents areas. It is possible to add notes on the two sub areas of the risks area, meaning the risk monitoring area and the risk documents area. The same process takes place on the financial area, being the two sub areas the financial documents and the contracts areas.
The Notes package uses the Projects package to perform its functions.

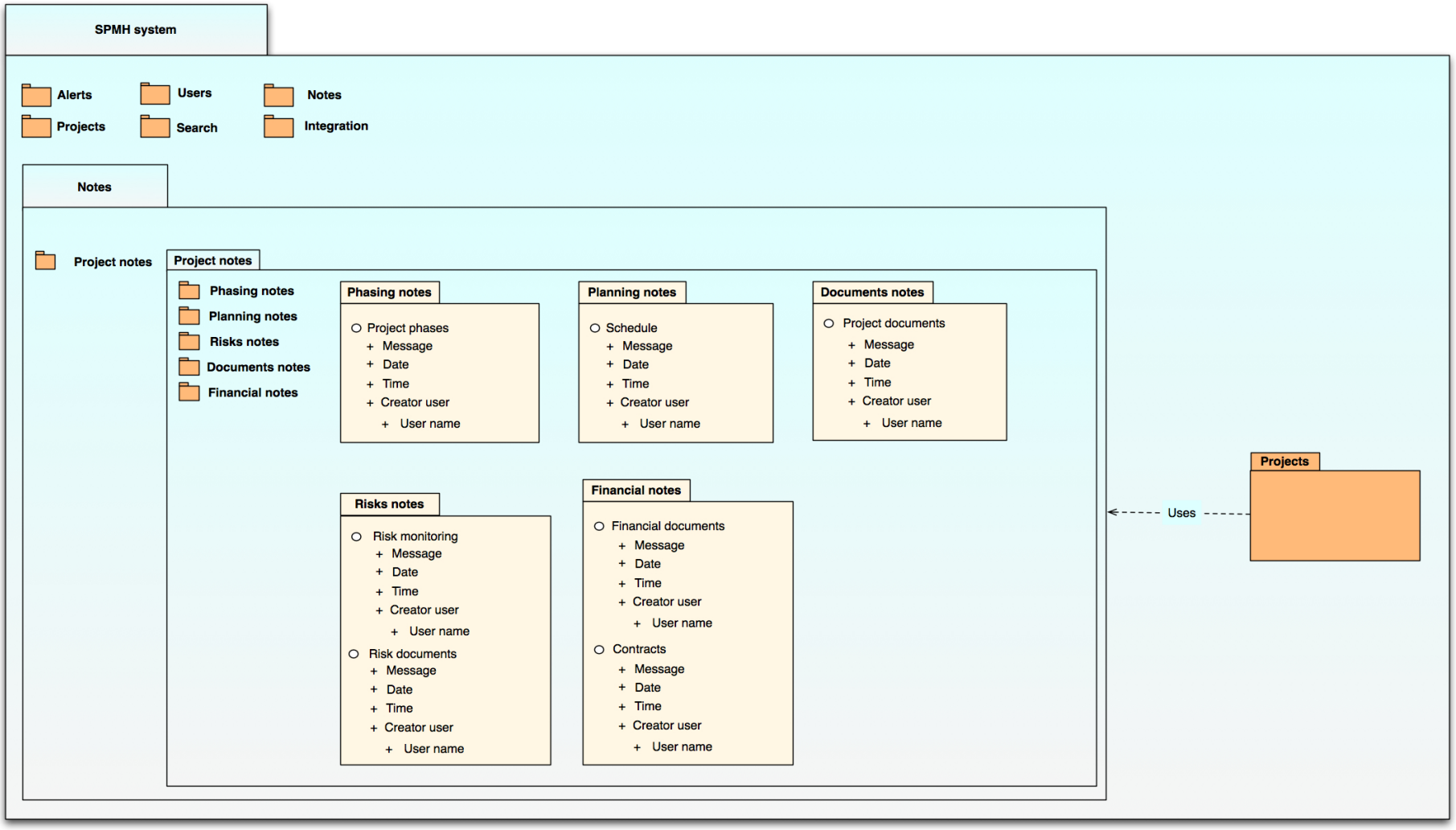


Figure 4.11: Notes package

4.2.6 Search

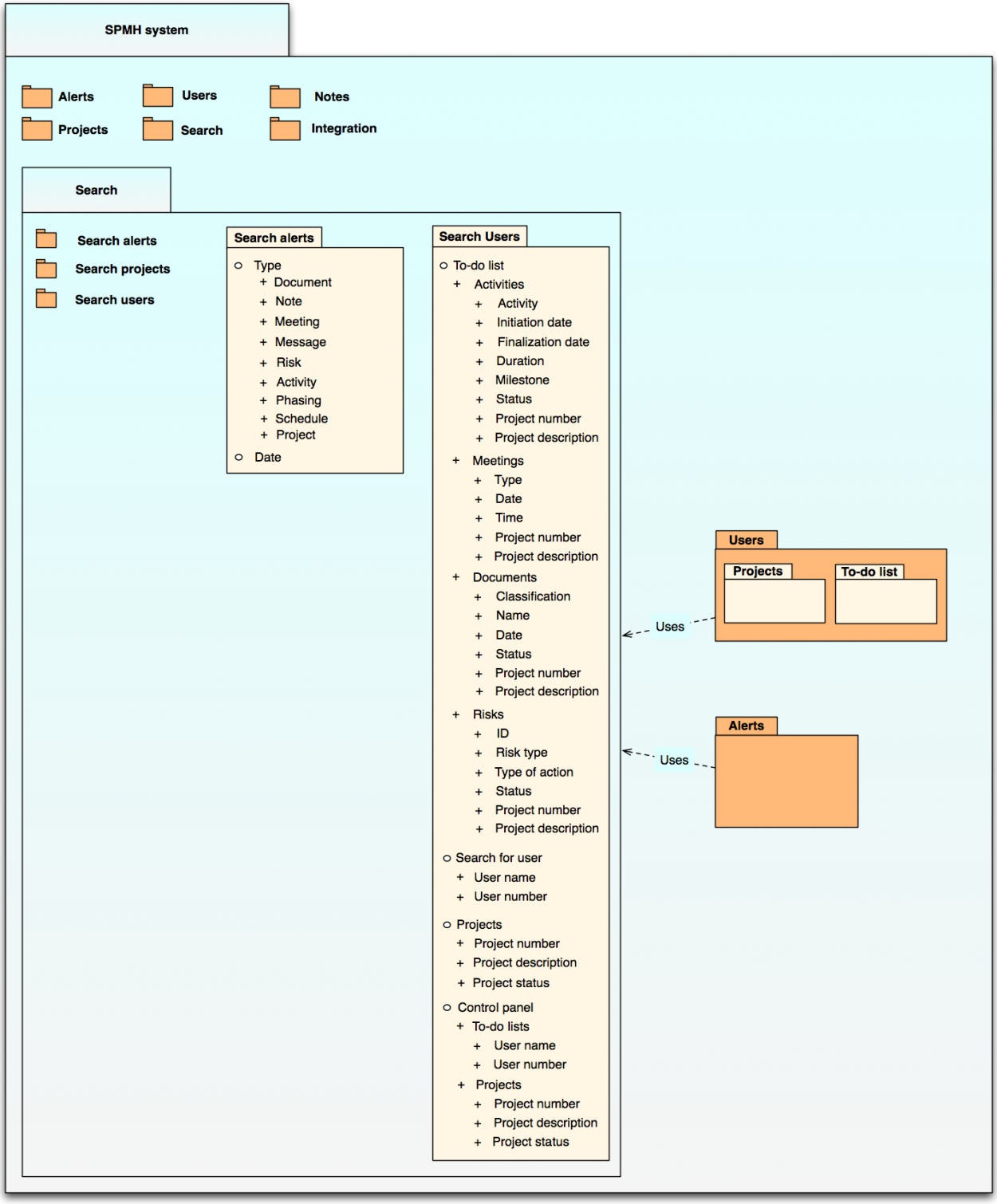


Figure 4.12: Search package - Alerts and Users

The Search package is a very important one because it allows the users to perform searches within the areas of the system. This feature can dramatically save time on searching for information, helping the users to be more efficient when it comes to their work. The figure 4.12 presents two inner packages, the search alert package that allows the user to perform searches by type of alert or by date of occurrence within the alerts area and the search users package that gives the option to perform searches within the personal to-do list, meaning to search for activities by their key labels, search for a meeting by its type, date, time, or by associated project, search documents by their major labels, as well as search for a registered risk by its ID, type, type of action, status or associated project.

The users can also search the system for other users or projects on the Users area and Projects area respectively. On the project manager's control panel he can also search the to-do lists for each user by using the user name or number, he can also search for a project by its respective number, description or status. The Search package uses the Users and the Alerts packages to perform its described features.

At last, the Search package is also defined for its searches within project areas, starting at the planning area, the search can be performed within the schedule by the different labels presented in the figure 4.13. On the meetings area, the user can search for a meeting using its type, date, nominated users or document name filters. On the financial area, the system allows to perform searches on the contracts, by their references, dates of submission or types, and on the financial documents, by their names, dates of submission, nominated users or status. On the risks area, the users can search the risk monitoring area using the ID, type of risk, type of action, status or nominated user, it is also possible to search for documents and their associated risks within the risk documents area.

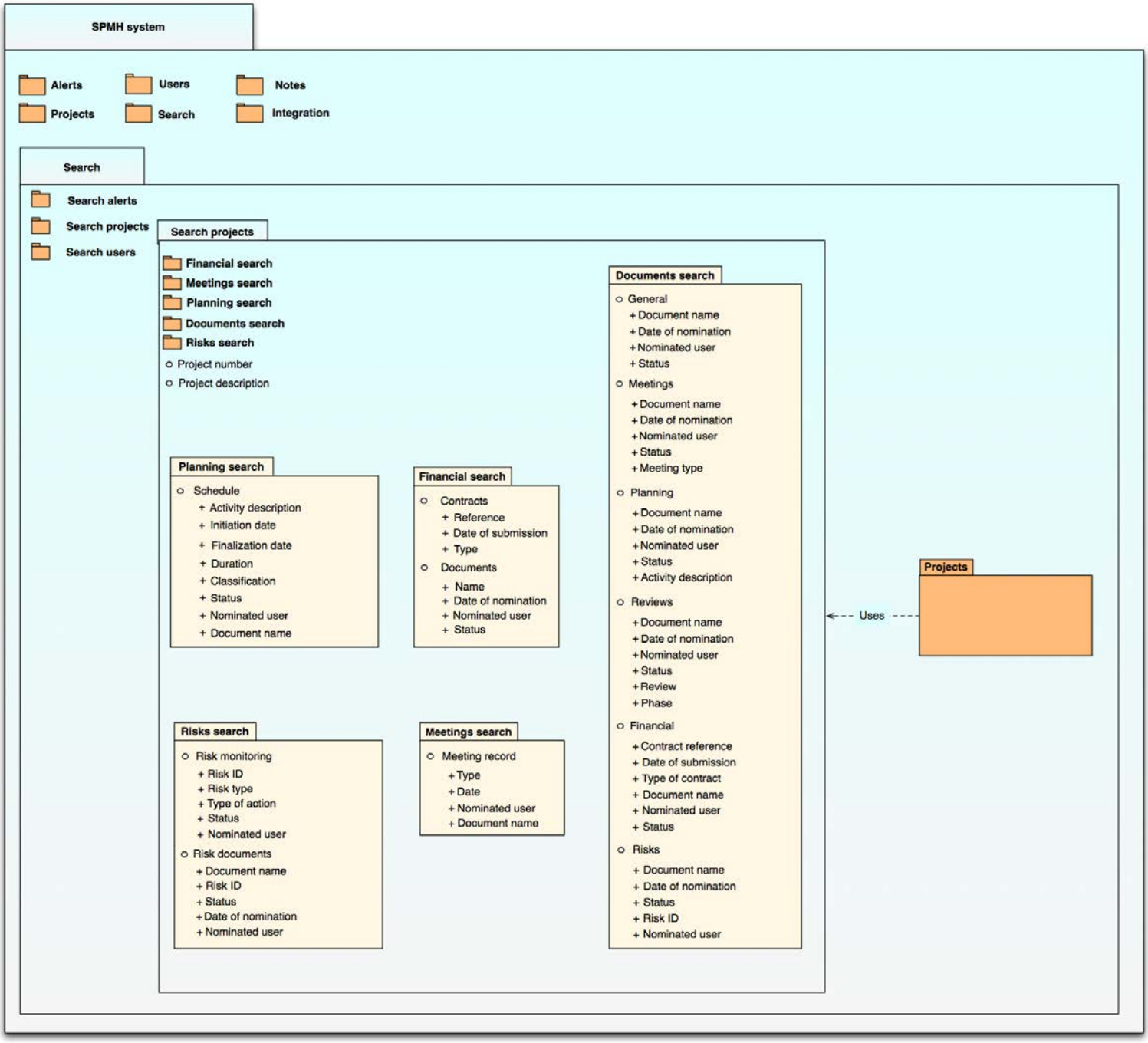


Figure 4.13: Search package - Projects

Finally, on the documents area, the users can search within each respective area for any document using the filters shown in the figure 4.13.

The Search projects package uses the Projects package to perform the searches within its defined areas.

4.3 Permissions

It is important to define permissions rules when specifying a complex system like the one in this document, the users are not all the same, in fact, there must be a differentiation between normal users such as project development team members, project manager, responsible for the team, and external users identified as customers/suppliers. The table 4.1 defines the permissions, associated to the three types of users, to be implemented on the system.

The figure 4.14 represents the levels of permissions within the system, the project manager has management permissions and access to all system functionalities and areas, which will be defined ahead, the normal user has access all system functionalities and areas, and the external user will only be given access to the financial consult area within a specific project in the system. These are the three actors defined for the system, the project manager, the users and the external user.

Type of user	**Major actions**	**Permission level**
Project manager	Submission of new projects	HIGH
	Submission of projects schedules	HIGH
	Approval of new users	HIGH
	Rejection of new users	HIGH
	Removal of projects	HIGH
	Removal of users	HIGH
	Access to all areas of the system	MEDIUM
	Access to all users to-do lists	HIGH
Normal user	Access to all areas of the system	MEDIUM
	Access only to the respective personal area	MEDIUM
External user	Access to the contracts on a project's financial area	LOW

Table 4.1: System permissions

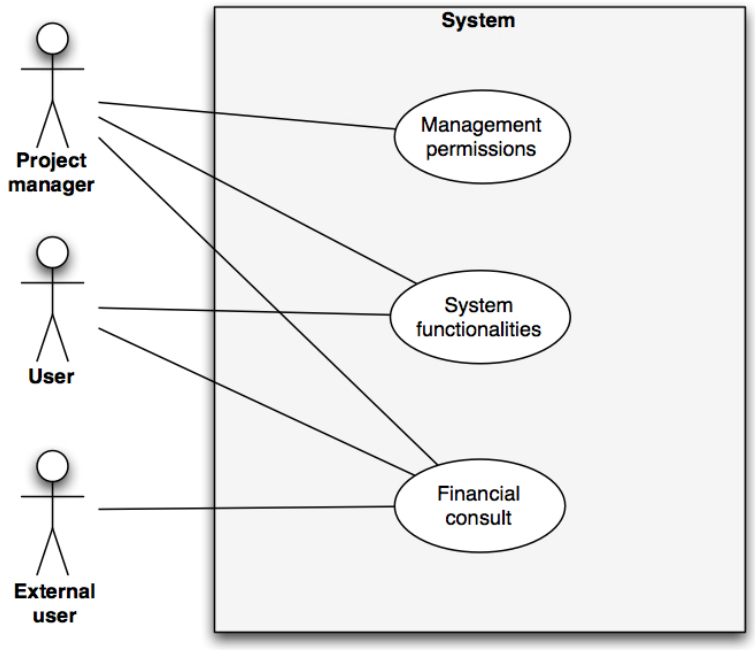


Figure 4.14: System permissions

4.4 Database structure

In the figure 4.15 it is presented the first part of the database structure dedicated to illustrate all entities and attributes necessary to support the system definition presented above [20], [21]. Starting at the center of the diagram, the User entity is composed by a series of attributes such as an id which will be the user's key attribute, the user name and number, password, e-mail, photo, security question and security answer. The relationship between users and projects can be translated into the Project and ProjectsUsers entities,where one user can have several projects and one project can have several users. The Projects entity has an id, defining each project as key attribute, the project's number, description and status drawn by the Bann platform and a user_id which represents the user responsible for the project importation in this case the user will be always the project manager. The ProjectsUsers entity represents the relationship between one user and one project due to the fact that it is necessary an extra entity when defining several-to-several associations.

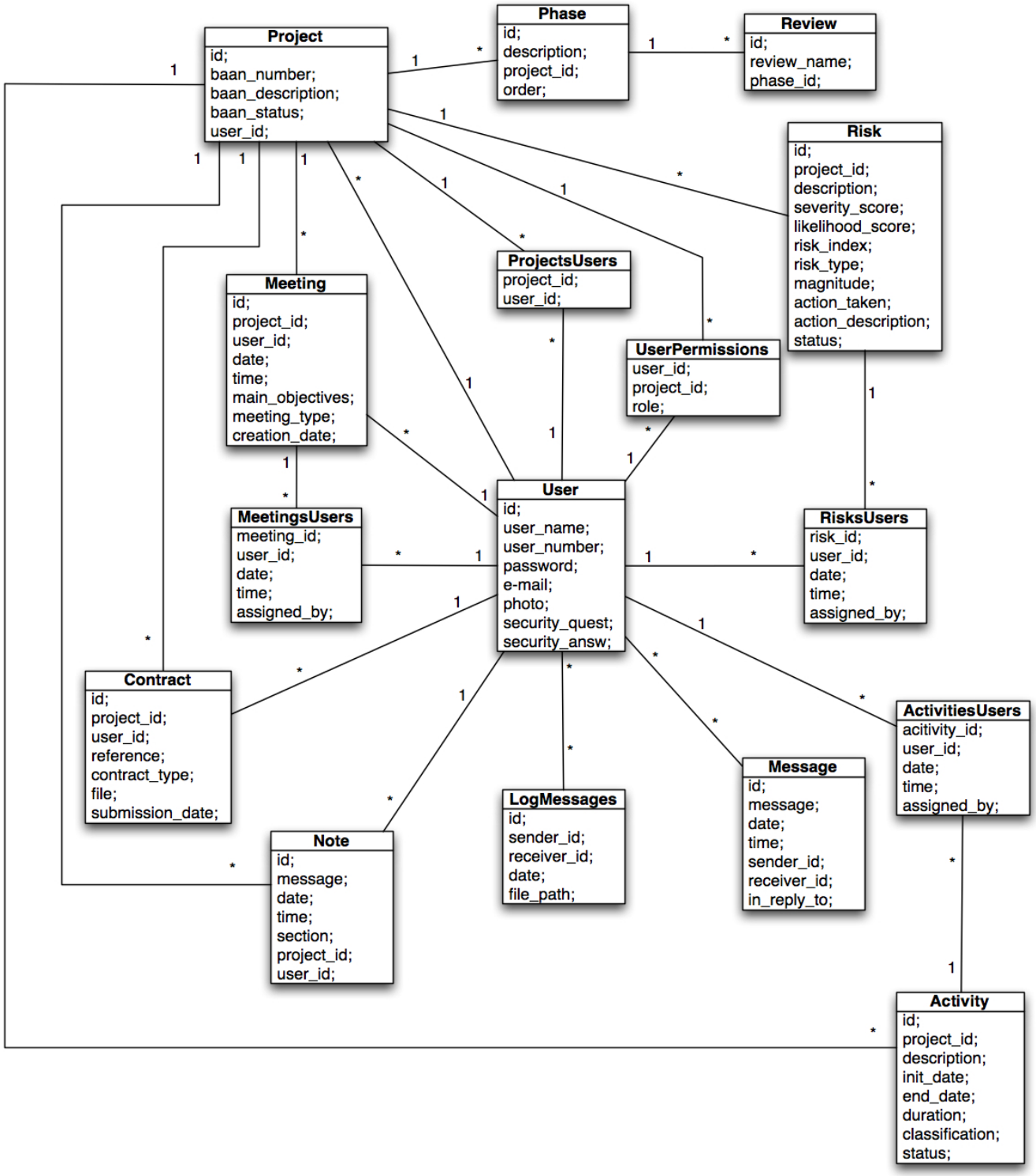


Figure 4.15: Database structure

For the the system meetings the same logic is applied, since a user can have several meetings and a meeting can have several users as well, the need for an extra entity to help define this relation is done by the MeetingsUsers where the meeting's id is the key attribute, the user_id represents the nominated user and the assigned_by the nominator user, the date and time of the nomination are also stored on this entity. Each meeting is defined by its id as key attribute, by the associated project id, by the creator user id, by its date and time, and by its main objectives, type and creation date. Of course that a project can have several meetings but a meeting is exclusive to one project and not for all.

For the financial part of a project, it was defined that a user has several contracts that he can upload into the system, the Contract entity is defined once again by its id as key attributed, by the associated project id, the user id which was responsible for uploading the contract, the contract's reference, type and file, and at last by the contract's submission date. The relation between a contract and a project is defined as one project can have several contracts but a contract has only one project associated and it not gets uploaded to all projects within the system.

Moving to the notes system, this one is defined through the Note entity which has an id as key attribute, the message, associated date and time, the section being the area on which the note was created, the associated project id and the creator user id. One user can have many notes and one project also can have several notes.

The messages system defined for this platform consists on a user being able to chat with other users and to keep the conversations logs available. The Message entity is defined by, once again, an id as key attribute, the message, date and time, the sender's id and the receiver's id, and the in_reply_to attribute responsible for keeping the messages order. The LogMessages entity is responsible for the conversation logs, thereby it has, besides the id, the sender's and receiver's ids, conversation date and the file path where the log file will be stored. Note that these two entities are associated by several-to-several associations but these represent two-to-two associations since the conversations are made only between two users.

On the activities system defined for this platform, the database must have the ActivitiesUsers where the nomination process is stored using the activity_id key attribute, the nominated user id, the nominator user defined by the assigned_by attribute and the date and time of the nomination. Like it was defined, a user can be nominated to many activities as well as an activity can have many responsible users, so once again, it was necessary to define an extra entity called Activity which stores all attributes defined for an activity, these are the id, the associated project id, description, initiation date and finalization date, the respective duration, the milestone classification and the associated status. A project can have many activities but these activities are only associated to one project and are not replicated to all projects within the system.

The risk registration and monitoring can be translated into two entities, the RiskUsers which defines the association between a user and a risk through the risk id, user id, date and time of nomination and the nominator user attributes. The Risk entity is composed by many attributes visible in the figure that translate the risk registration and monitoring processes defined previously. A user can be responsible for many risks but a risk can have more than one responsible user and only an associated project.
For the phasing area defined for the system there are defined two entities, the Phase entity is defined by an id, the phase description which includes the actors and major tasks defined above, the associated project id and the order being 0 to F. Each phase can have many reviews as seen but a review is exclusive to one phase, the Review entity is defined by the id, the review's name and by the associated phase id. One project can have many phases but these only have one associated project.
At last, it is defined the UserPermissions entity which translates the identification of the three types of users, through the user id, associated project id and role attributes, the role attribute is the one which defines the user as project manager, normal user or as external user.
The second part of this database structuring is dedicated do the documents entities present on this system. There are four types of documents defined for the system: the documents associated to the risks, to the activities, to meetings and to reviews as shown in the figure 4.16.

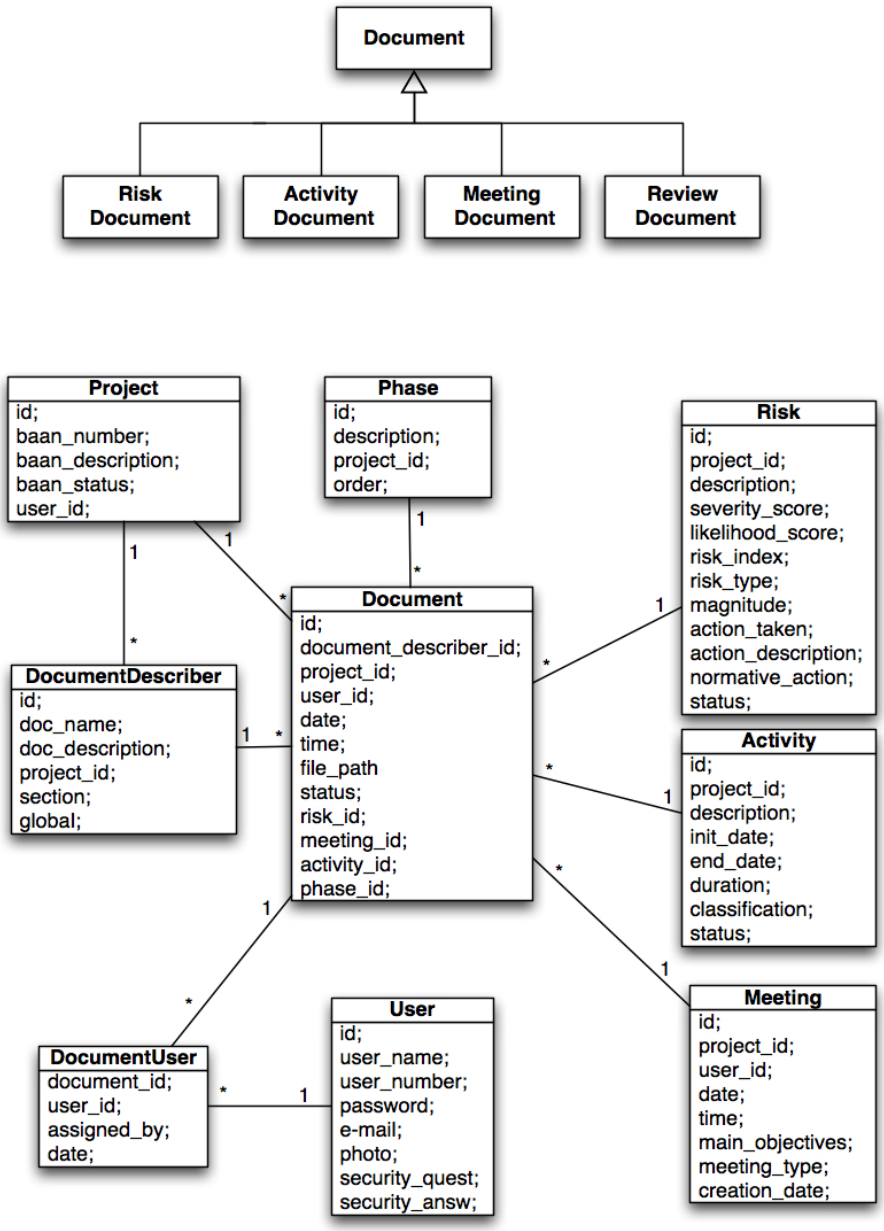


Figure 4.16: Database structure - Documents

The Document entity has many attributes such as an id serving as key attribute, the document_describer_id which will store the document's name and description, the associated project and user, date and time, the file_path where the document's file will be stored, the associated status, the associated risk/meeting/activity or phase id. Each Phase entity has, as said before, the attributes shown in the figure 4.16 and the relation between these two entities is one to many, meaning that one phase can have many associated documents.
The Risk entity has an id, a associated project, a description, the severity and likelihood scores, a risk index and type, the associated magnitude, the action to be taken, the action description, the

normative proposed actions and at last the associated status. One risk is defined to have many documents but these documents are associated to one risk exclusively not being associated to all registered risks.

The Activity and Meeting entities, described above, have the same relation with the Document entity, one activity or meeting can have many documents associated but these have only one activity or meeting. Moving now to the DocumentUser and User entities, once again the necessity to create an extra entity raised from the many-to-many relation between the User entity and the Document entity since one user can have many documents but a document can have more than one associated user. The DocumentUser entity is responsible for translating the nomination process, it has the associated document id, the date of the nomination and the id of the nominated and nominator. This relation can be described has one user can have many nominations and one document can also have many associated users.

At last, the DocumentDescriber entity once again translates the relation between the Project and Document entities since one project can have several documents but also the documents can be present in several projects. The attributes defined for the DocumentDescriber entity are the id, the document name, description, the associated project id, the section in which the document will be present within the project, and the global attribute which defines the documents that are inserted by the users.

4.5 Conclusions

On this chapter there were defined all system packages and their major features, with these packages it becomes more clear on how to design the system interfaces. Each one of the defined packages will form the basis for the next step of the system specification, this specification can be considered as an iterative process in a way that it is only possible to move on to the next phase when all of the information and previous outcomes are consolidated and approved. For each one of these packages, the next chapter will present the interfaces and screens designed to translate the system's definition into a platform that is user friendly and that represents a strong management tool for the project manager and for all members of the project development team. The database structure presented on this chapter supports the definition made to the system and gives this specification a solid basis for perhaps a future implementation.

Chapter 5

System design

This chapter presents all system interfaces and screens that reflect the defined requirements and the system's definition presented on the previous chapter. The last section of this chapter is dedicated to exemplify a few use cases for the major functionalities of the platform. Each major area of the system is composed by features and functionalities that aim to provide the users useful tools that will allow for a more effective work development during the projects life cycles.
The design platform used to create the system interfaces and screens is called OmniGraffle [22], this platform uses stencils with design elements to be used by drag and drop that facilitate the construction of any interface. For the interfaces presented on this chapter there were used about three stencils [23],[24],[25] and four icons groups [26] that can be window interfaces [27], action icons and folders [28], or arrows [29].

The figure 5.1 presents the scheme of the interfaces designed for this platform providing a better understanding about the defined hierarchy for the system. This figure shows the interfaces inserted within each area of the main menu, these areas are subdivided into their main features and screens. These screens and respective functionalities will be described in this chapter ahead.

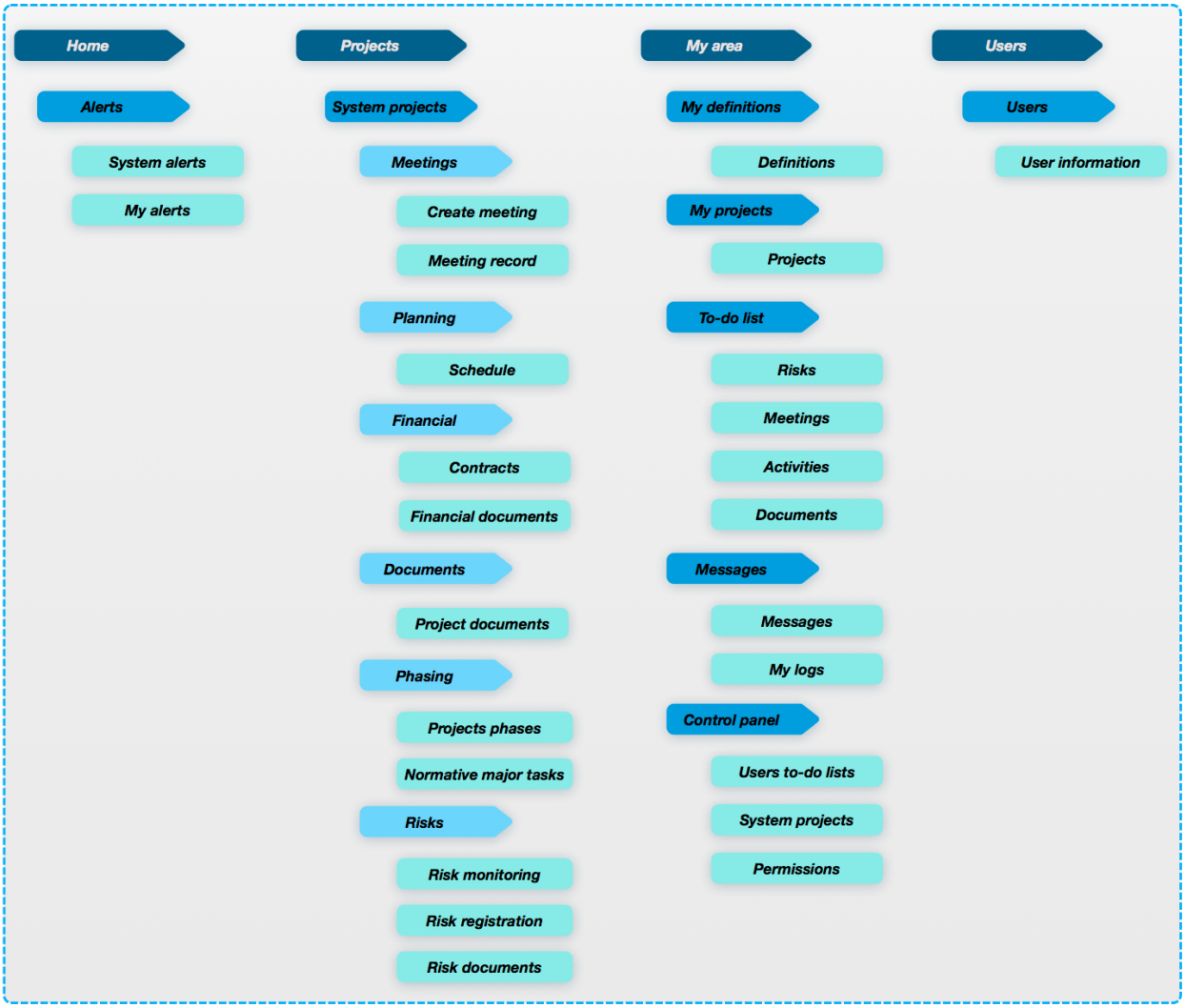


Figure 5.1: Interfaces scheme

5.1 System interfaces

The system's platform is divided into four major areas:

- Home;
- Projects;
- My area;
- Users.

Each one of these areas have many characteristics that will be described in this chapter. Due to the fact that this system specification was made during an internship on an electronic products space department, the platform had to be named, therefore, from now on the platform will be referred as EFASpace.

5.1.1 Log in

To enter the EFASpace platform, all users must be logged in, to do so, the log in area was design as shown in the figure 5.2.

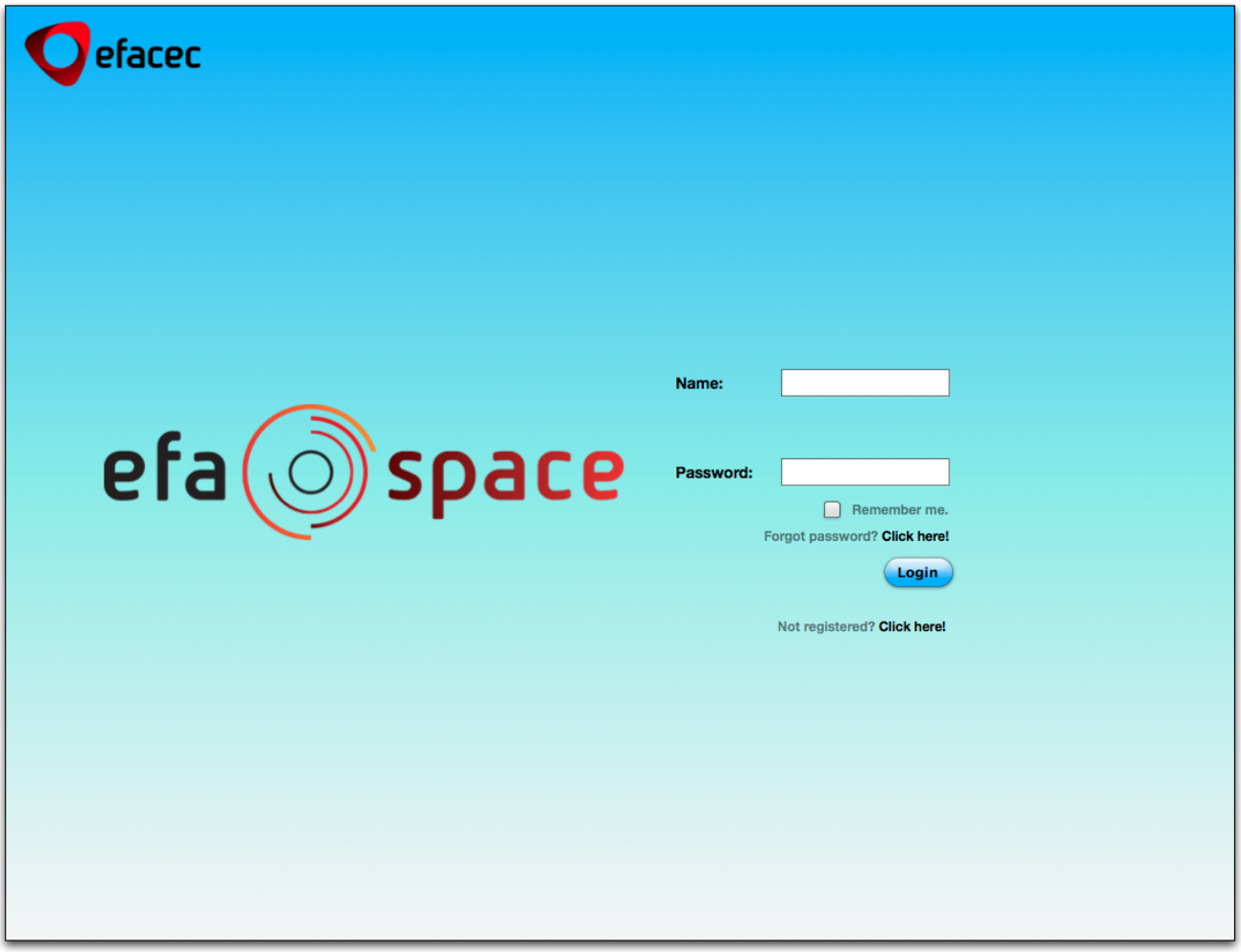


Figure 5.2: Log in area

In case the user forgot his password he must click on the forgot password link and receive by e-mail the new password. To log in, the user must have a valid name and password previously registered in the system. If the user has not been registered, he can access the register area and fill the registration required fields as shown in the figure 5.3.

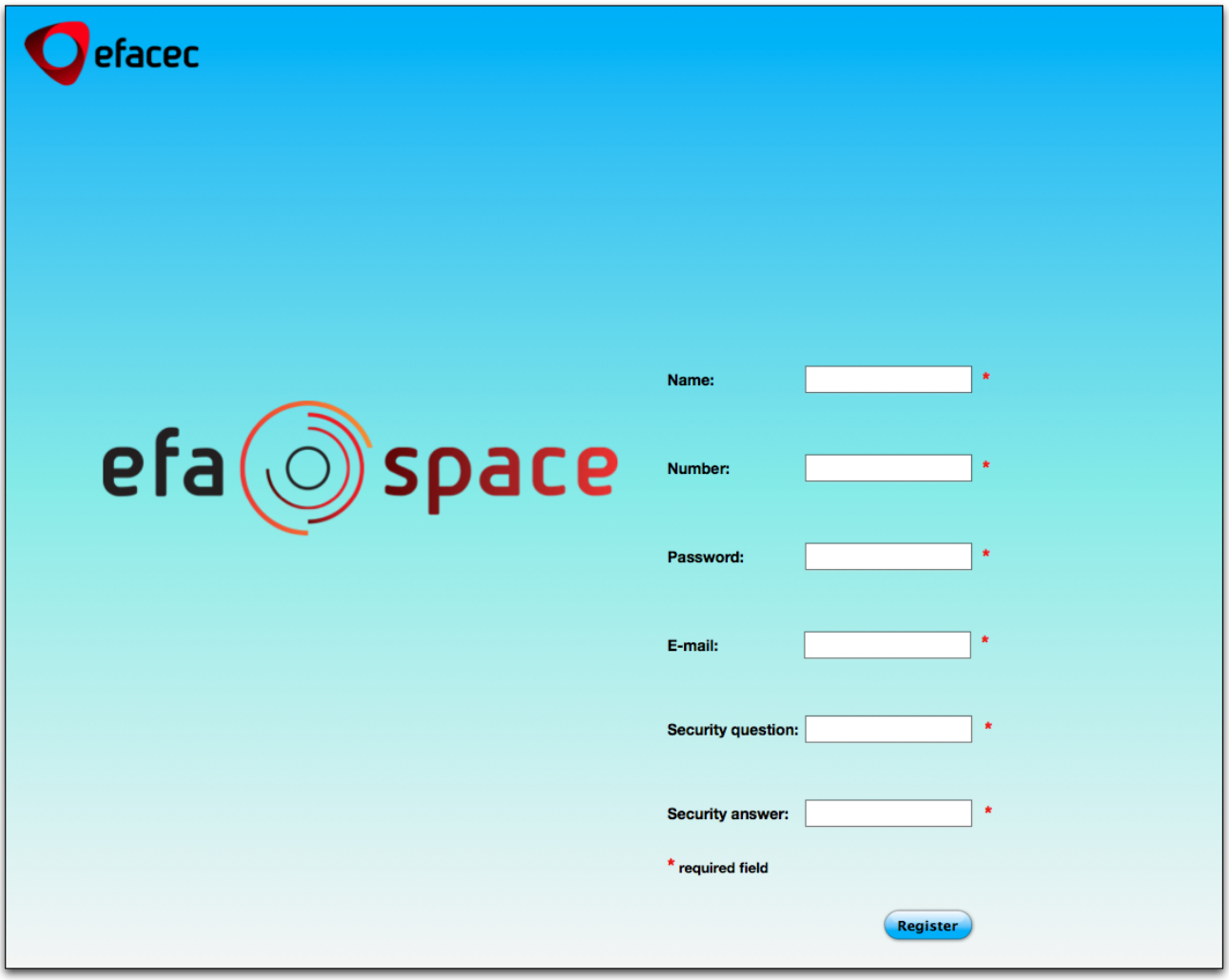


Figure 5.3: Registration fields

After registration, the user must wait for approval from the project manager which receives all the registration requests. The approval or rejection for the registration request is sent to the user's e-mail (figure 1).

5.1.2 Home

The "Home" area is the main entrance into the EFASpace platform, here the user can view all the system alerts and his personal alerts defined on the chapter 4 . As shown in the figure 5.4, the user has available the search fields to help him find information in a fastest way using the filters as shown in the figure. After log in, the top right corner of all interfaces will be always the same, welcoming the user and indicating the current date and time, the user can always log out of the system using the lock icon.

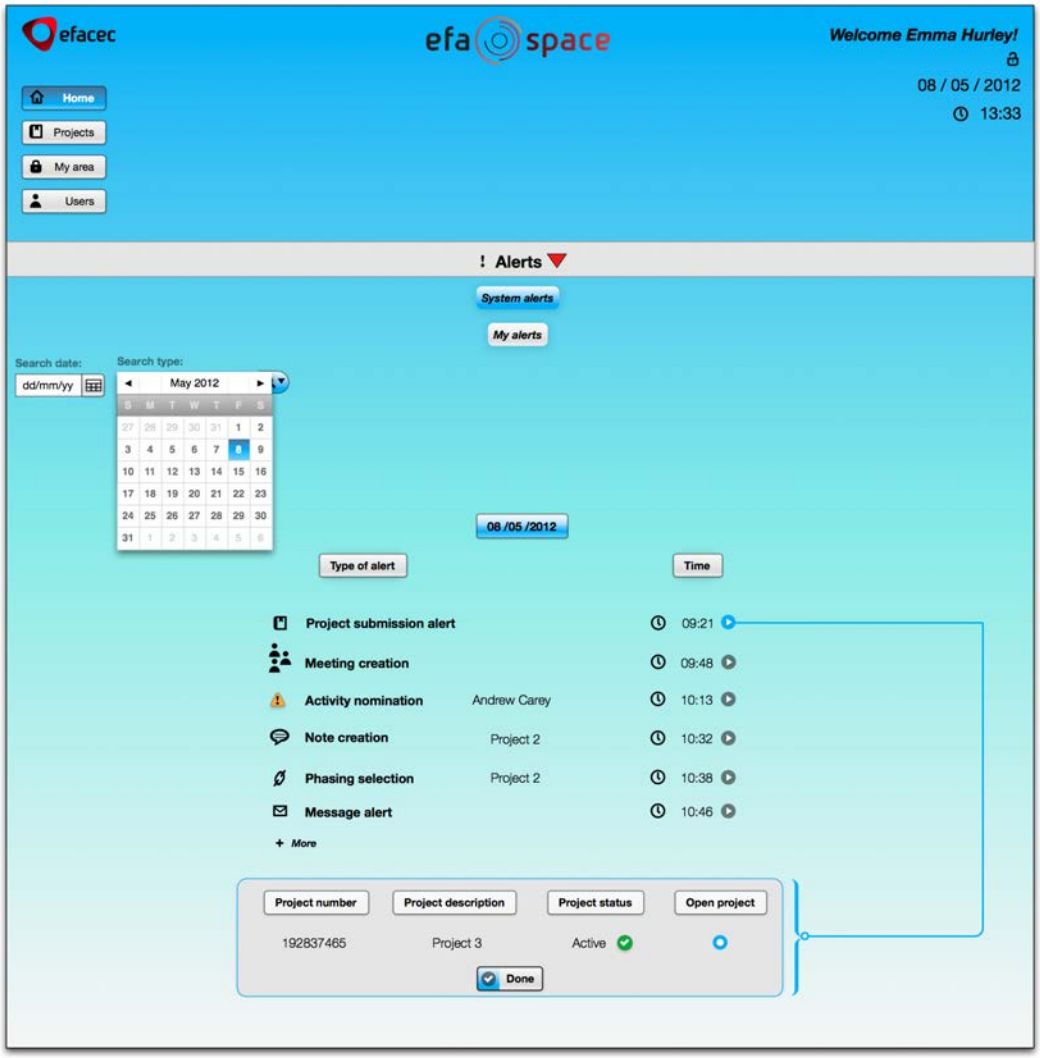


Figure 5.4: Home - System alerts

The user can access his alerts by clicking on the "My alerts" button on the menu bar (figure 2). Here the screen presents the alerts directed to the user, these alerts can be messages, meeting nominations, activities nominations, etc. This screen provides the user an overview on his alerts and also allows the user to search for any type of alert using the search fields on the left corner.

5.1.3 Projects

When selected, on the main menu in the top left corner of the screen, the "Projects" button gives access to all registered projects in the EFASpace platform. The user can select the project that he wants to open by clicking on the open project icon in front of each project. Also in the figure 5.5 it is possible to notice an alert pop-up on the right top corner of the screen which the user can open to access the area on which the note has been created. The user can also search for a project by typing the project's number or description on the search field.

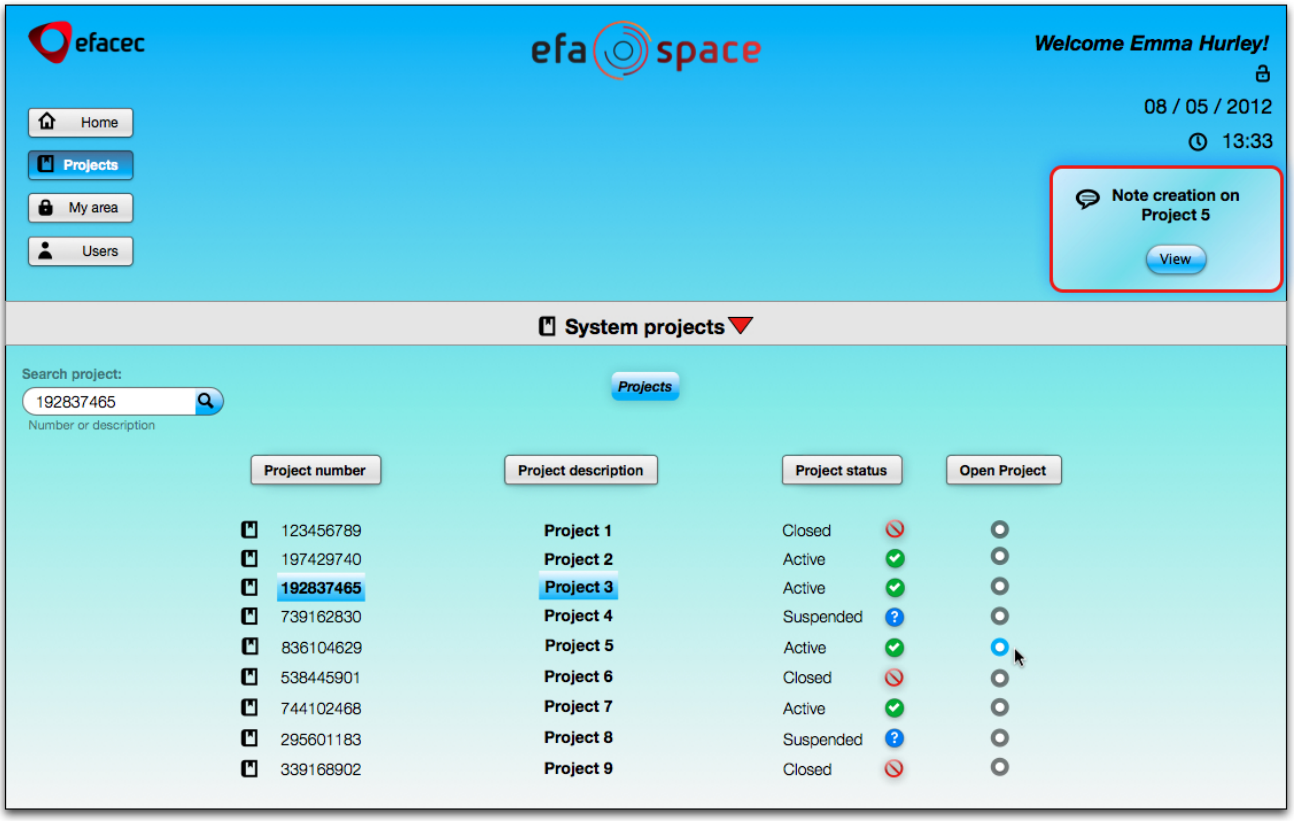


Figure 5.5: Projects

After selecting a project, on this example case Project 5, the user enters the project's main area, here the menu bar is divided into the project's major areas and the project number, description and status will always be in the middle top of the screen indicating that all actions made are related exclusively to Project 5. In this screen, all project active users photos [30] are identified as well as the responsible for the project submission and date of importation (figure 5.6). On this screen, the user can view all created notes as exemplified in the figure 5.7, the red icon numbers represent the number of notes created on that day in the calendar.

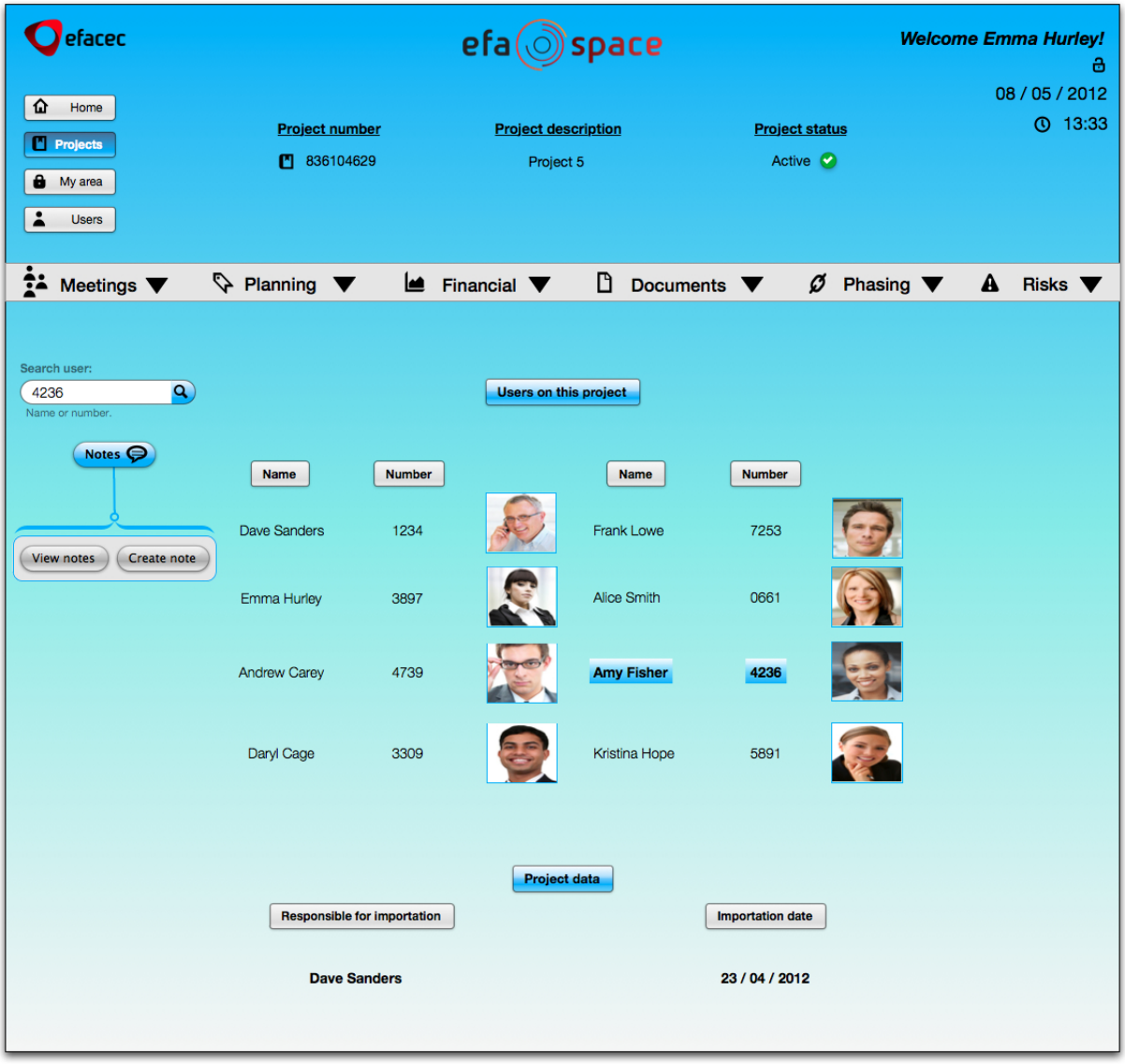


Figure 5.6: Projects - Project selected



Figure 5.7: Projects - View notes

The note creation process is shown in the figure 5.8 and its applicable to all other areas within the project which have the "Notes" button present.

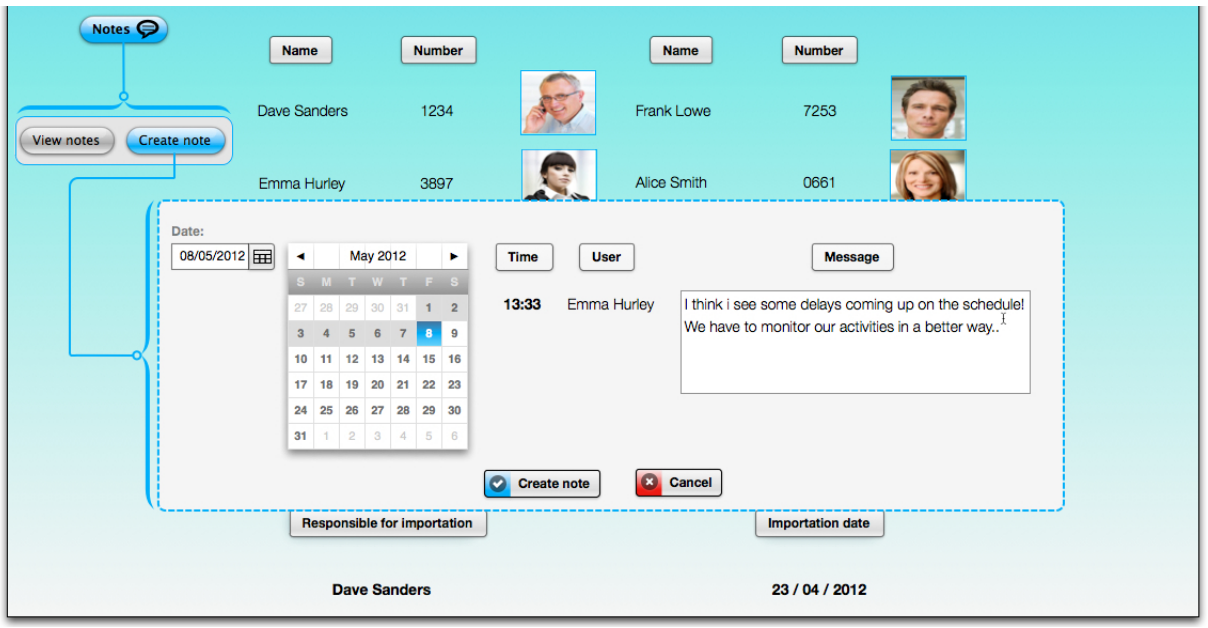


Figure 5.8: Projects - Create note

On the menu bar, as said, the user accesses the project's main areas, starting at the "Meetings" area, the user can either create a meeting or view all registered meetings within the selected project. The figure 5.9 shows the screen presented when the user clicks on the "Create meeting" button. For the meeting creation process (figure 3) defines all involved steps in a diagram form.

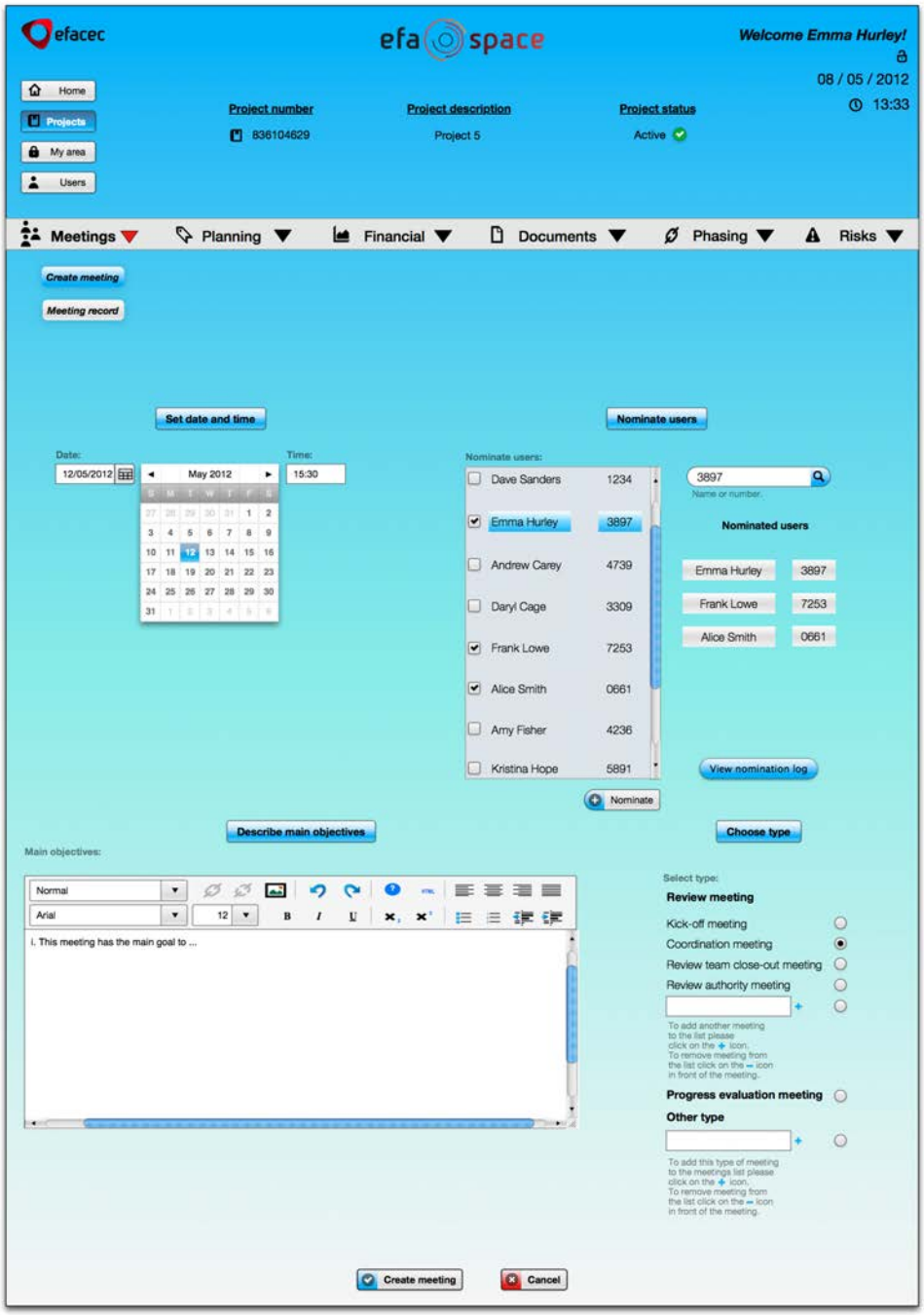


Figure 5.9: Meetings - Create meeting

After creating a meeting, the user can now access to its informations by clicking on the "Meeting record" button. Here the user can also add documents to a meeting and nominate the responsible users for its execution as shown on the figures 5.10 and 5.11.

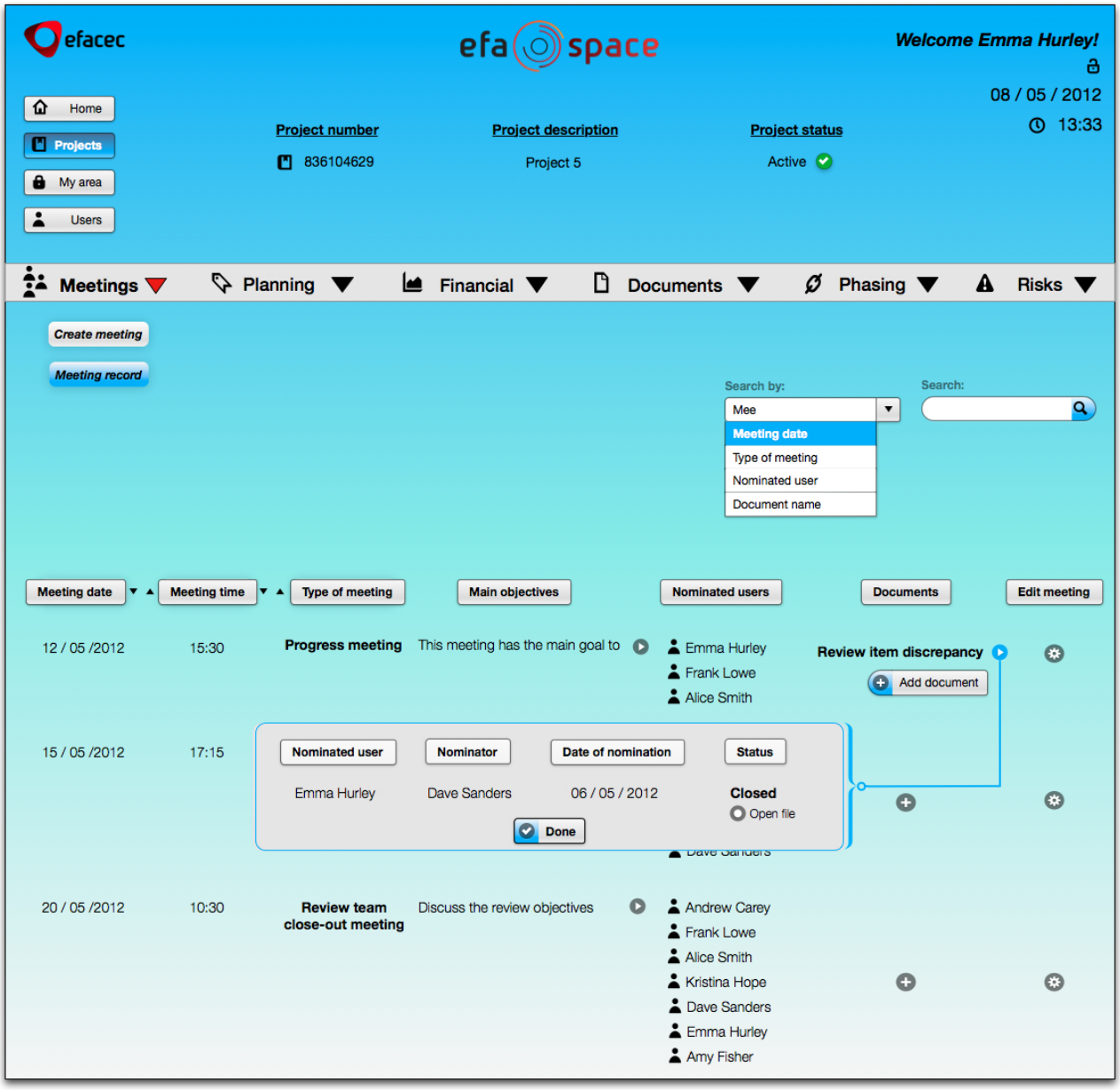


Figure 5.10: Meetings - meeting record

For better understanding of the document selection and users nomination process the diagram (figure 4) represents all of the necessary steps to be taken.

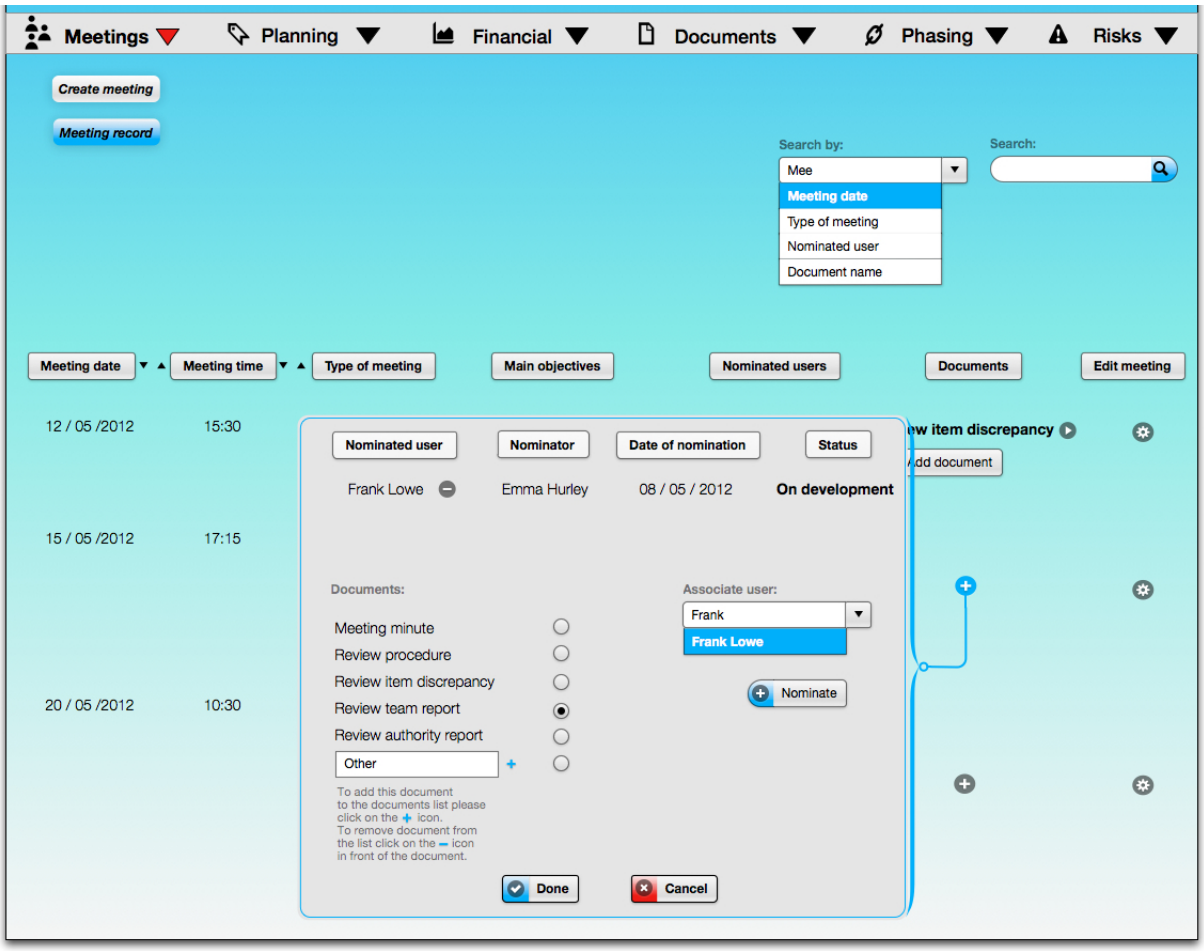


Figure 5.11: Meetings - document selection

Finally, on this screen, the user can also read the meeting's main objectives by clicking on the icon shown in the figure 5.12. All meeting's definitions can be changed by clicking on the edit meting icon which leads the user to the "Create meeting" screen.

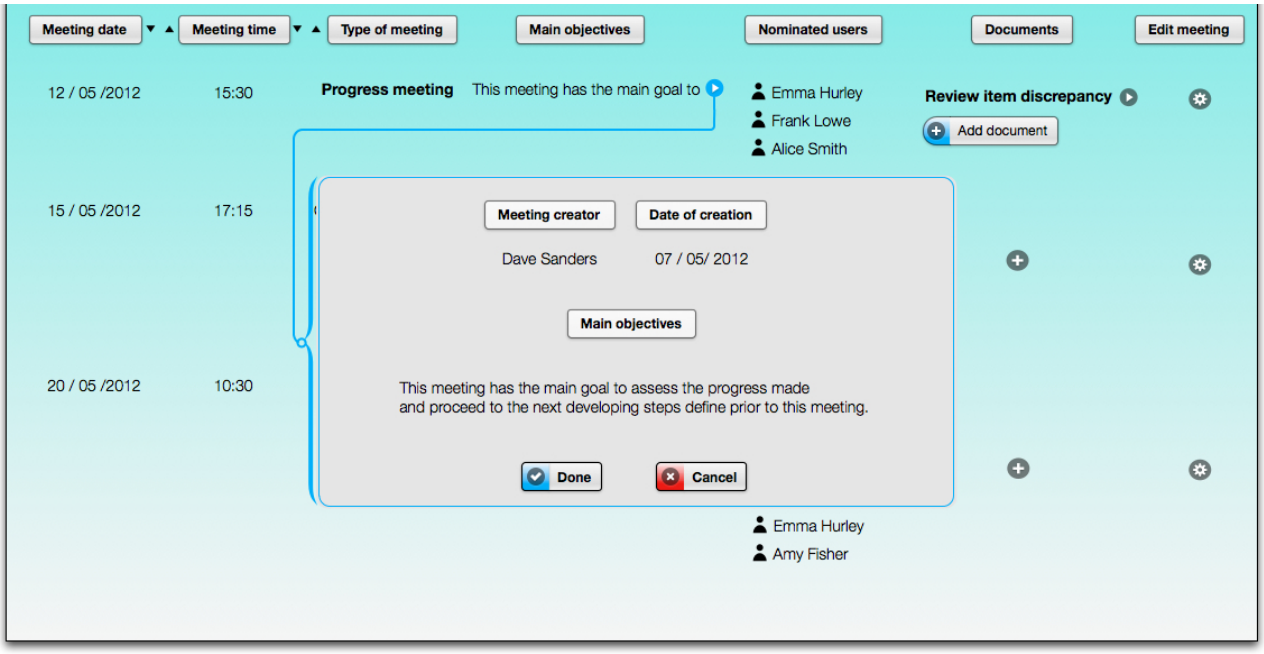


Figure 5.12: Meetings - main objectives preview

Moving to the "Planning" area of the project, here the user can access to the schedule submitted by the project manager. All activities have an associated description, initiation and finalization dates, duration, nominated users and reporting documents. To consult the requested documents or nominate users to execute any document, the user must click on the reporting icon in front of each activity. To nominate users to execute the activity's development the user must click on the users icon in front of each activity description. Once again, the user can create and view all notes associated to the "Planning" area. The figures 5.13 and 5.14 show the project's schedule with all of its activities and the activity execution nomination process. In relation to the reporting process,

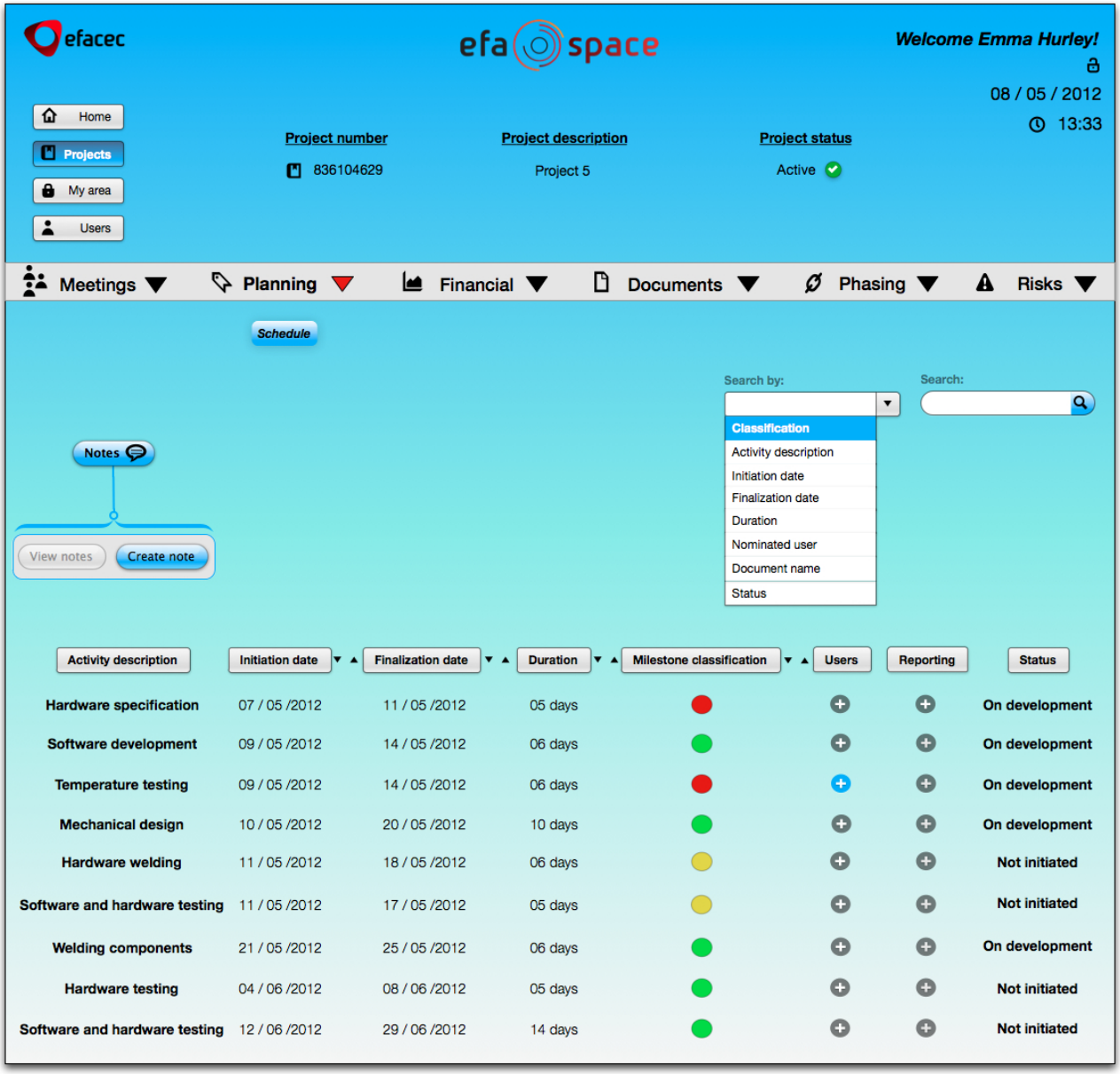


Figure 5.13: Planning- Schedule

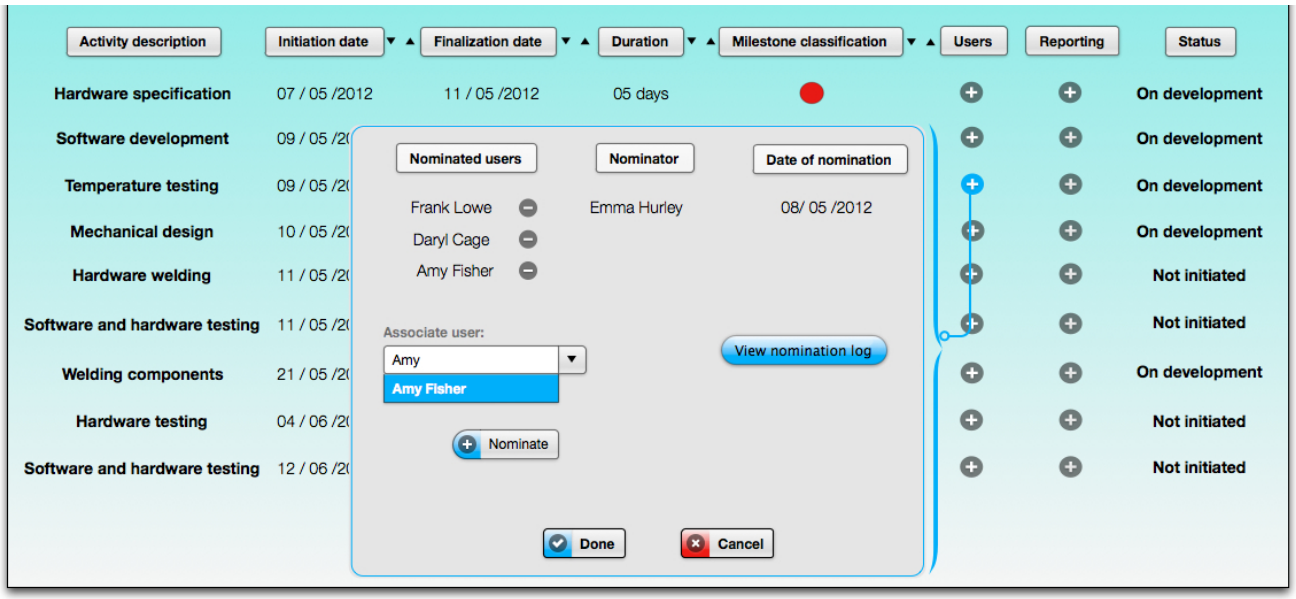


Figure 5.14: Planning - Users nomination

the figure 5.15 shows the selection of a document, the nomination of the users for its execution and the nomination log associated to that document so far, this one indicates the alteration of the nominated users.

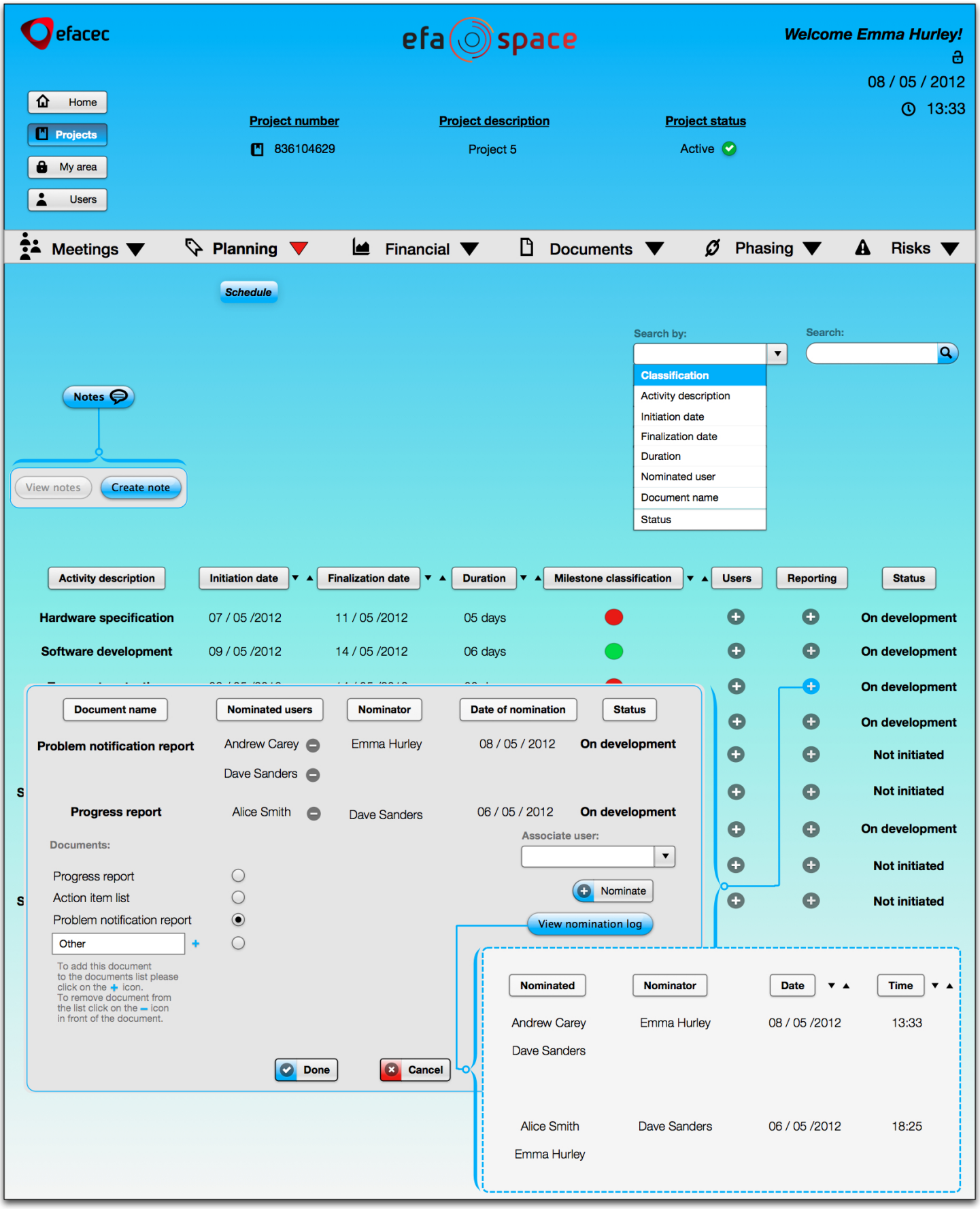


Figure 5.15: Planning - Reporting selection

In the "Financial" area, the user can find two buttons, the first gives access to the contracts and the second to the financial documents involved in the project. On the "Contracts" screen, the user can view and open the contracts uploaded into the system and also create new contracts and upload them as well. As said, due to the fact that almost all contracts are made previously to the Baan registration, all projects have contracts that are finalized, that is the reason why that the system will only upload and store them for consultation. The figures (5) and 5.16 show the screens present on this area.

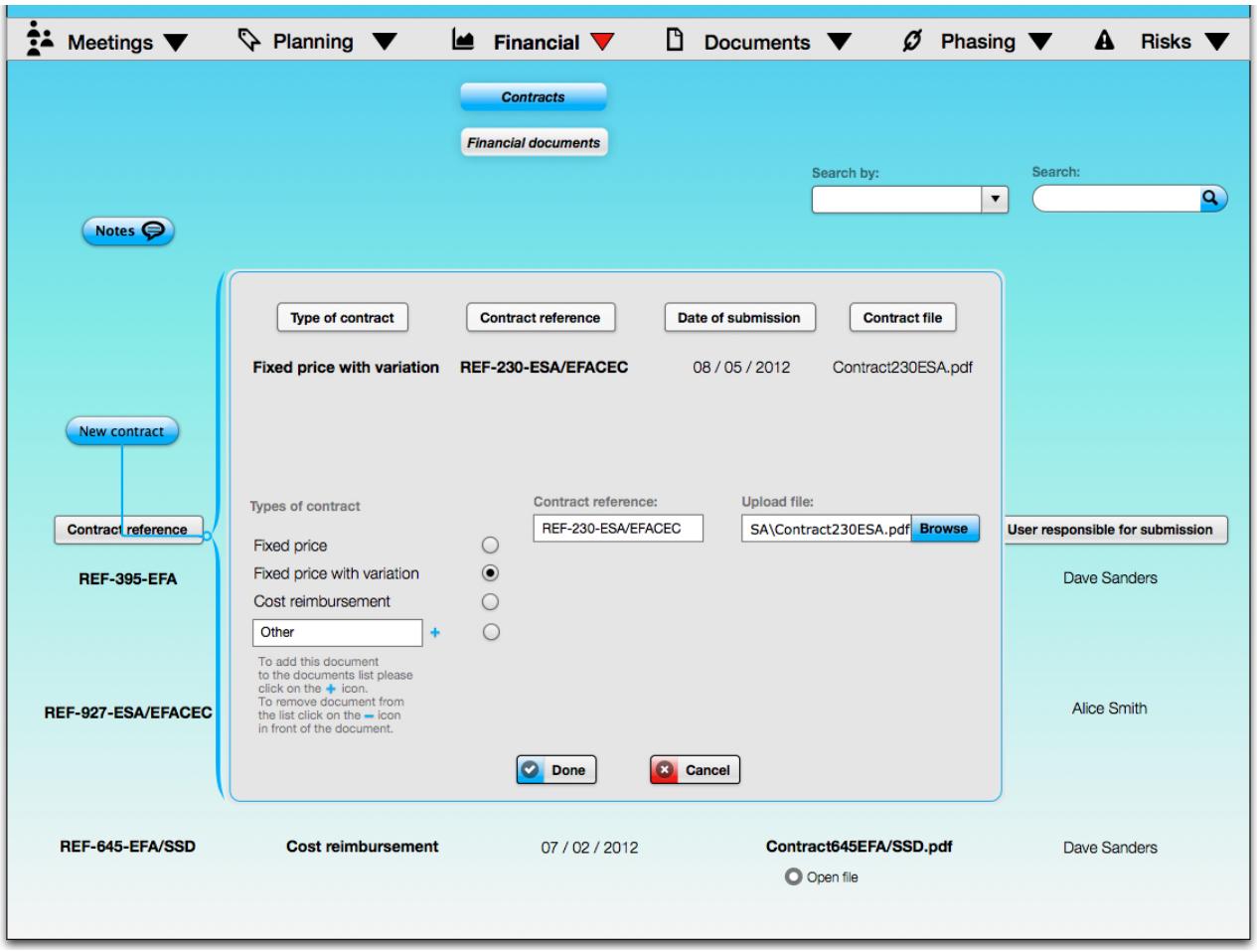


Figure 5.16: Financial - New contract

On the "Financial documents" screen, the user can view all of the financial documents selected for the project and also select a new document and nominate responsible users. All document selection areas in the system allow the user to add a different document to the available documents list, the user can always remove the document from the list by clicking on the minus icon that will be in front of the document. The figures 5.17 and 5.18 show the "Financial documents" screen and the new document selection process.

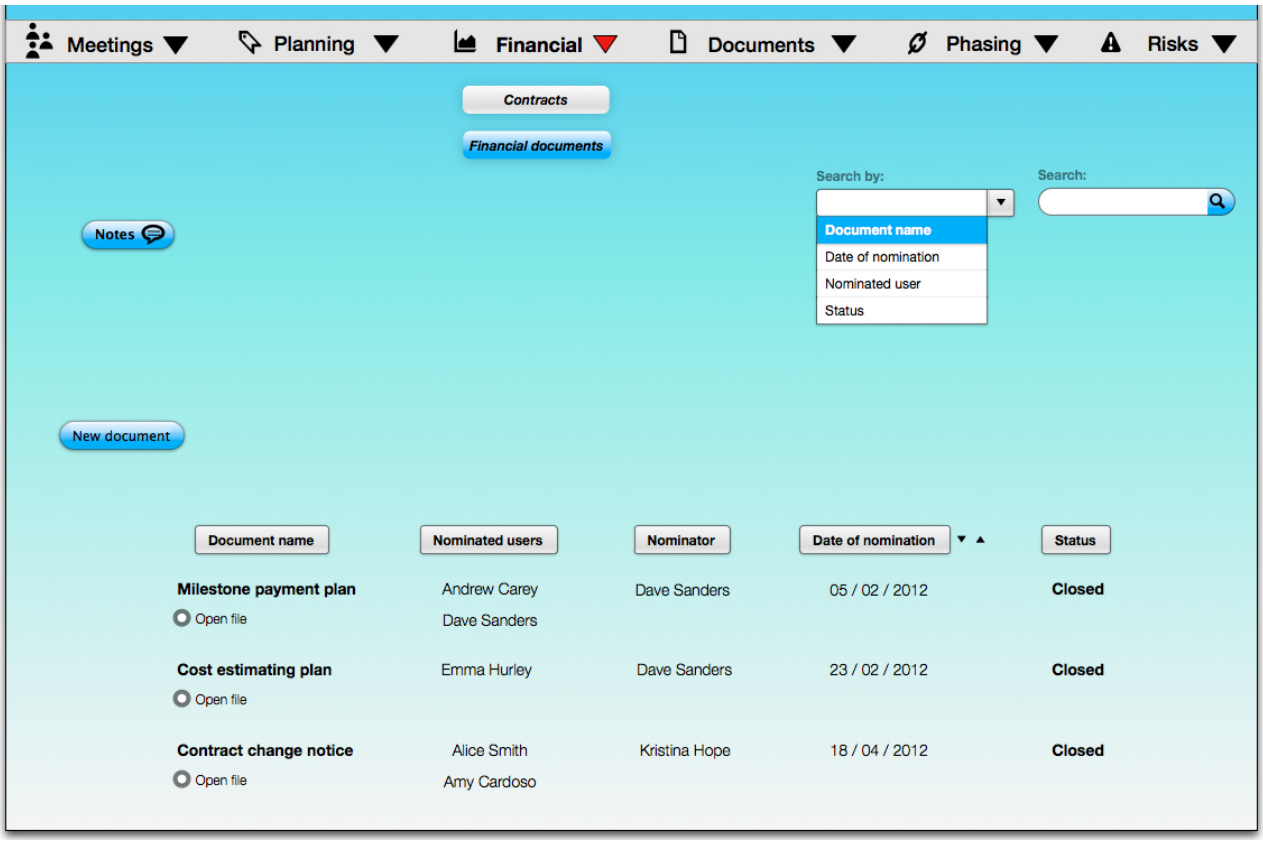


Figure 5.17: Financial - Financial documents

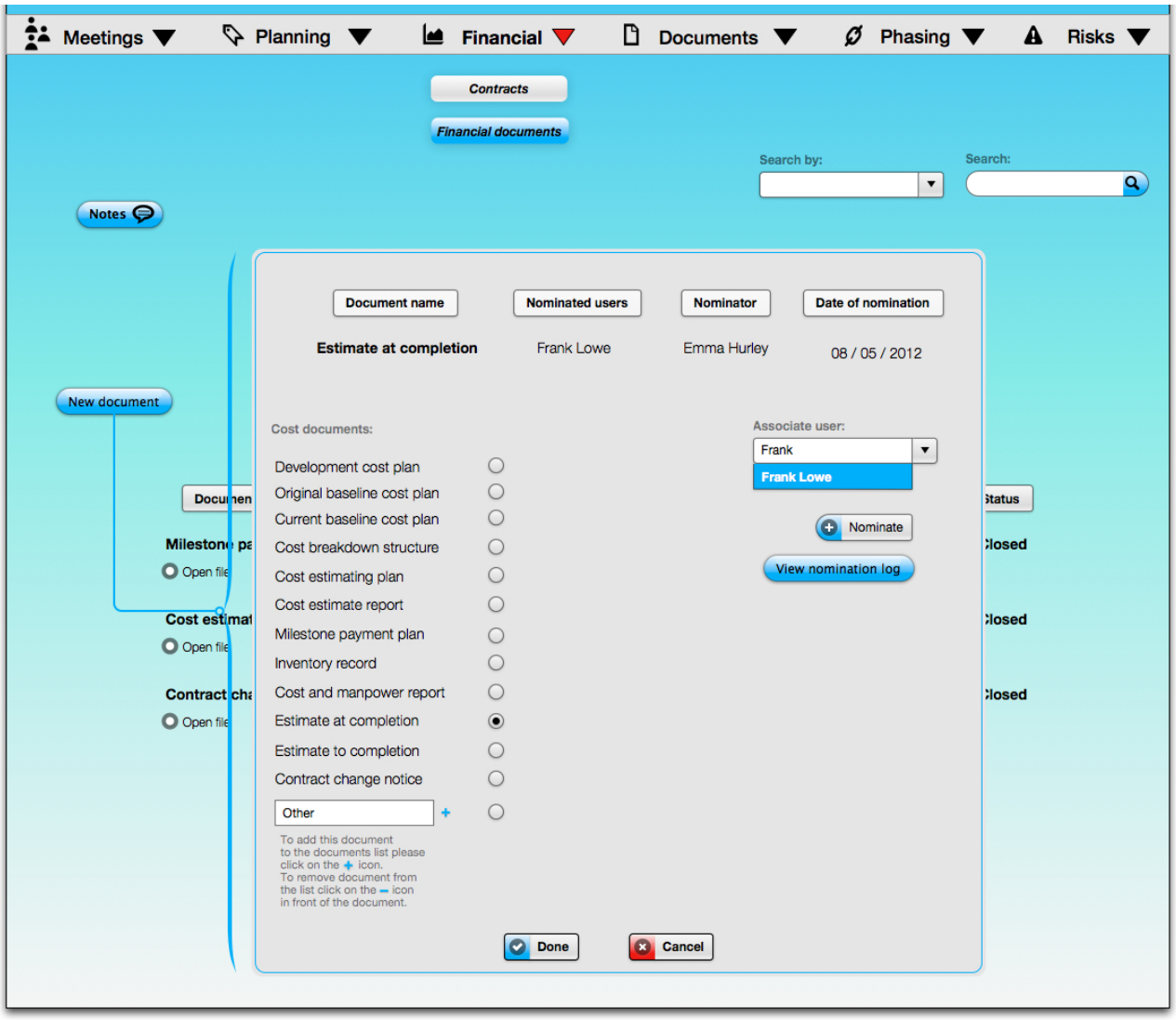


Figure 5.18: Financial - New document

The "Documents" area, as described before, gives access to all active documents within the selected project. Here the documents are divided into their respective areas and the user can access them by simply clicking on the areas buttons as shown in the figure 5.19. In this figure it's also showed the selection of a document within the general category.

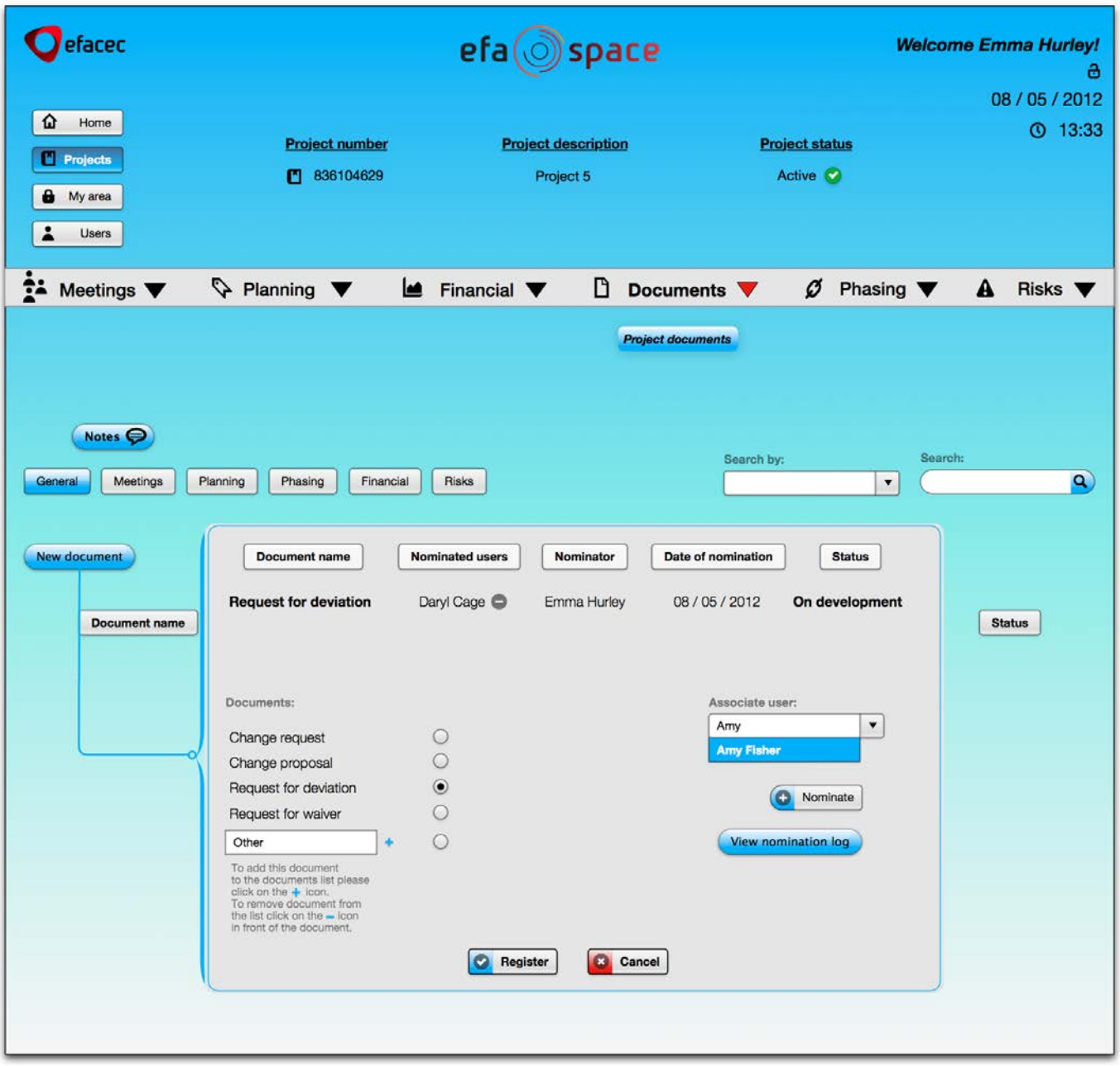


Figure 5.19: Documents - General

Documents associated to the "Meetings"/"Planning"/"Financial"/"Phasing"/ and "Risks" areas of the project can be all consulted in the "Documents" area. For each button in this area, the user can access to the information associated to each document, for example, on the "Meetings" button the user views all documents selected in the "Meetings" area and all related useful information such as the meeting's date, time, type, main objectives and nominated users (figure 6).

The same occurs to the documents associated to the "Planning" area (figure 7), here the user can view the associated activity description, initiation and finalization dates, duration, milestone classification, nominated users and current status. On the "Phasing" button, the user views the documents associated to the project selected reviews, these documents have always an associated phase on which the user can choose to view the major tasks defined by the ECSS standards by clicking on the icon as shown in the figure 8. In case of the existence of a uploaded file, the icon below it allows the user to open the file. For the "Financial" area documents, there are two options, the visualization of the contracts or the financial documents as shown on the figures 9 and 10. Finally for the "Risks" documents, the user can, besides viewing all documents, see also the information related to the risk associated to each document, meaning the risk ID, description, type, proposed actions, nominated users and the type of action to be taken (11).

Moving to the "Phasing" area on the project, there the user can find all of ECSS defined phases for a project. The figures 5.20,12,13, 14, 15,16, and 17 show all major tasks and involved actors that the user can consult by clicking on the icon in front of each phase.

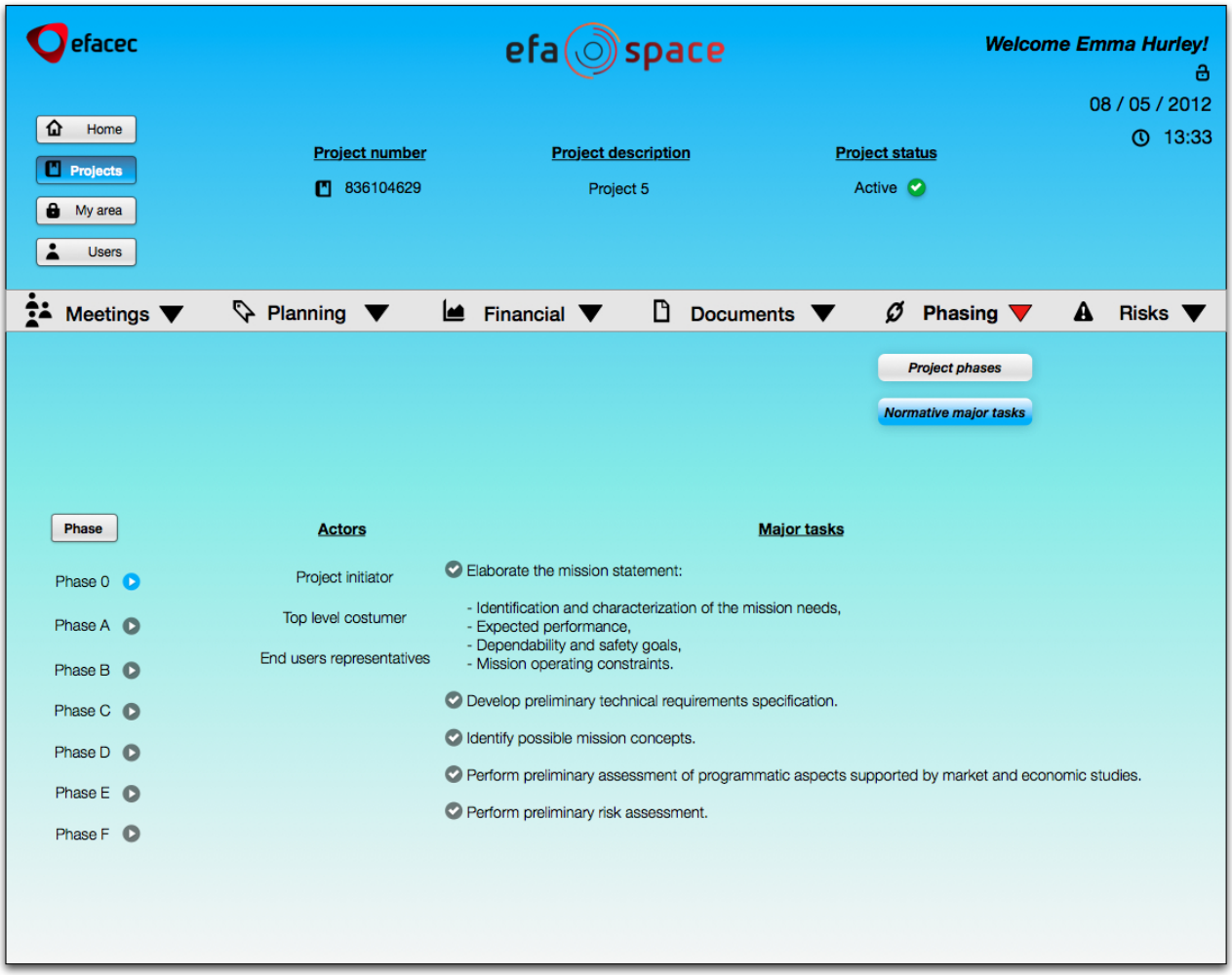


Figure 5.20: Phasing - Phase 0

Each phase has associated reviews and each review associated documents. This area allows the user to consult the major tasks of each phase defined by the standards("Normative major tasks" button) and also select the phases and respective reviews to be performed in the project ("Project phases" button). All of the defined documents for each review are available for selection.

On each review, the ECSS standards define a selection of documents to be presented and assessed, therefore the EFASpace platform gives the user the opportunity to choose from this list of documents on each review the ones to be executed. On each phase (from 0 to F) the user must choose the respective review/s to be performed and then select the documents to be associated on each review. For phase 0 the figure 5.21 presents a review previously selected and a document already submitted into the system. The figure 5.22 shows the list of documents available on the selected review.

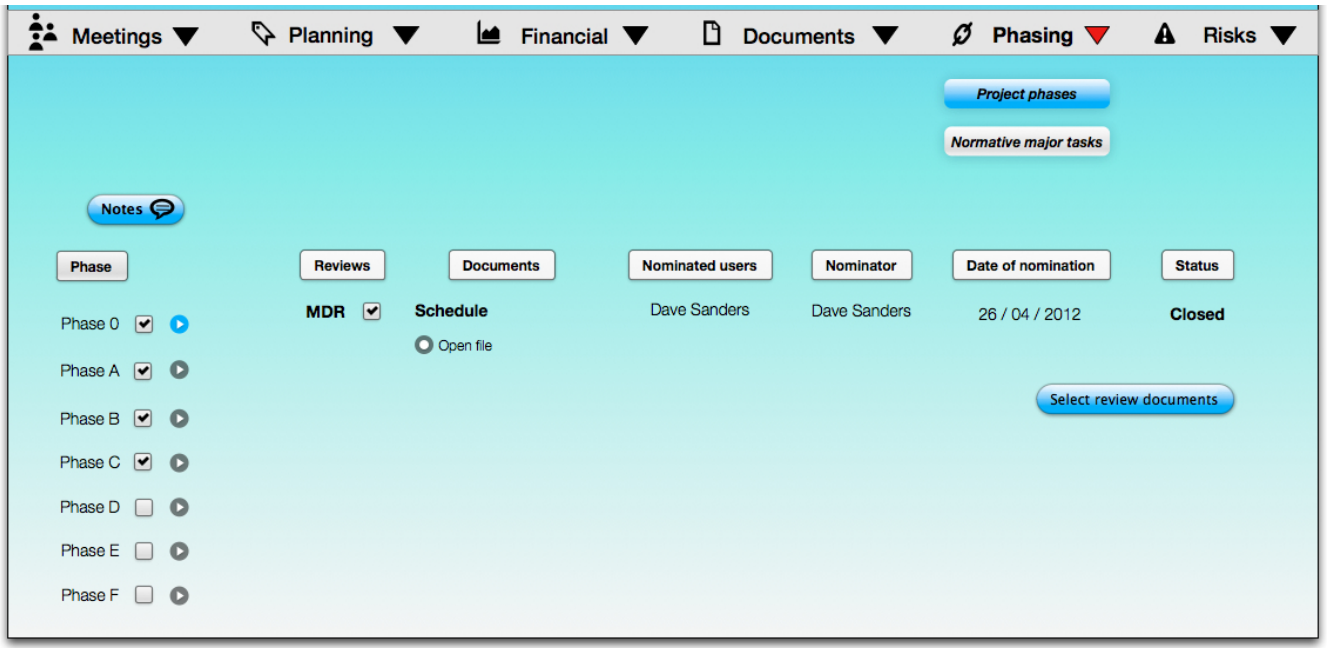


Figure 5.21: Phasing 0 - Selected review

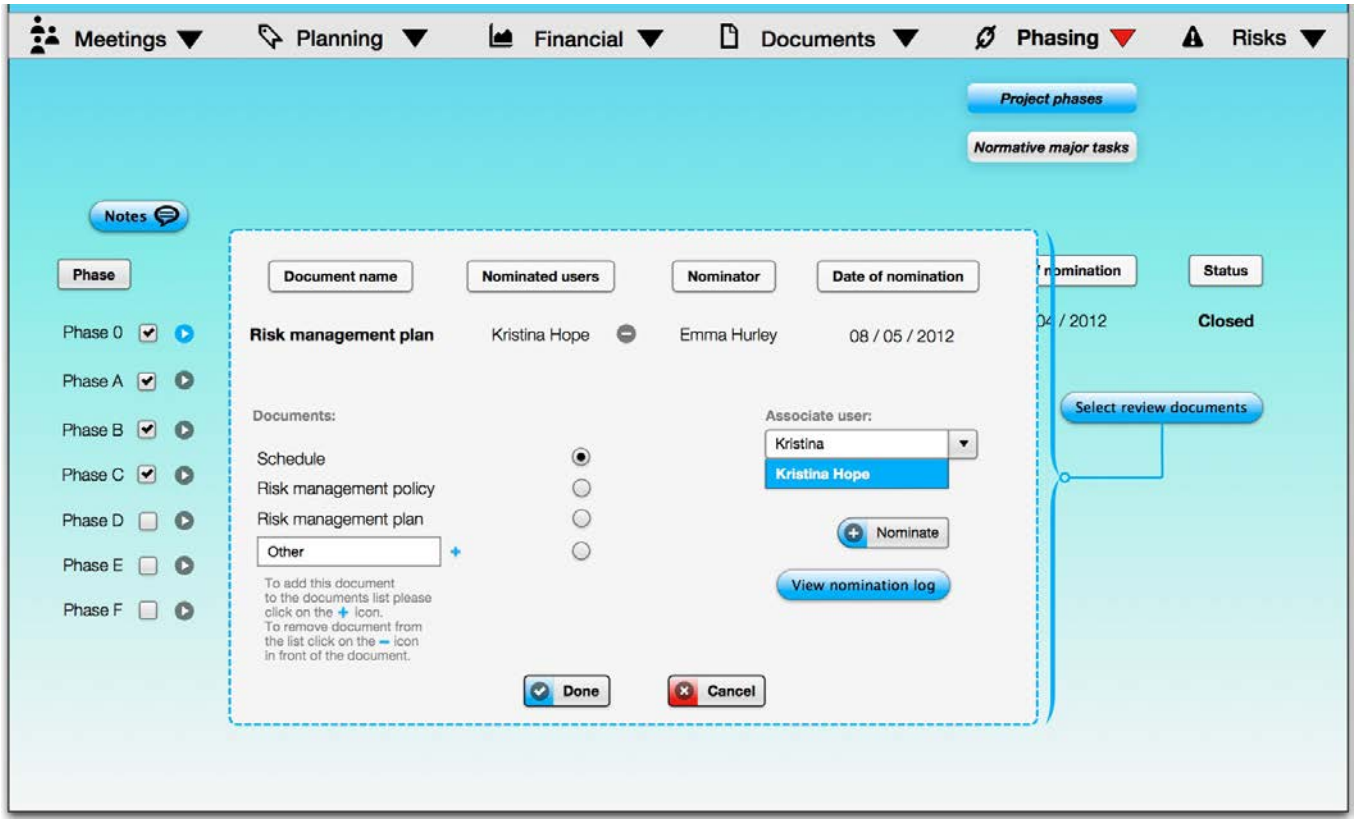


Figure 5.22: Phase 0 - Document selection

For the phase A and all of the remaining others, the process is the same described for the phase 0, the figures 5.23 and 5.24 present the only review associated to phase A and the respective document selection. Notice that on this case there weren't any previously documents selected.

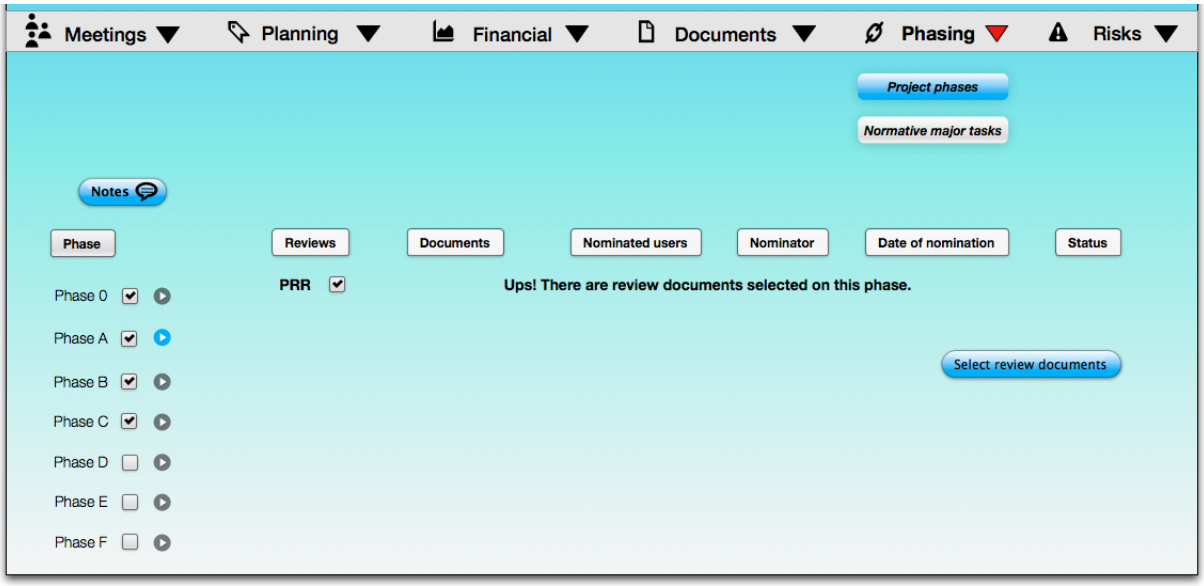


Figure 5.23: Phase A - Selected review

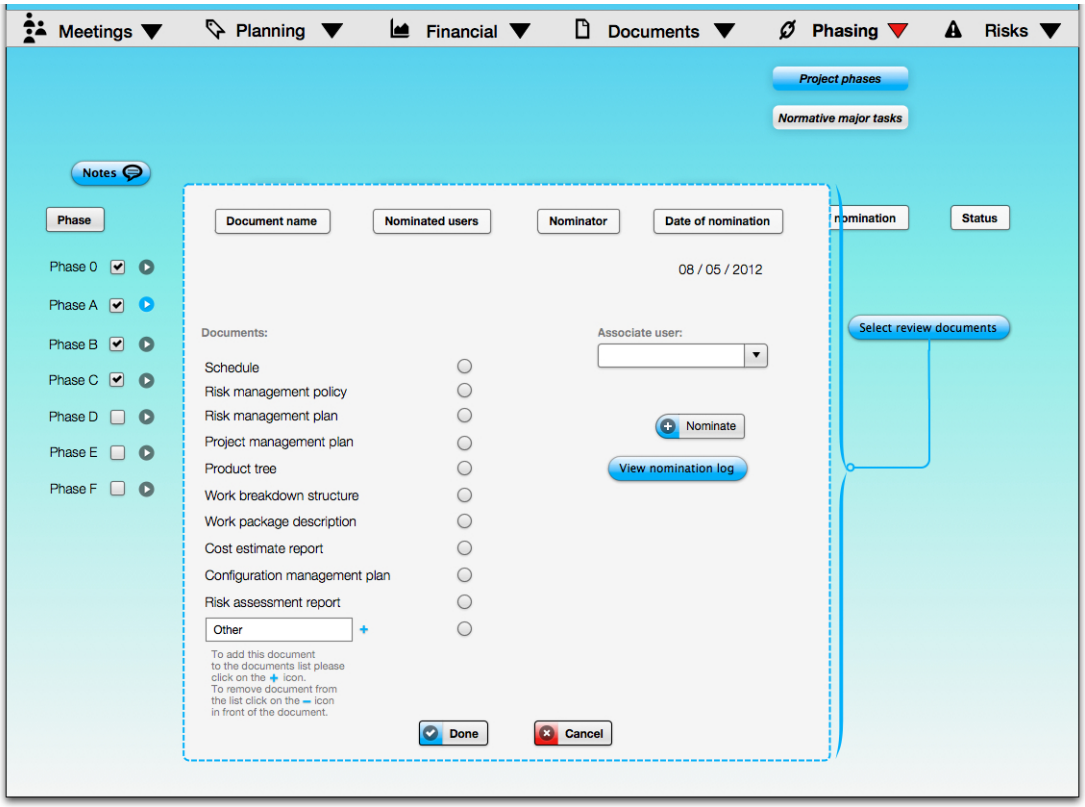


Figure 5.24: Phase A - Document selection

In phase B there are two reviews selected, as shown in the figure 5.25, two uploaded documents and one selected and associated to an user. The figure 5.26 shows the list of documents available on the PDR review.

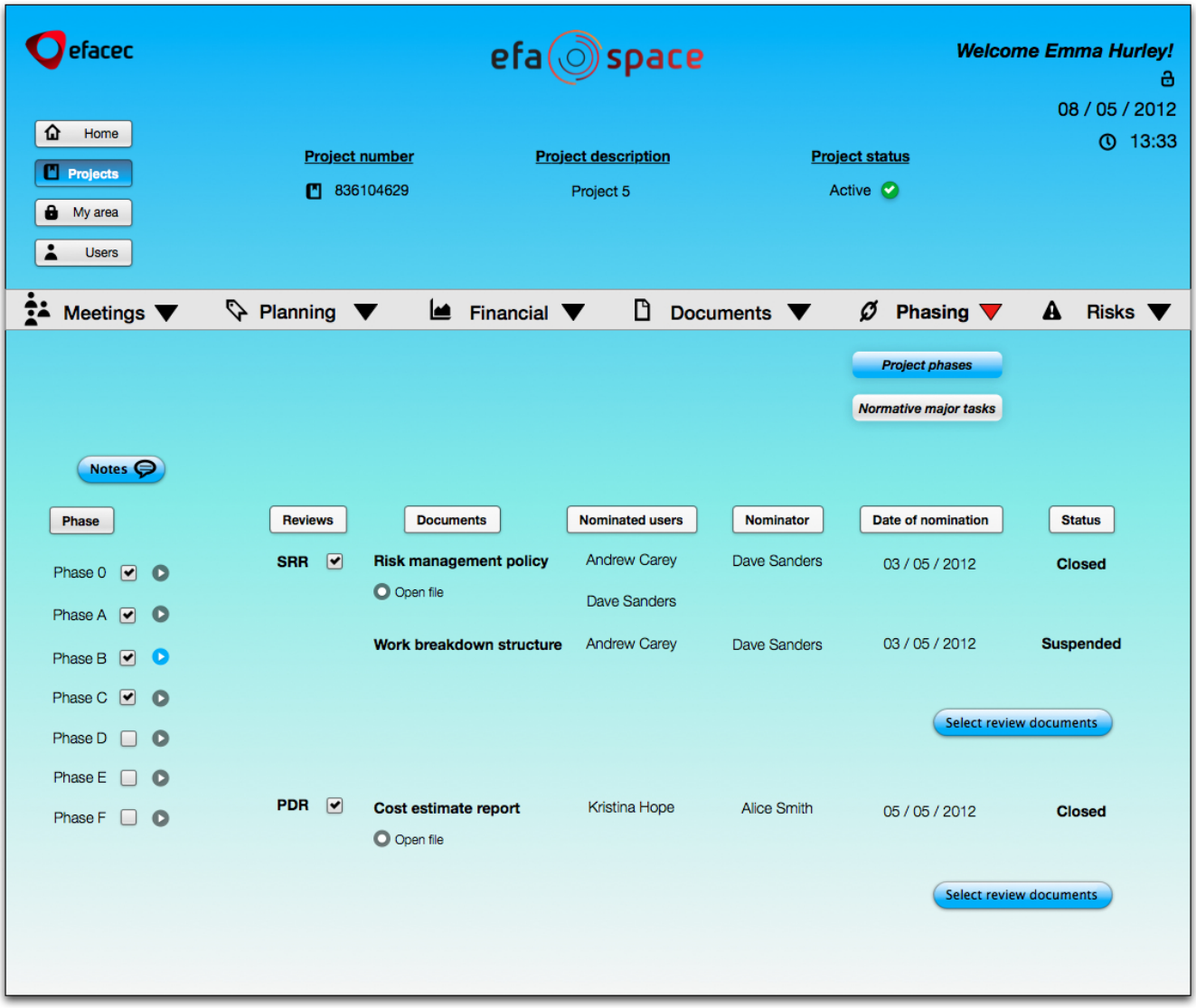


Figure 5.25: Phase B - Selected reviews

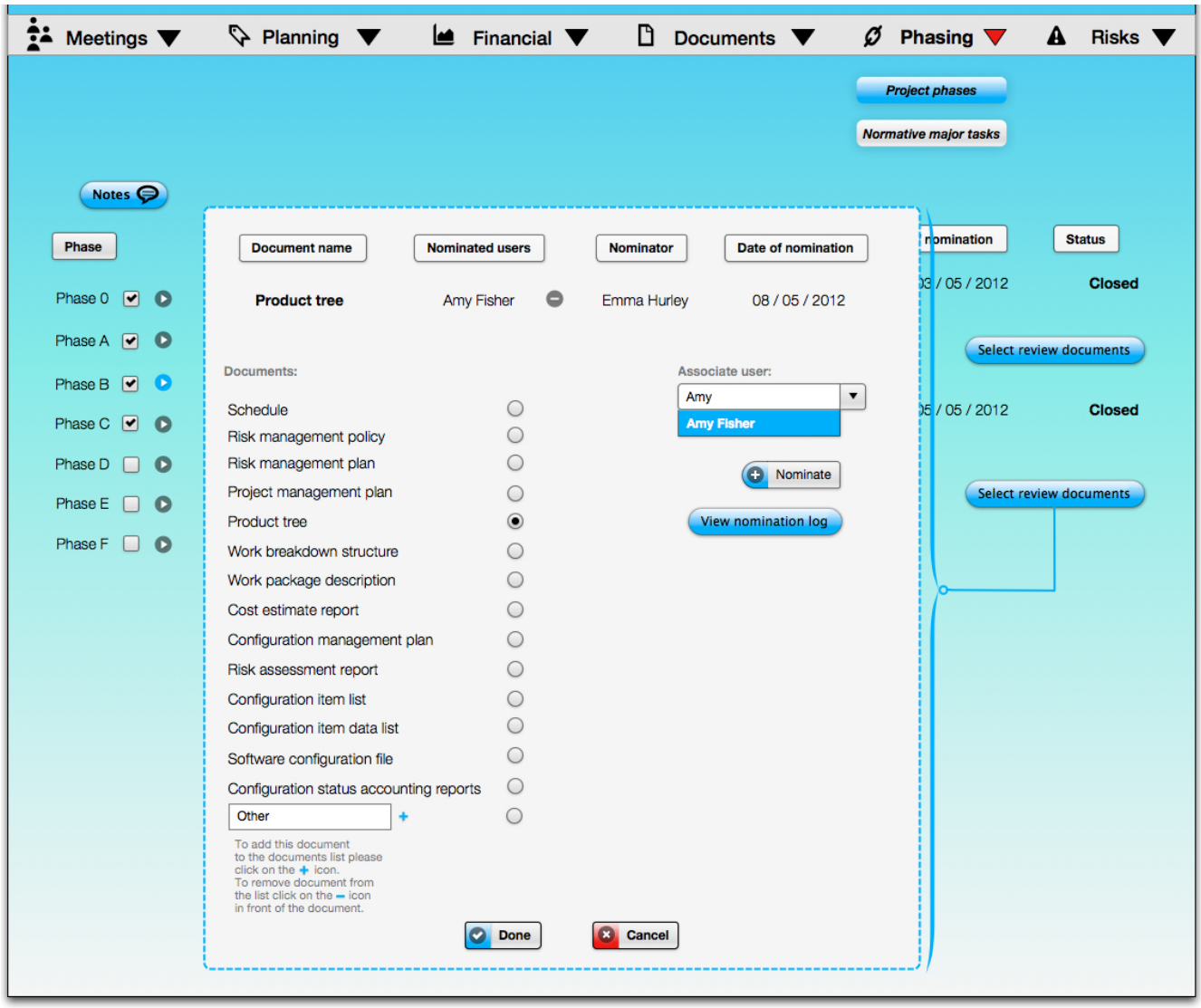


Figure 5.26: Phase B - Document selection

For phase C the figure 5.27 shows that it has been selected the only review associated to this phase but no document was associated to the review. The list of documents available for selection on this review are presented in the screen of the figure 5.28.

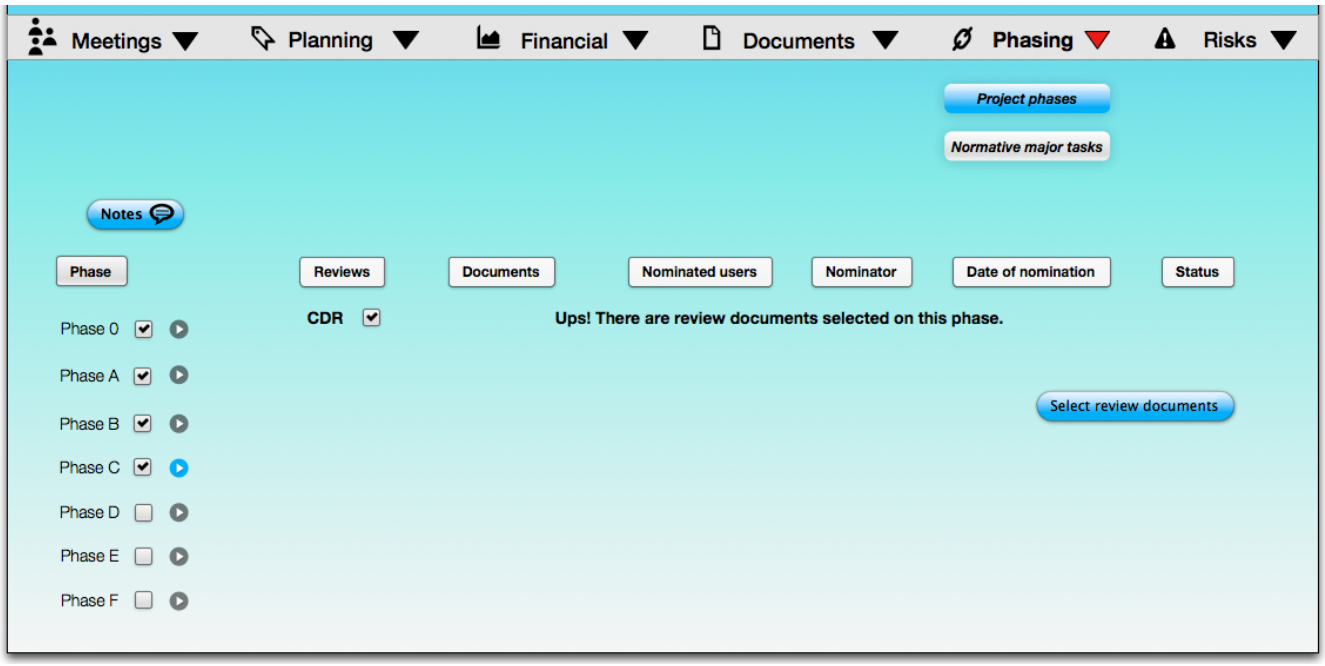


Figure 5.27: Phase C - Selected review

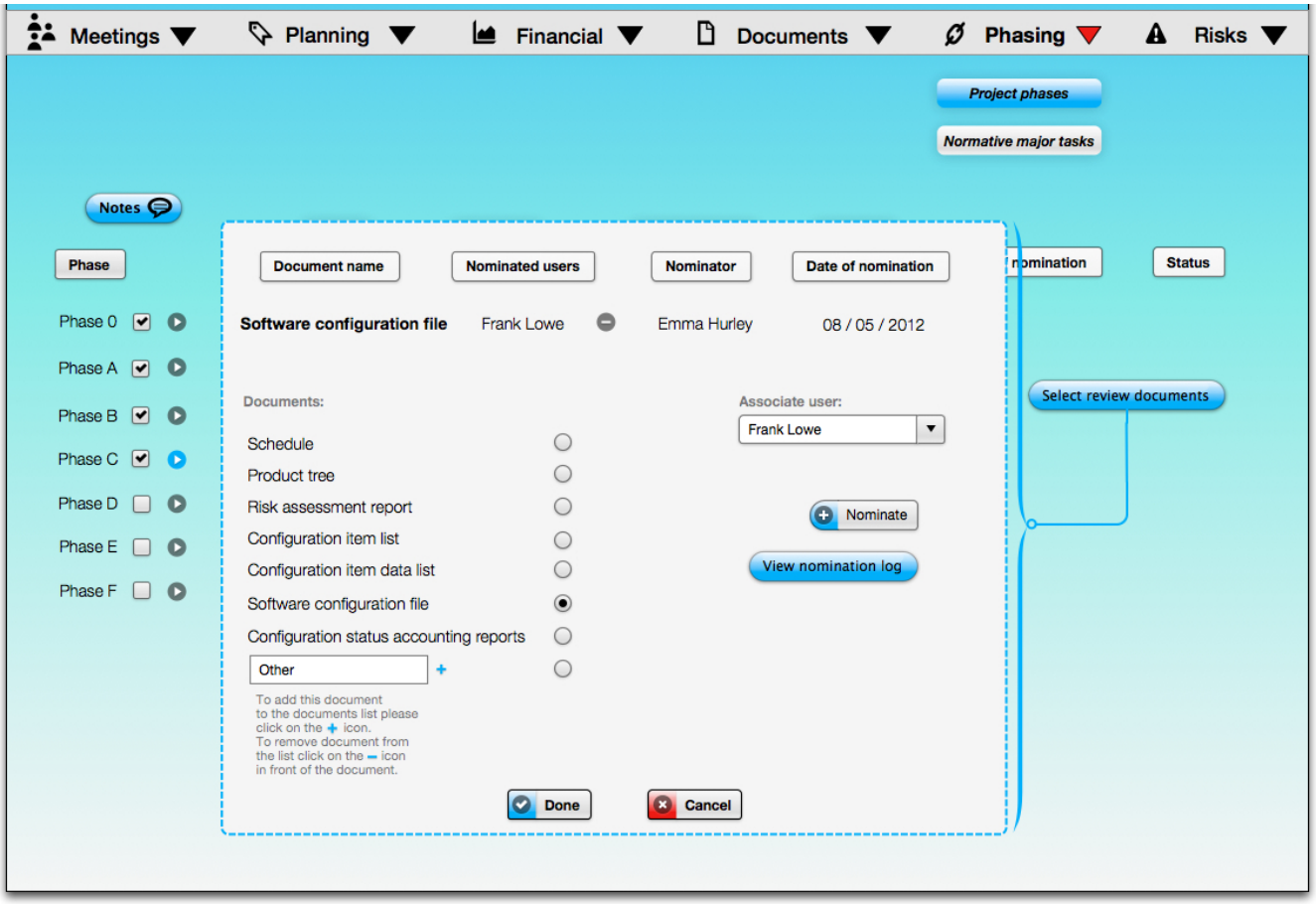


Figure 5.28: Phase C - Document selection

For phase D, the figure 5.29 shows that it has been selected one of the two available reviews, as well as a document to be executed by the nominated users, the figure 5.30 also shows the document selection from the documents list defined for this review.

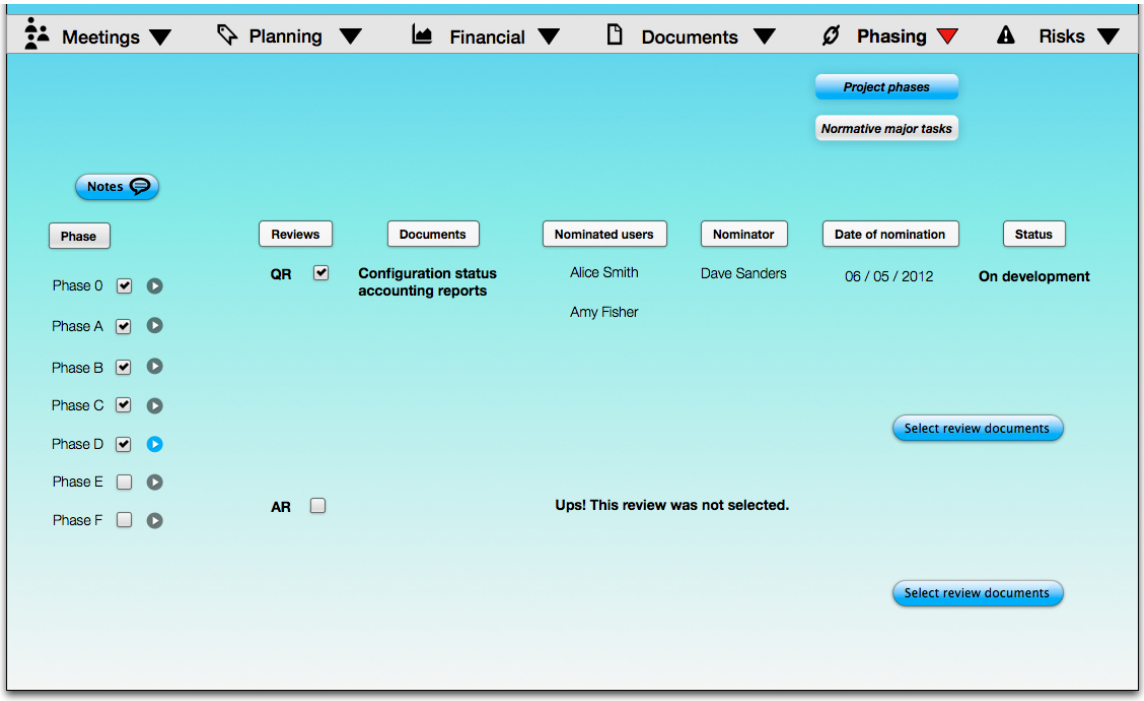


Figure 5.29: Phase D - Selected review

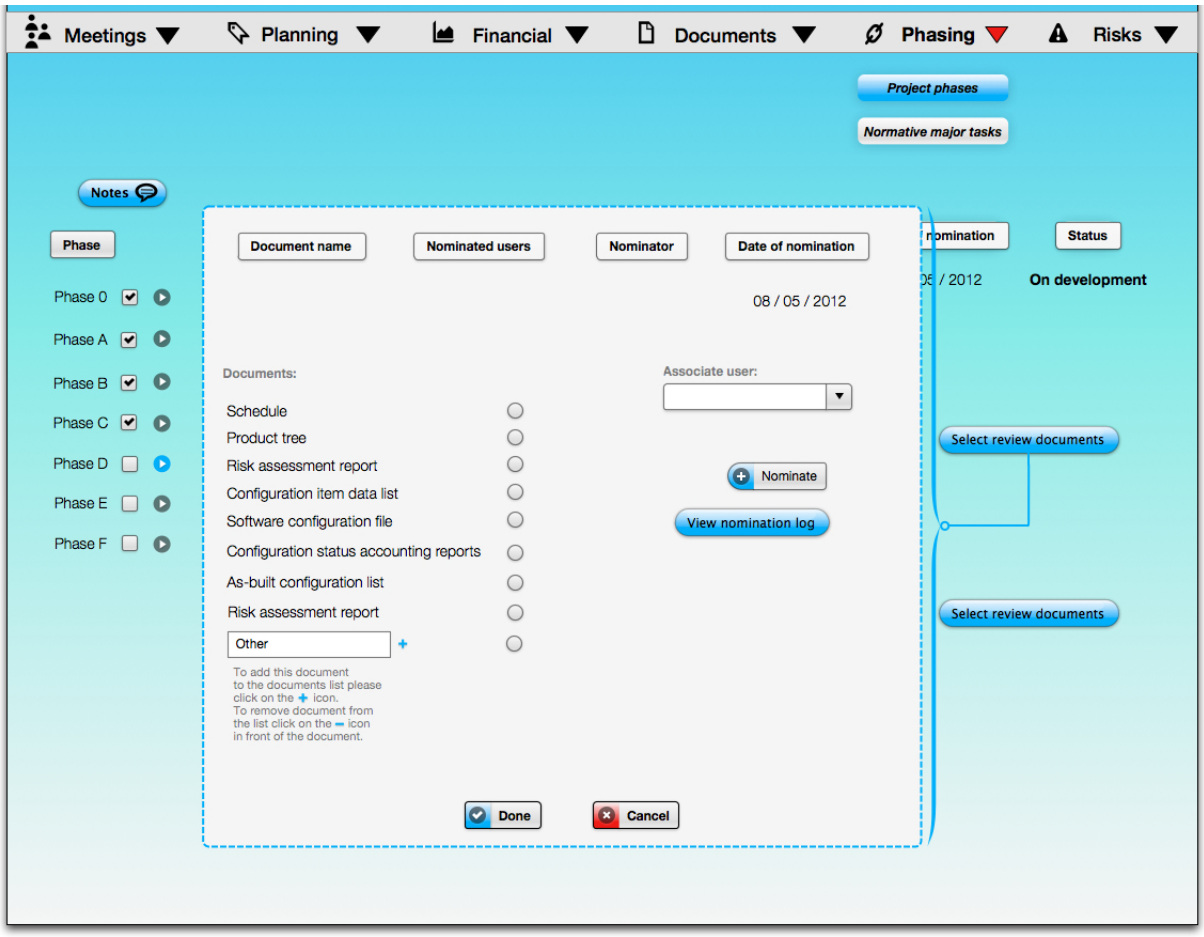


Figure 5.30: Phase D - Document selection

Following the same process as the other phases, the figures 5.31, 5.32 show all of the available reviews on phase E and the available documents. Note that, on this phase, there are six reviews but only the two first ones have documentation defined by the standards this occurs because these reviews are performed during the operation of the space on-orbit mission not having documentation involved.

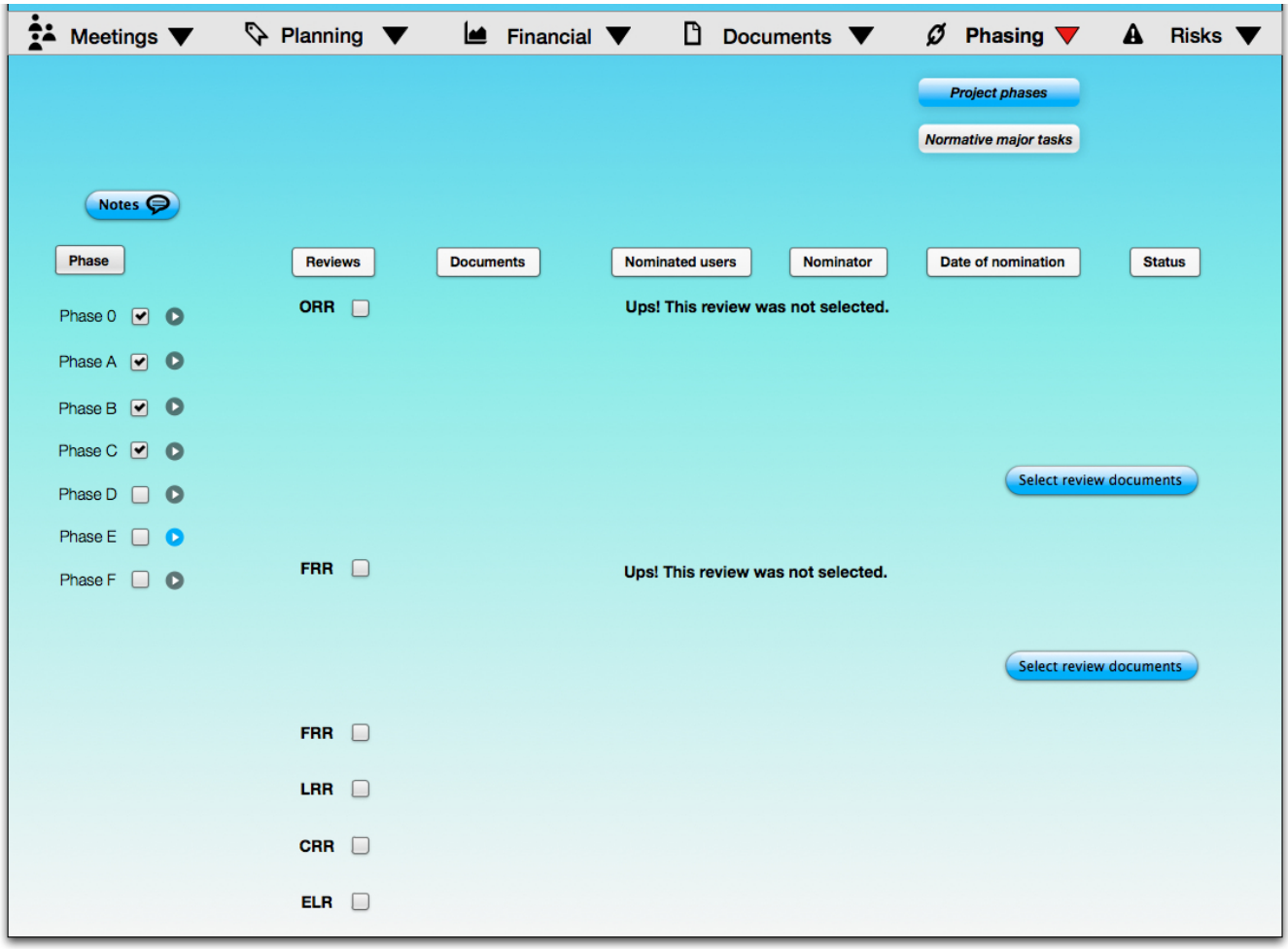


Figure 5.31: Phase E - Reviews

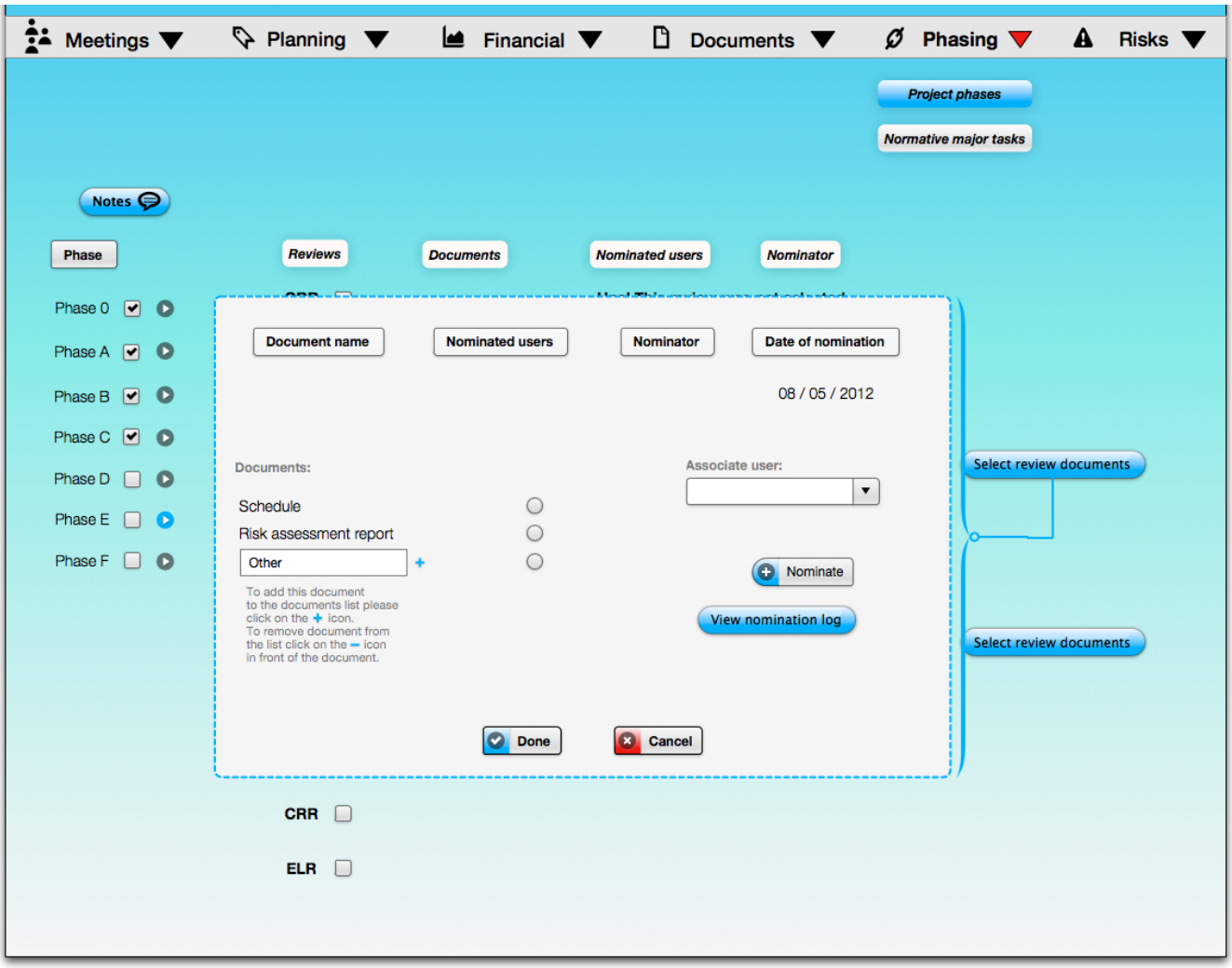


Figure 5.32: Phase E - Document selection

At last for the phase F there aren't any documents associated to the the only review defined by the standards for this phase. The figure 5.33 shows the screen presented for this review.

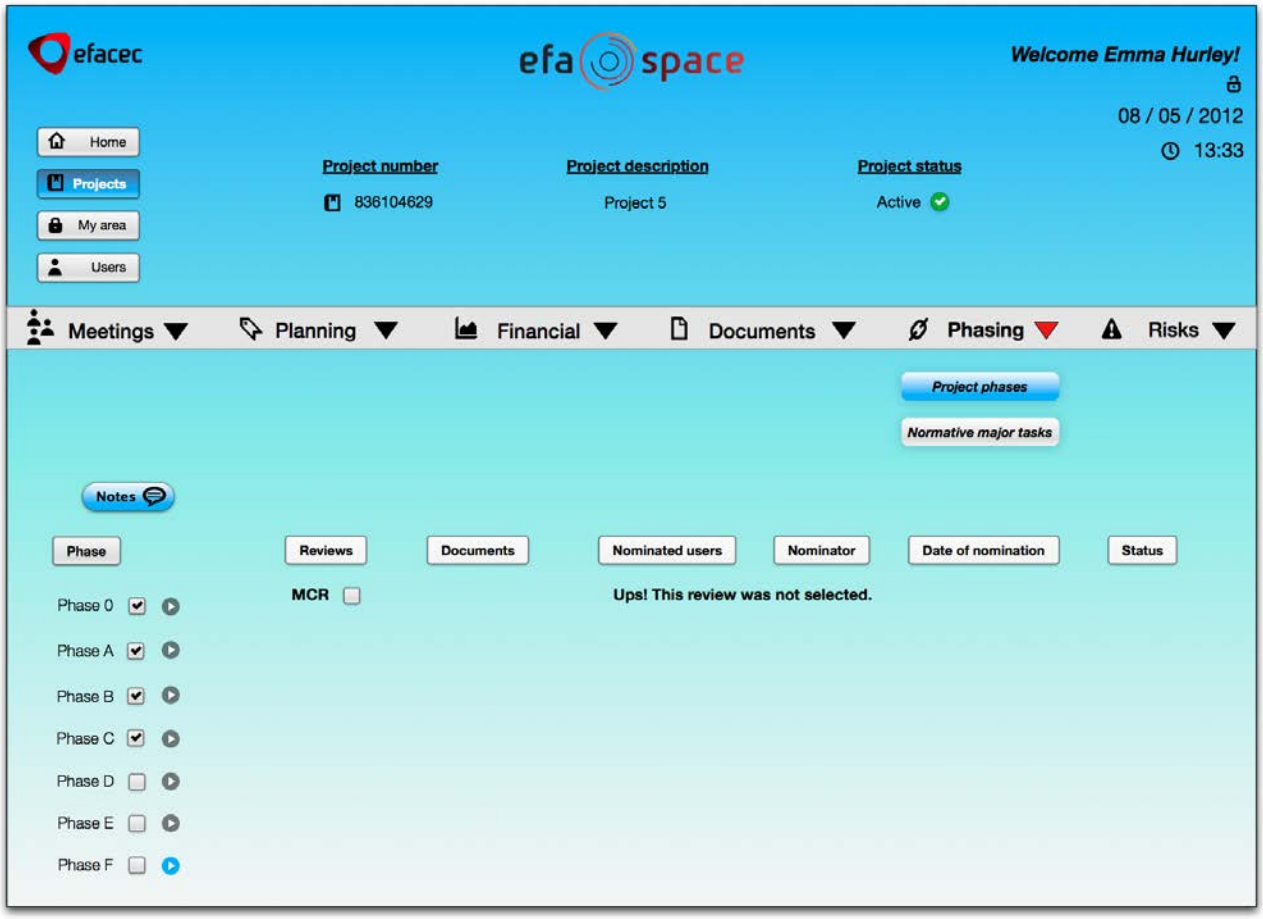


Figure 5.33: Phase F - Reviews

Moving now to the the "Risks" tab on the menu bar, this tab allows the user to register any detected risk during the development of the project's work, to monitor all registered risks and finally to associate documents to registered risks or to simply request the execution of documents related to the risk management process defined in the ECSS standards.

For the risk registration process, the user must describe the risk on the description field, and select the risk likelihood and severity according to the score defined by the ECSS standards. After these steps the user must click on the "Generate risk index" button so the system generates the risk index, defined by the standards, magnitude, type and normative proposed actions. The last steps are to choose the type of action (reduction or acceptance) to be implemented on the risk and to describe the actions to be taken. For these actions the user can nominate other users to be responsible for the execution by clicking on the "Associate users" button.
Note that for every new risk registered, the system gives automatically a risk ID. To conclude this registration process the user must click on the "Register" button. The figures 5.34 and 5.35 show the risk registration screen and the association of users to the defined actions to be taken.



Figure 5.34: Risk registration

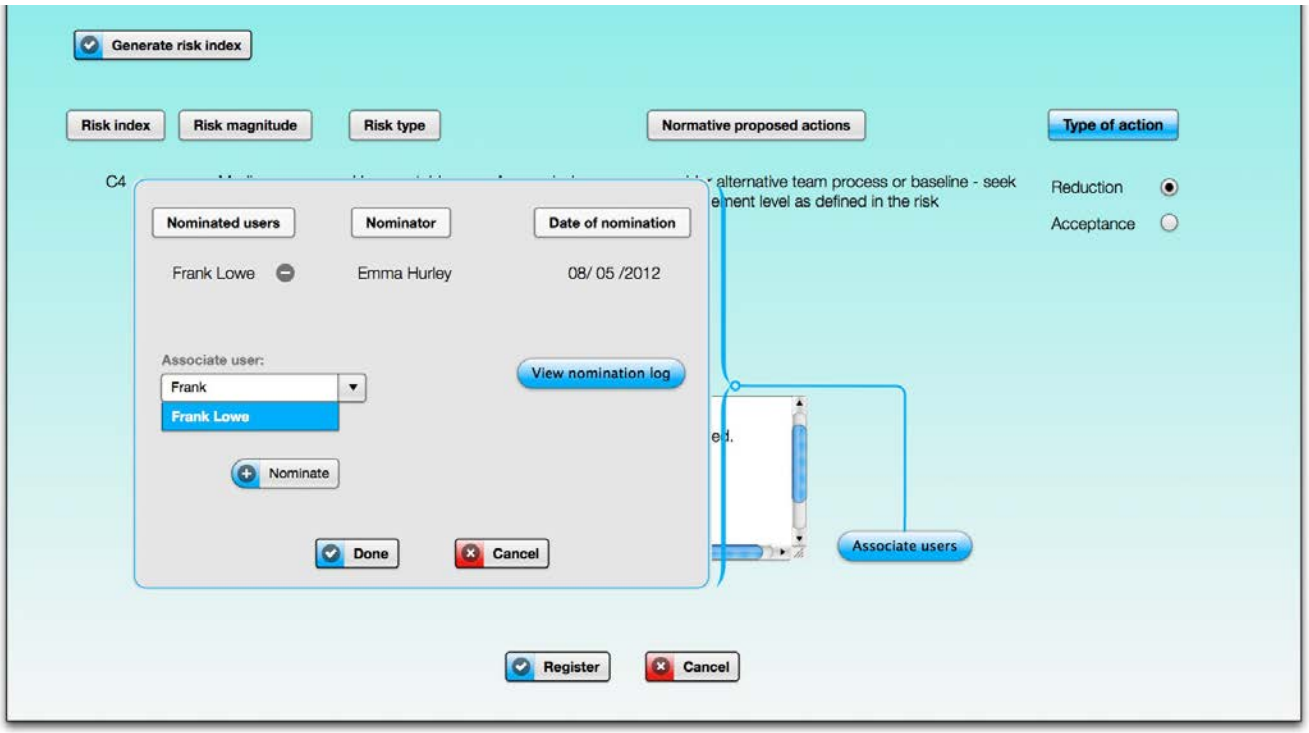


Figure 5.35: Risk registration - Associate user

On the "Risk monitoring" area, the user can find all registered risks and its useful informations, such as, the risk ID, description, type, proposed actions, nominated users, type of action and the assessment status. The user can also edit any risk on the system by clicking on the edit risk icon in front of each risk. In the figures 5.36 and 5.37 it is possible to see the risk monitoring board and the proposed actions pop-up screen. Note that, in case of the type of action being acceptance, the proposed actions field is named risk acceptance justification instead of risk reduction actions.



Figure 5.36: Risk monitoring

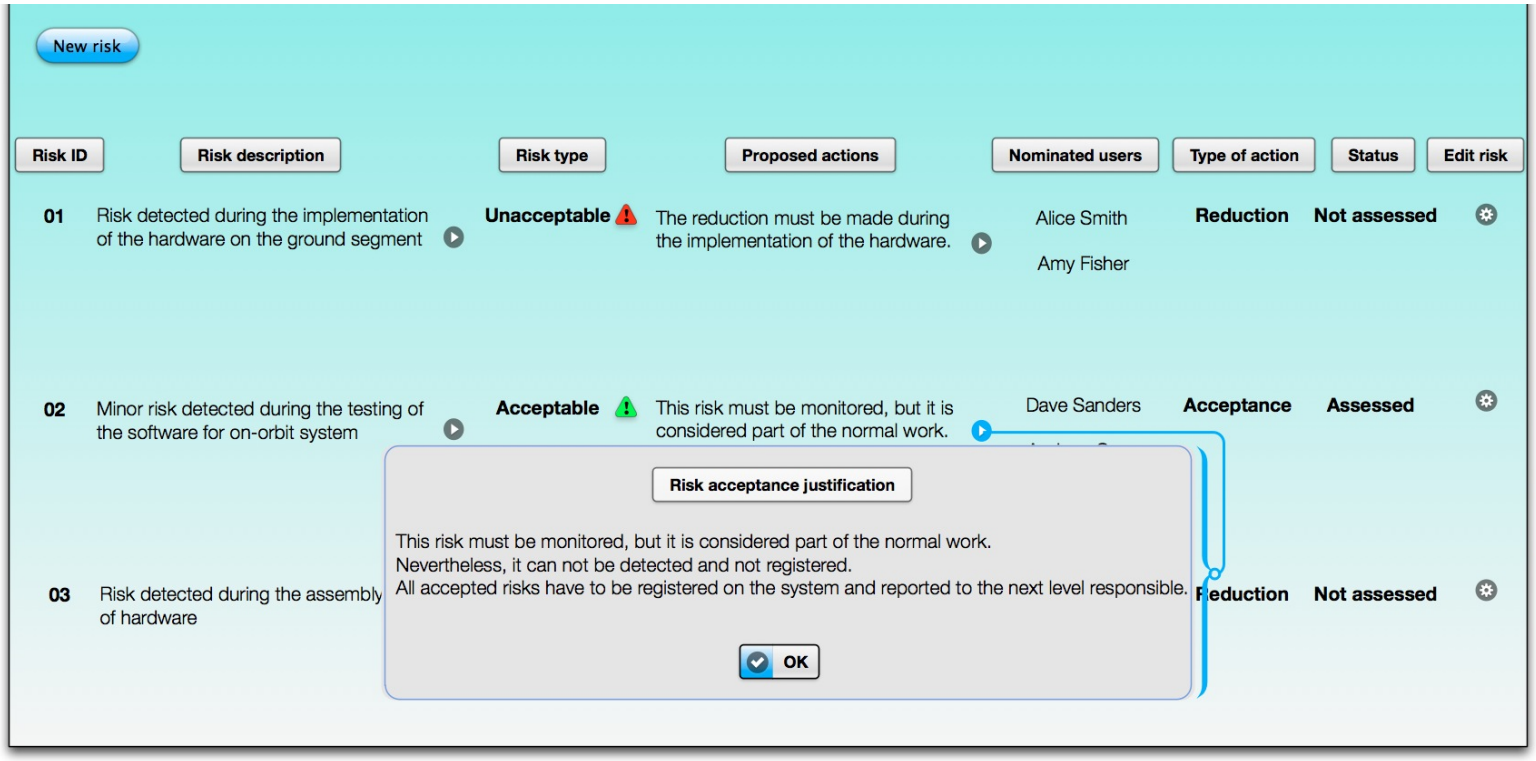


Figure 5.37: Risk monitoring - Proposed actions preview

At last, the "Risk documents" button allows the access to all documents related to the risk management activities or registration process. All selected documents are visible to all users on the risk documents main area, here the user can view all documents and nominated users as well as open the ones which have been already uploaded.

The figure 5.38 shows the "Risk documents" main screen where the user can also search for documents by name, associated risk ID, development status, nominated users or date of nomination. On this screen, the user can edit the document selection/nominated users and associated risk by clicking on the icon in front of the document name. However, these changes can not be performed on documents which status have been changed to closed and the document file has been uploaded as well. Note that, the user can always access the risk monitoring area by clicking on the icon in front of each associated risk ID.

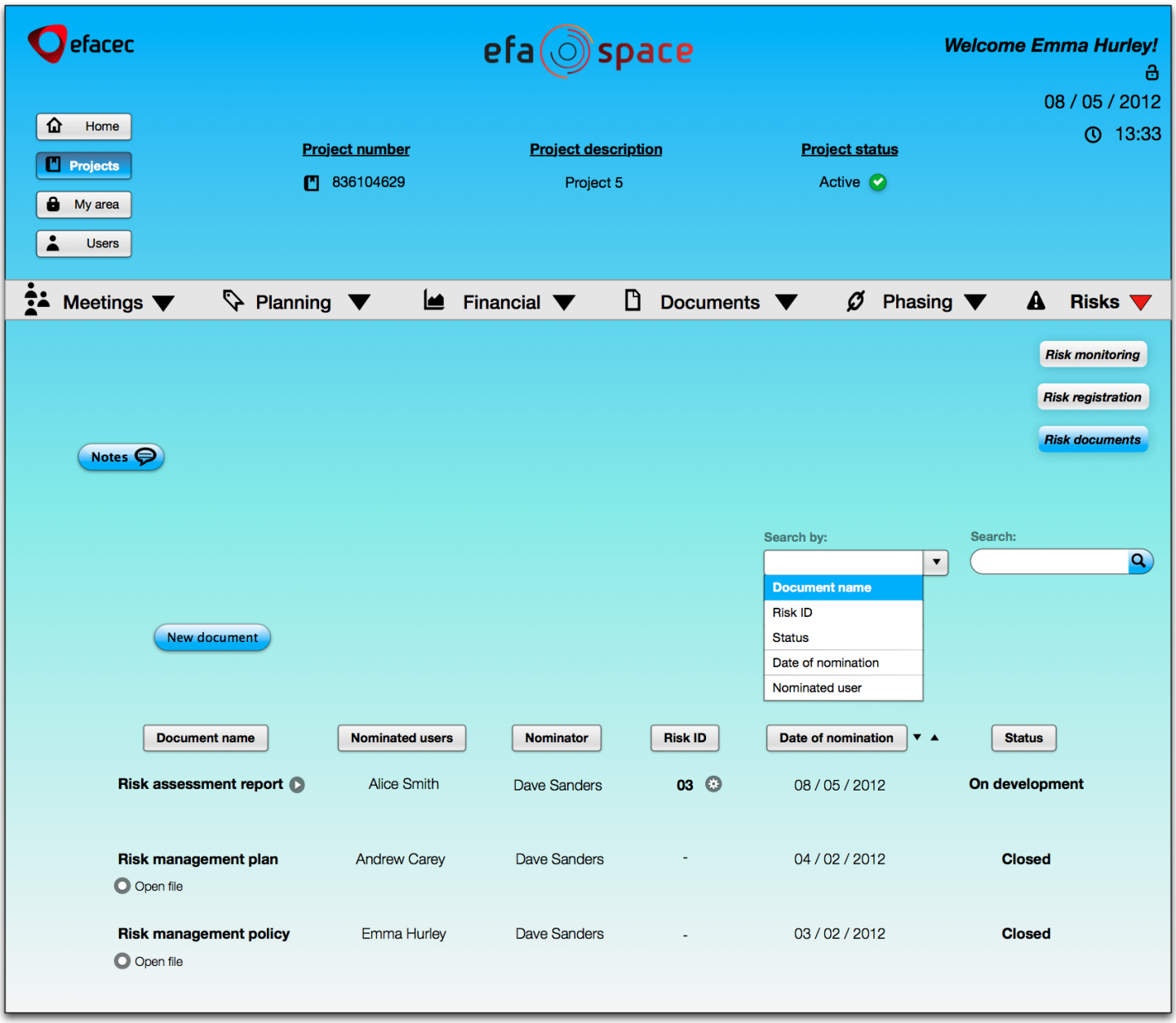


Figure 5.38: Risk documents

The figure 5.39 shows the screen for the document selection process.

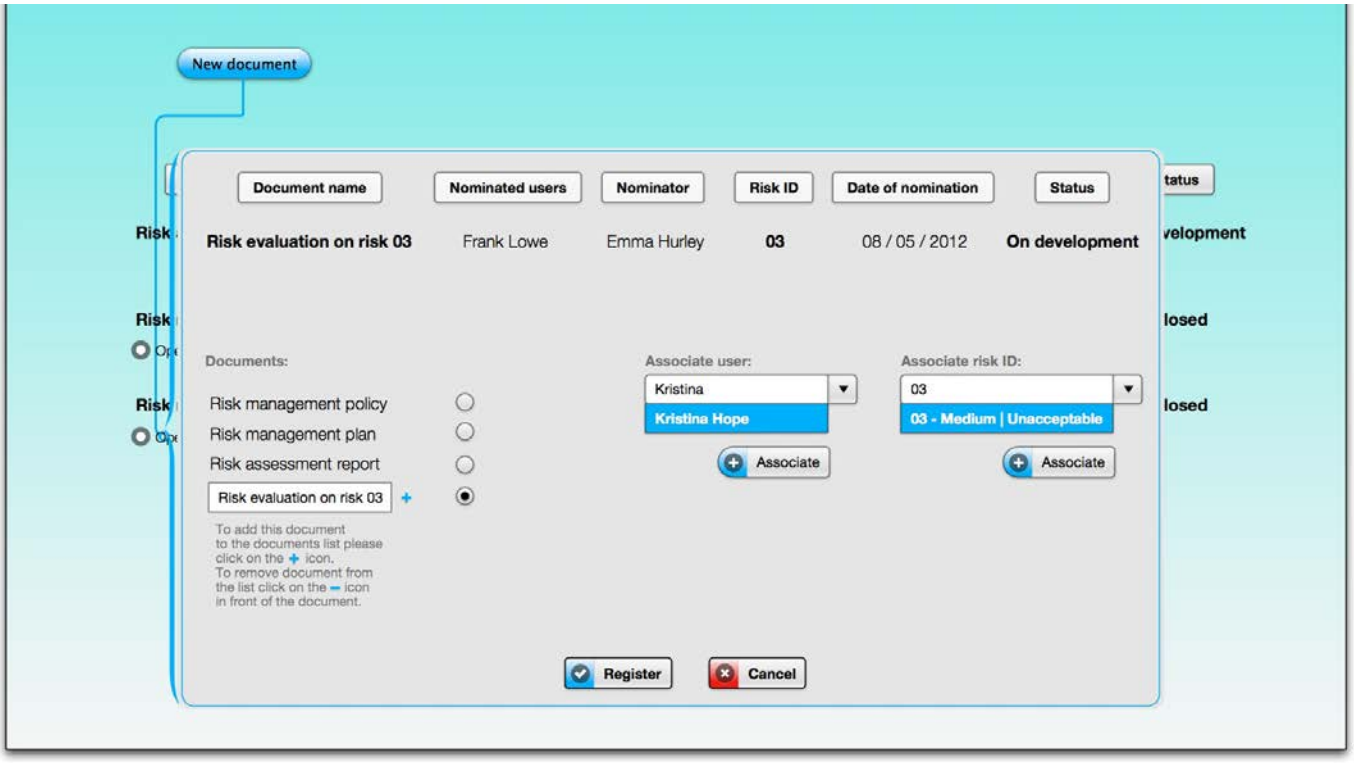


Figure 5.39: Risk documents - Associate user

5.1.4 My area

One of the most important features of the EFASpace platform is the "My area" area, by clicking on the "My area" button on the main menu on the top left corner of the interface, the user enters on his personal area which contains a menu bar with the "My definitions", "My projects", "To-do list" and "Messages" buttons. On the "My definitions" button, the user can view all of his system informations. These informations are: the user's photo, name, number, password, e-mail, security question and security answer, this screen is illustrated in the figure 5.40.

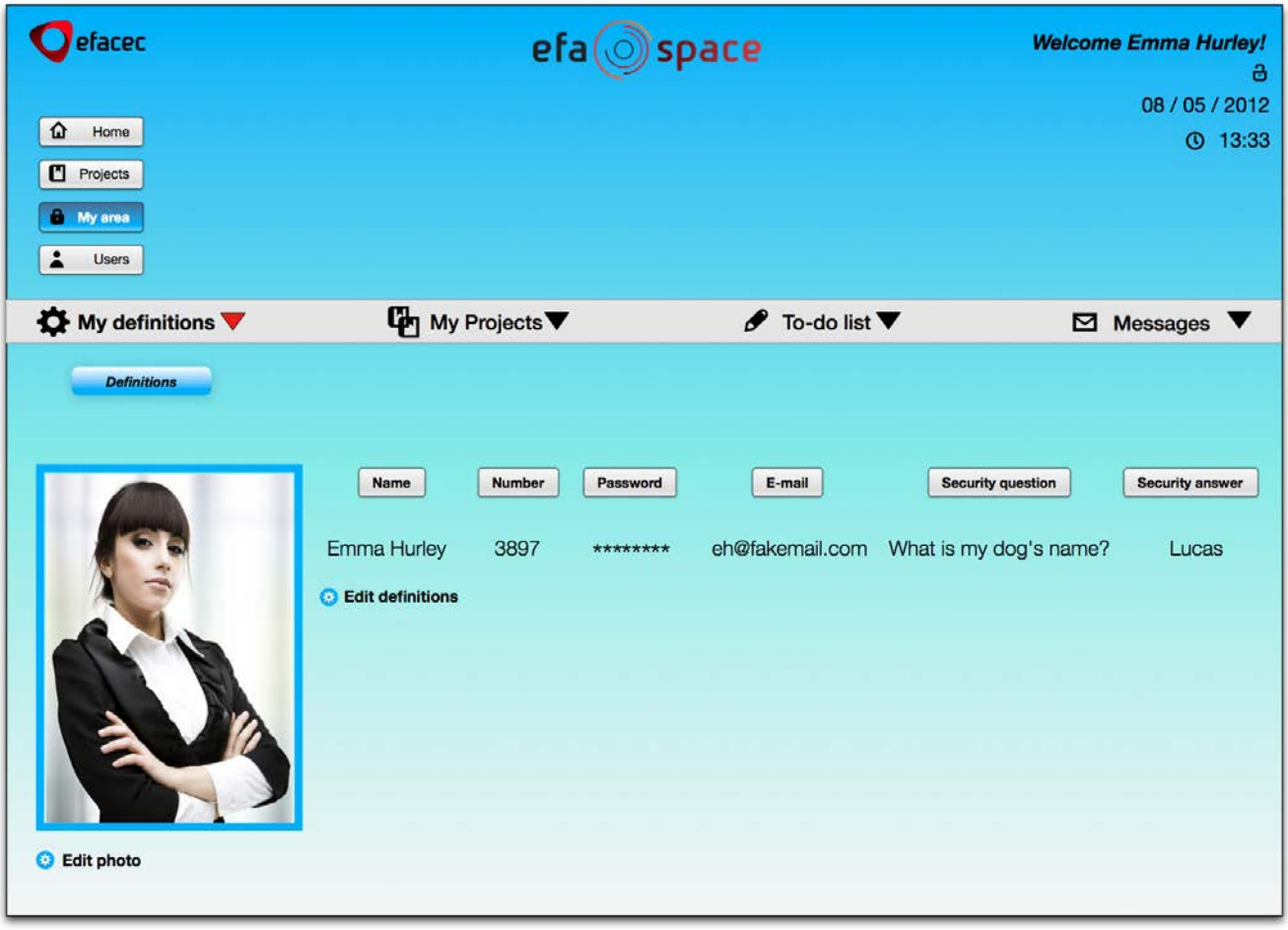


Figure 5.40: My area

By clicking on the edit photo icon below the current photo, the user can open a window to browse through his computer to select the new photo to be uploaded. To edit his definitions the user must click on the edit definitions icon. The figure 5.41 shows the two edition options described for this screen.



Figure 5.41: My area - Edit definitions

On the "My projects" button, the user can view all of his projects, meaning, all projects where he is considered an active user being a user who has been associated/nominated to perform any kind of activity/task during the project's life cycle. This screen is shown in the figure 5.42.

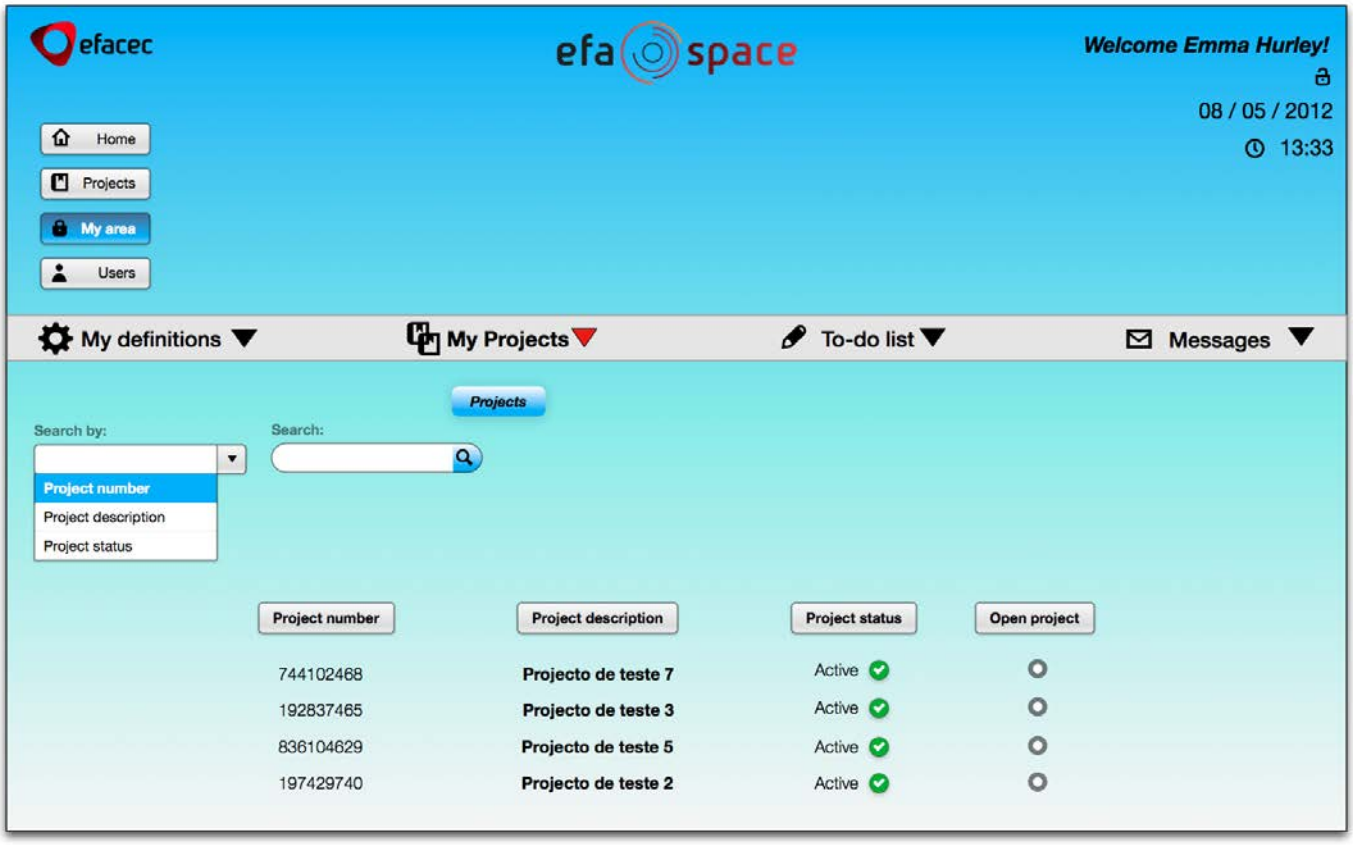


Figure 5.42: My Projects

One of the most important, if not the most important one, features on the EFASpace platform is the "To-do list" button, this button allows the user to manage and monitor all of his attributed tasks within a project, giving him an overview on his work in a effective way. The "To-do list" button gives access to four buttons, each one of these will guide the user through his tasks divided by project areas. To access the risk monitoring tasks the user must click on the "Risks" button that appears below the "To-do list" as shown in the figure 5.43.



Figure 5.43: To-do list - Risks

On this screen the user can view the risk ID, type, nominated users (the user may not be the only nominated), date of nomination, type of action, associated project number and description. The user can also access the risk monitoring informations by clicking on the icon below the "view risk" label on the screen. At last, the user must classify the risk status by choosing the available "Assessed" or "Not assessed" states. If the user has assessed the risk and performed the proposed actions he must click on the check box to attribute the "Assessed" status, if the risk as not been yet assessed or not all of the proposed actions have been implemented then the user must choose the "Not assessed" status. Note that all risks status are classified by default has "Not assessed".
By clicking on the "Meetings" button, the user can access to all meetings that he has been nominated to attend. For each meeting, the user can view the meeting date, time, type, main objectives, nominated users and the associated project number and description. The figure 5.44 shows the "Meetings" screen included on the "To-do list" button in the "My area" of the system.

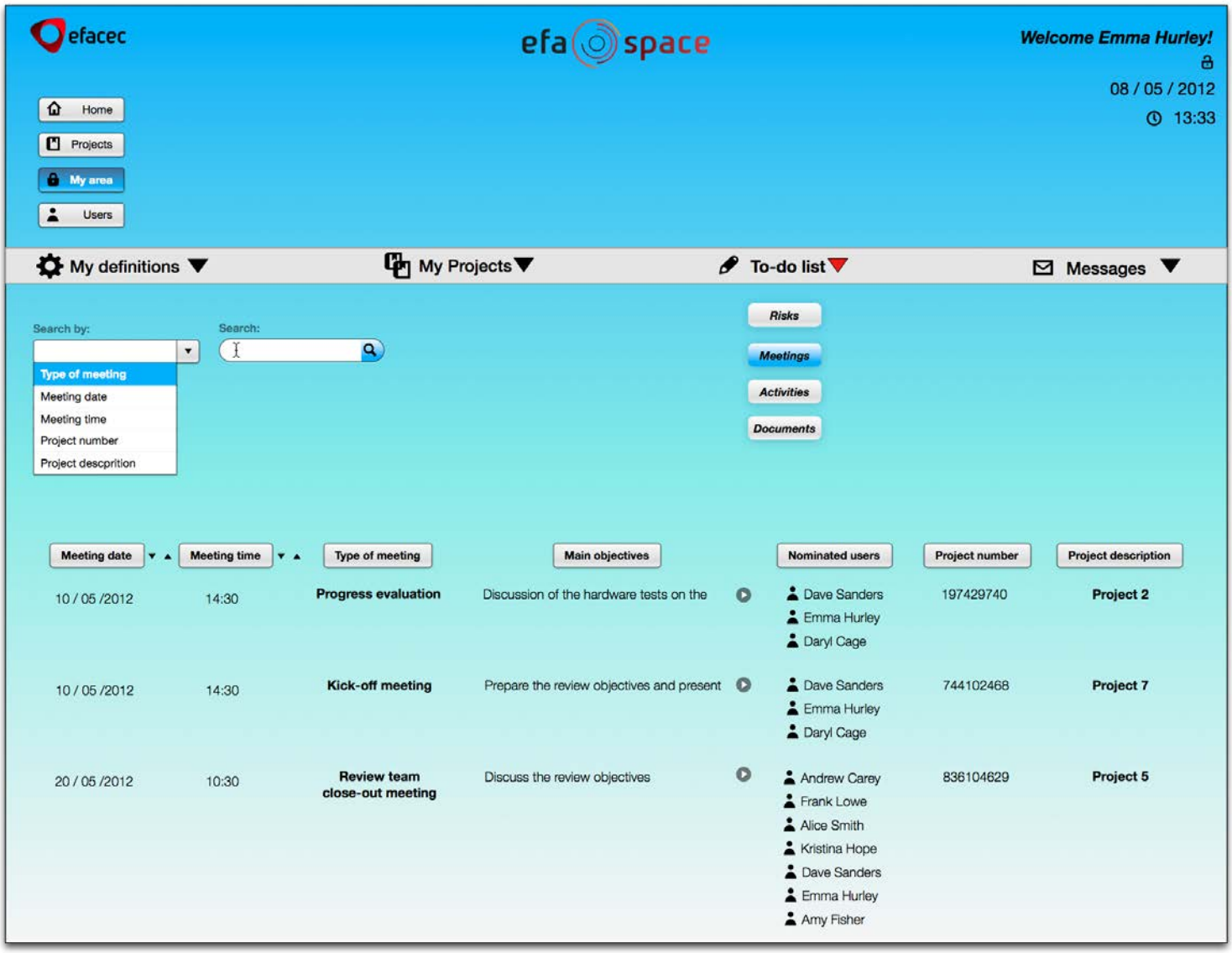


Figure 5.44: To-do list - Meetings

For the "Activities" button, the user opens the screen where all of his nominated activities are at sight. For each one the user can see the activity's description, milestone classification, initiation and finalization dates, duration and the associated project number and description. By default, the attributed status for each new activity is not initiated, however, the user can choose to classify the activity as closed if concluded or on development if its development is in course. The activities control screen on the "To-do list" tab is presented on the figure 5.45.



Figure 5.45: To-do list - Activities

At last, for the "To-do list" button, the system provides the user a screen where he can manage and submit all of his associated documents through the "Documents" button. Here the user can manage his documents and view all of the related useful information such as the nominated users (including himself), nominator user, the document's name, date of the nomination and the respective project number and description. Like on others "To-do list" screens, here the user can also classify the status of his documents as "On development" (default status), "Closed" if the document's execution has terminated and the file uploaded, or "Suspended" if its execution has been stopped. Note that in case of more than one nominated user to be responsible for a document/activity or risk assessment it is supposed that the users work has a team and classify the status equality on each personal area, the system will always present the last status given to the document/activity or risk. The figure 5.46 shows the screen for the "Documents" button on the "To-do list".

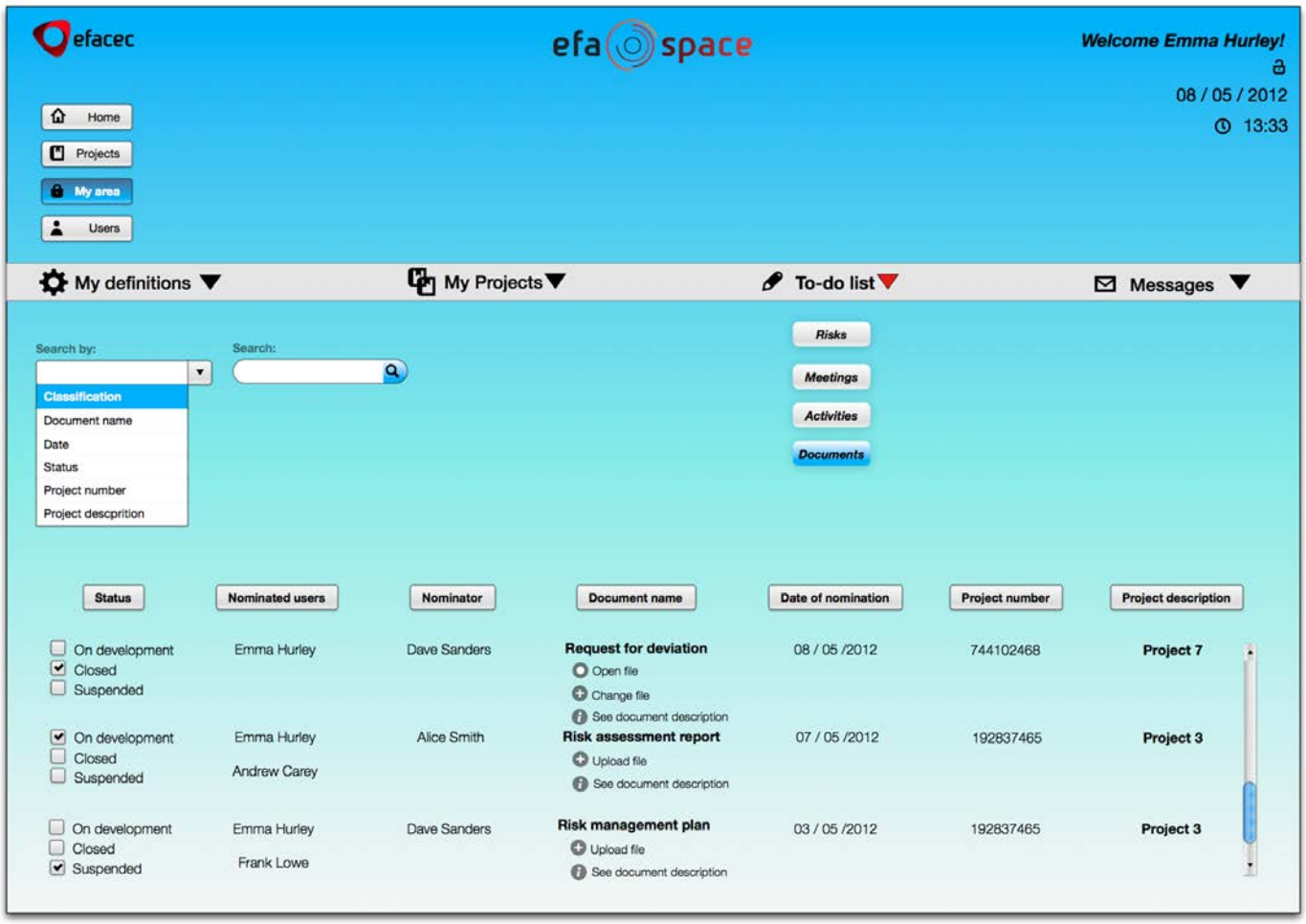


Figure 5.46: To-do list - Documents

Another important feature on the system is implemented on this screen, below each document name the user sees two icons: the first icon allows the user to upload the document file and the second one gives the document description defined on the ECSS standards, this description will help the user to know what the document's main objectives consist of and thereby execute the document according to the defined guidelines (figure 5.47). In case of a closed document, the user can always change the uploaded file by clicking on the change file icon.

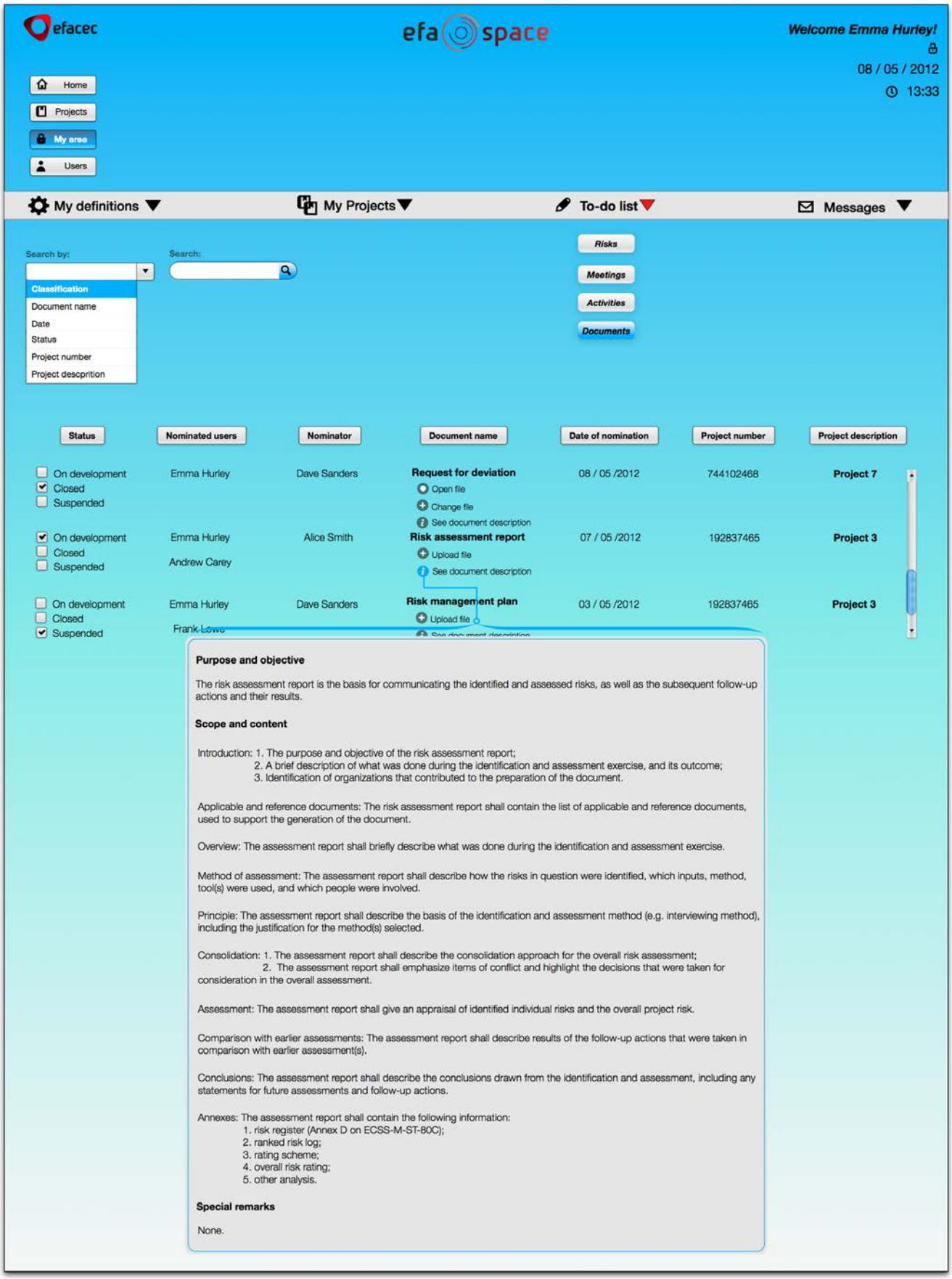


Figure 5.47: Documents - Document description

The last button on the "My area" menu bar is the "Messages" button, here is where the user can communicate with other users on the system. The "Messages" button shows the user's inbox where all of the received messages are identified with the respective user, date and time (figure 5.48), here the user can click on the reply icon and be redirected to the chat board where the exchange of messages takes place. On this screen (figure 5.49) the user can open each conversation log file organized by date.

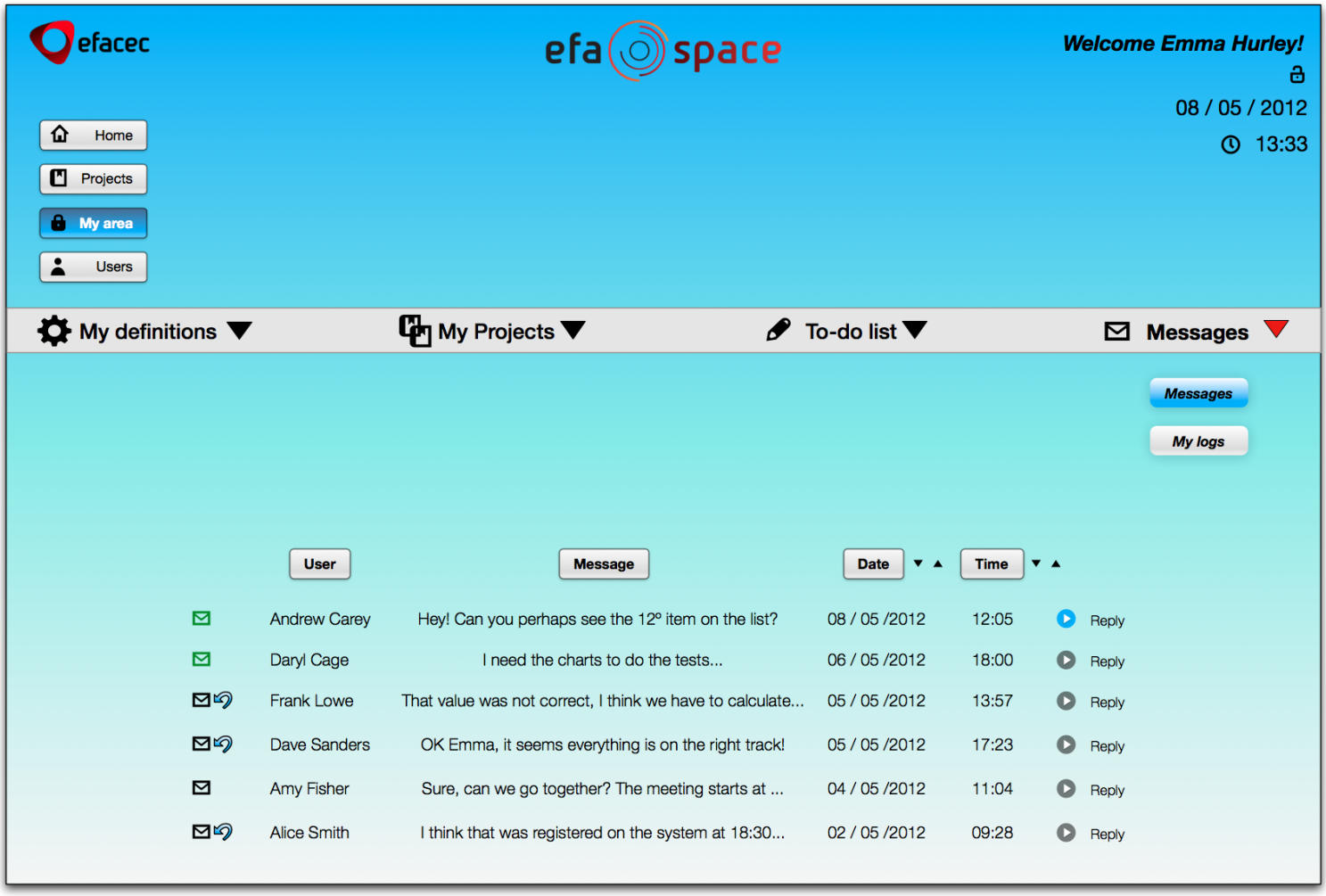


Figure 5.48: Messages - inbox

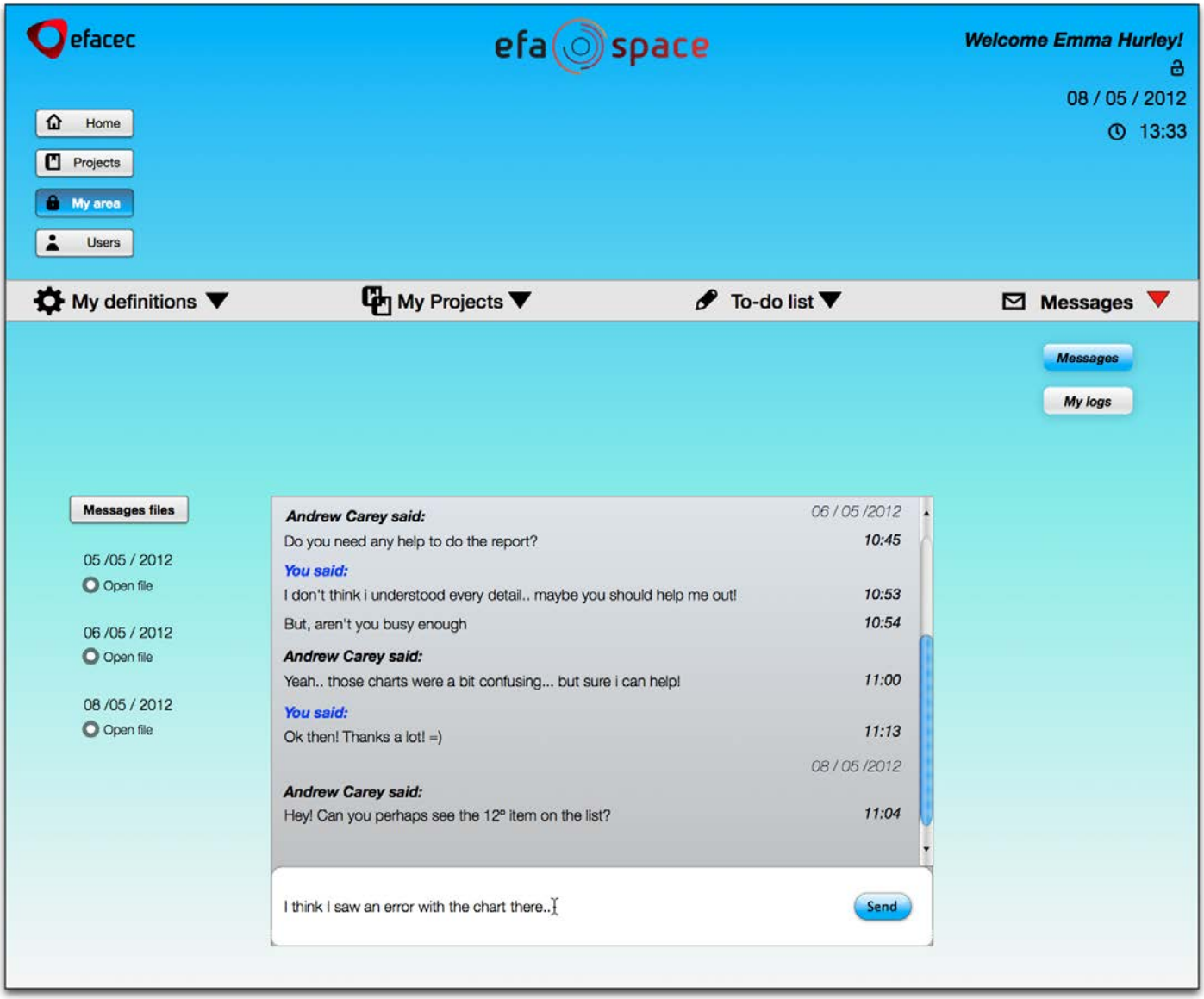


Figure 5.49: Messages

On the "My logs" button the user gets access to all of his conversations with all other users and can choose to open each conversation chat board to send a new message or open the messages files organized by date as well (figure5.50).

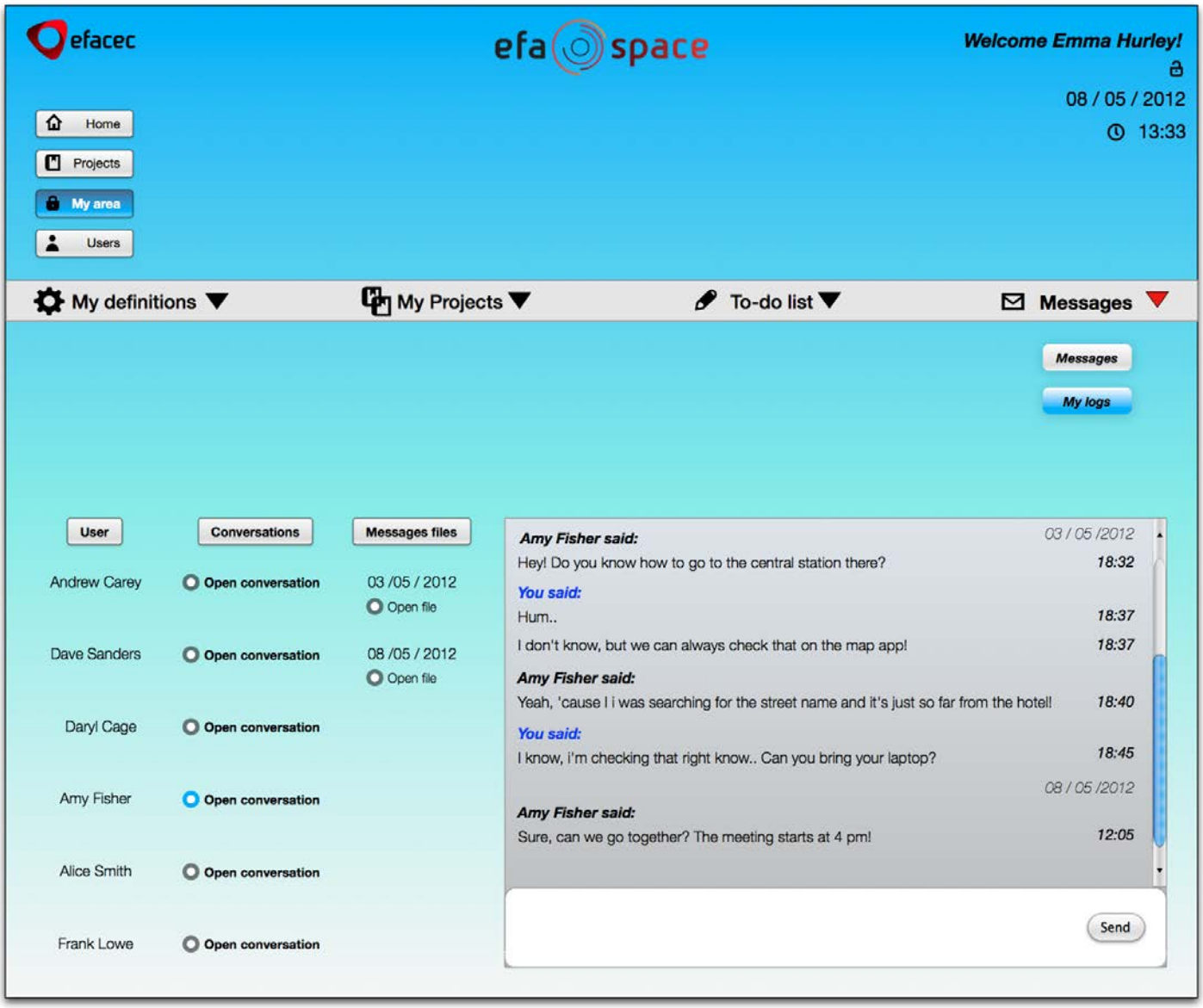


Figure 5.50: Messages - My logs

As defined previously, the project manager has exclusive management privileges on the system therefore the project manager "My area" has an extra button, this button is called "Control panel" and it contains three buttons: the "Users to-do lists" button, the "System projects" button and the "Permissions" button. The "Users to-do lists" button (figure 5.51)



Figure 5.51: My area - Control panel

gives access to all activities (figure 5.52), meetings (figure 5.53) and documents(figure 5.54) of each user, this way the project manager can monitor the work developed by each user involved in a specific project. On these screens, the project manager can always search for a user by typing his name or number on the search fields.

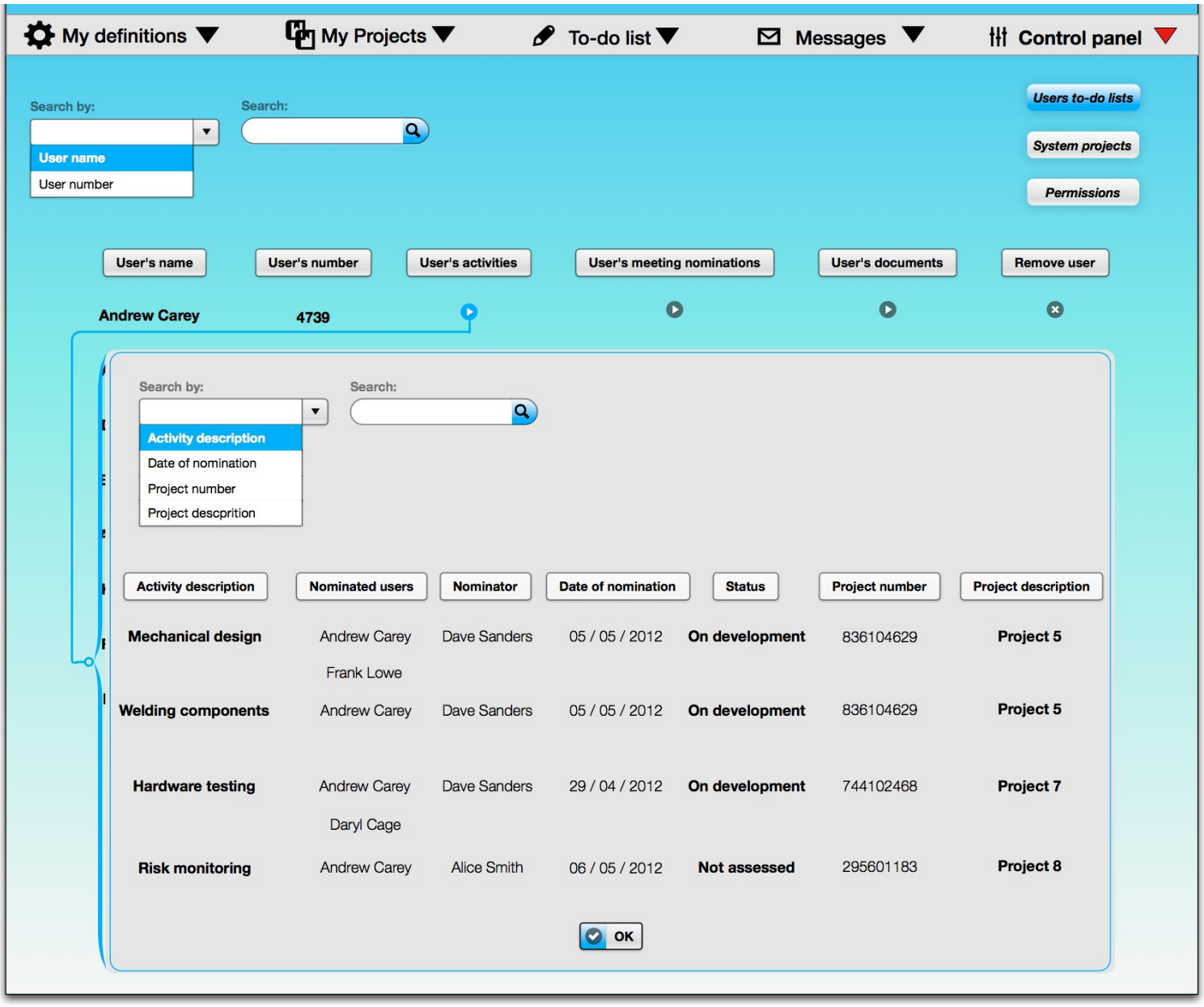


Figure 5.52: Users to-do lists - Activities



Figure 5.53: Users to-do lists - Meetings

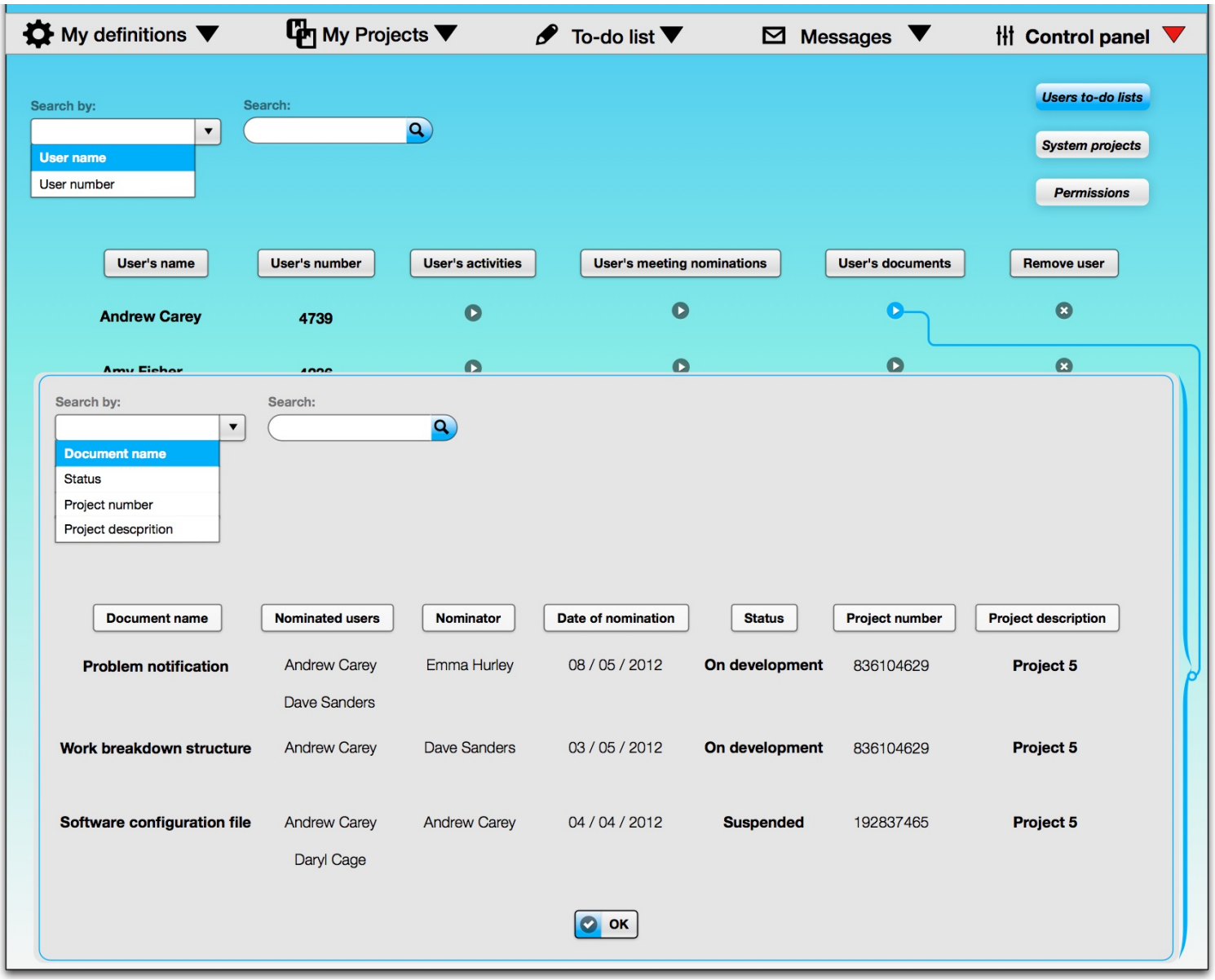


Figure 5.54: Users to-do lists - Documents

Another important functionality present on this screen is the project's manager ability to remove users from the system has shown on the figures 5.55 and 5.56.

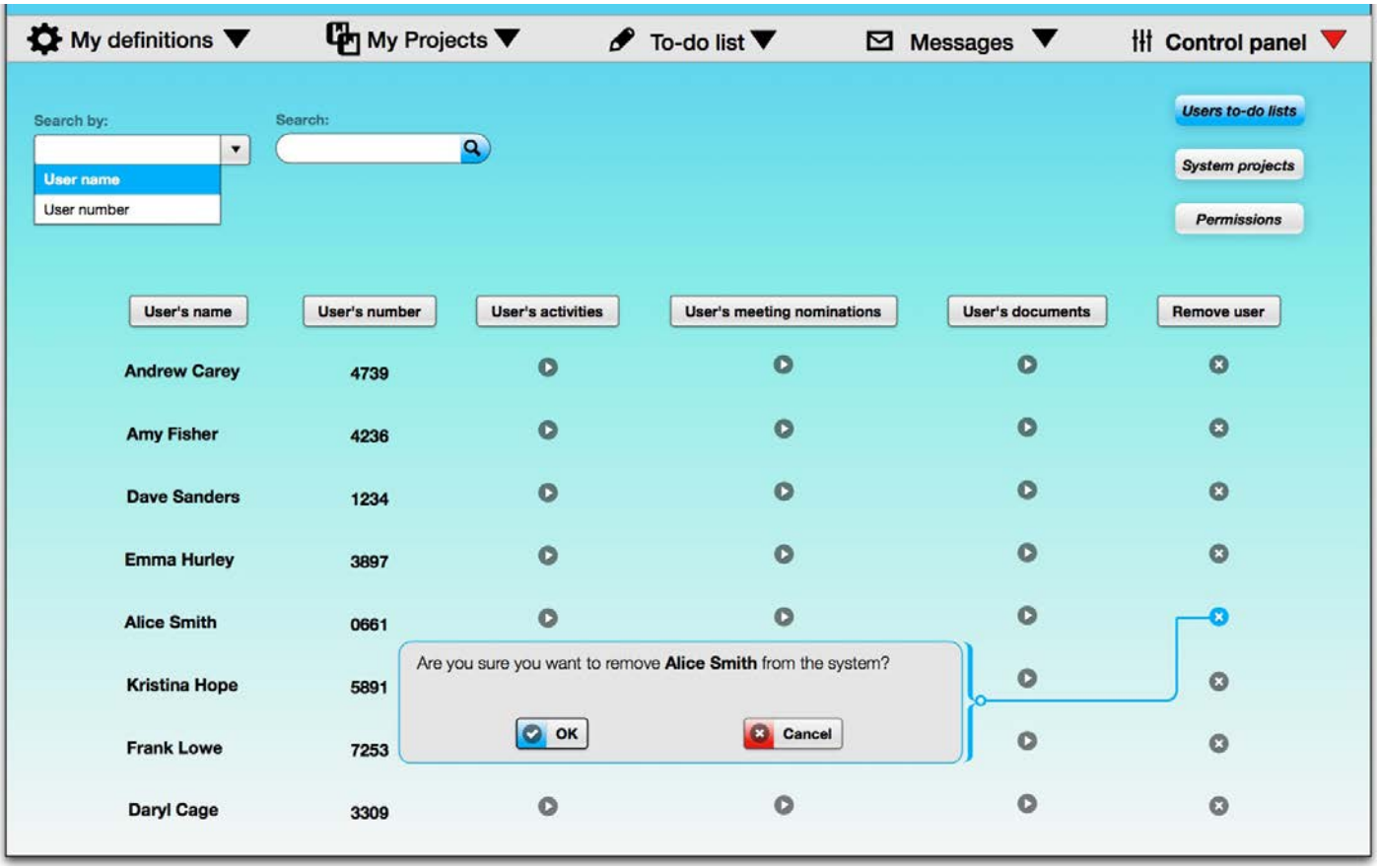


Figure 5.55: Users to-do lists - Remove user

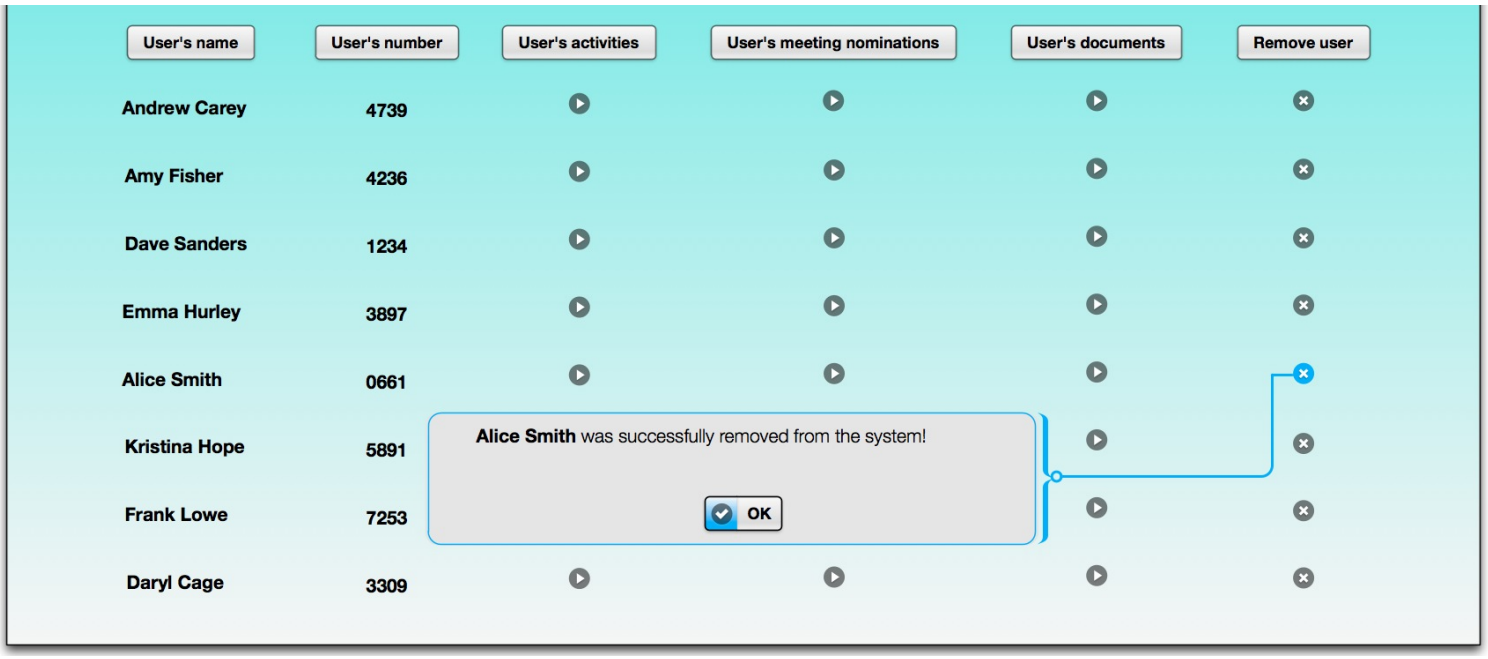


Figure 5.56: Users to-do lists - User removed confirmation

On the "System projects" button, the project manager is given access to manage all projects within the EFASpace platform (figure 5.57),

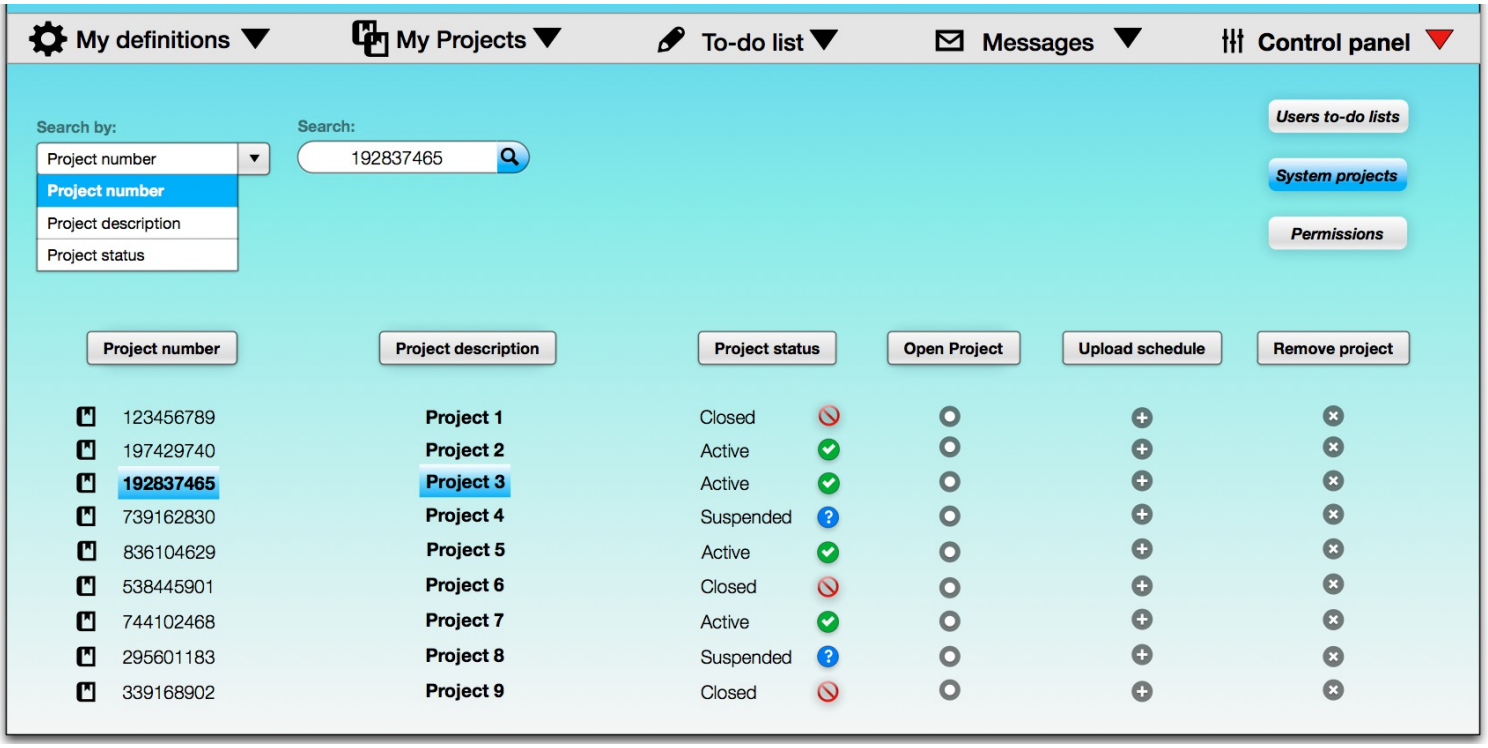


Figure 5.57: System projects

here he can remove a project or add a new one, however to add a new project, the process must be made upon the time of the project's detection alert as shown in the figures 5.58 and 5.59 or by accessing the alerts stored in the "Alerts" area described before, even if the project manager does not see the pop-up alert he can always access it by going to the "Alerts" area and clicking on the "My alerts" button which is where these alerts will be stored since they only appear to the project manager.

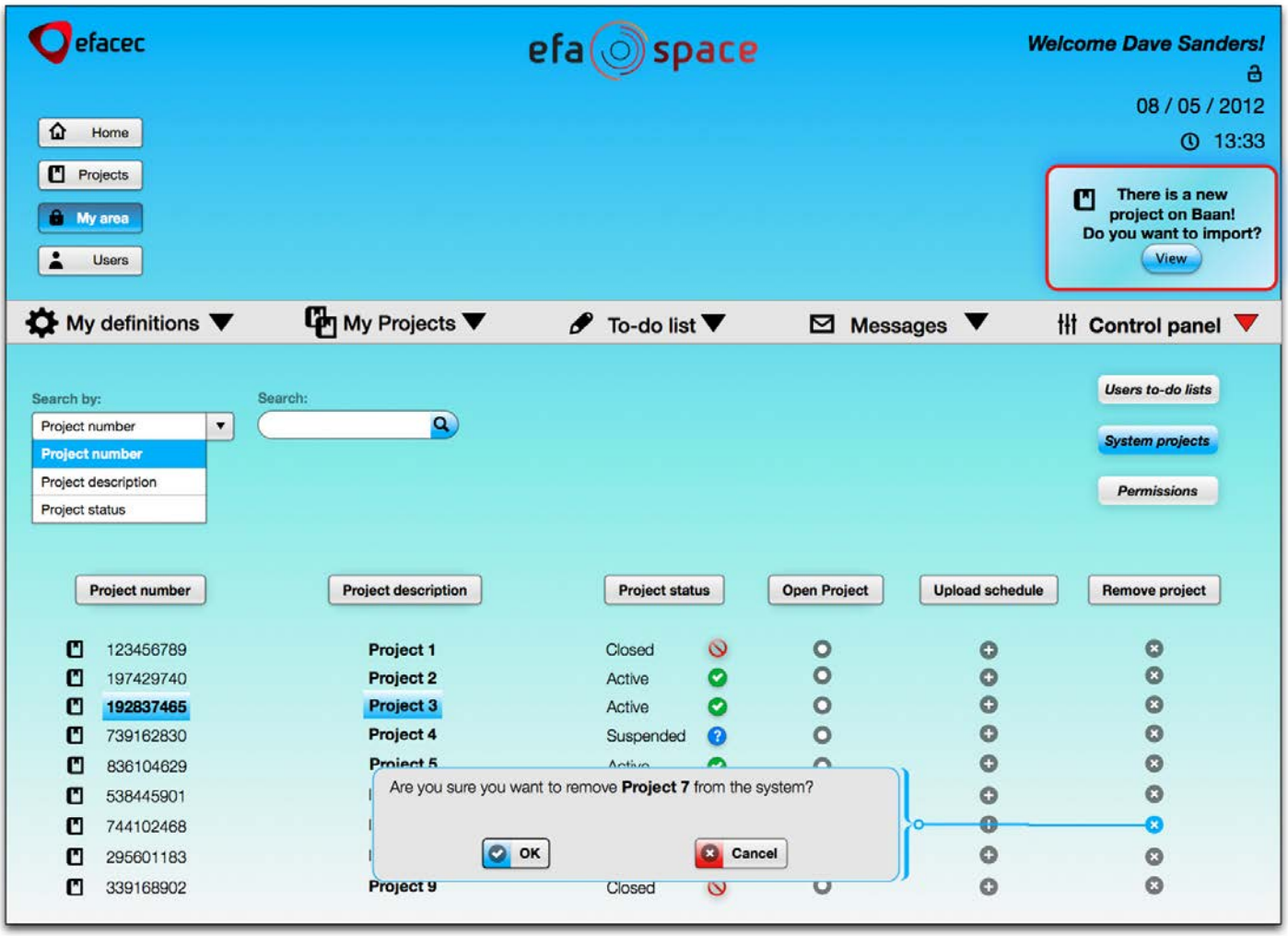


Figure 5.58: System projects - Remove project and Project detection alert

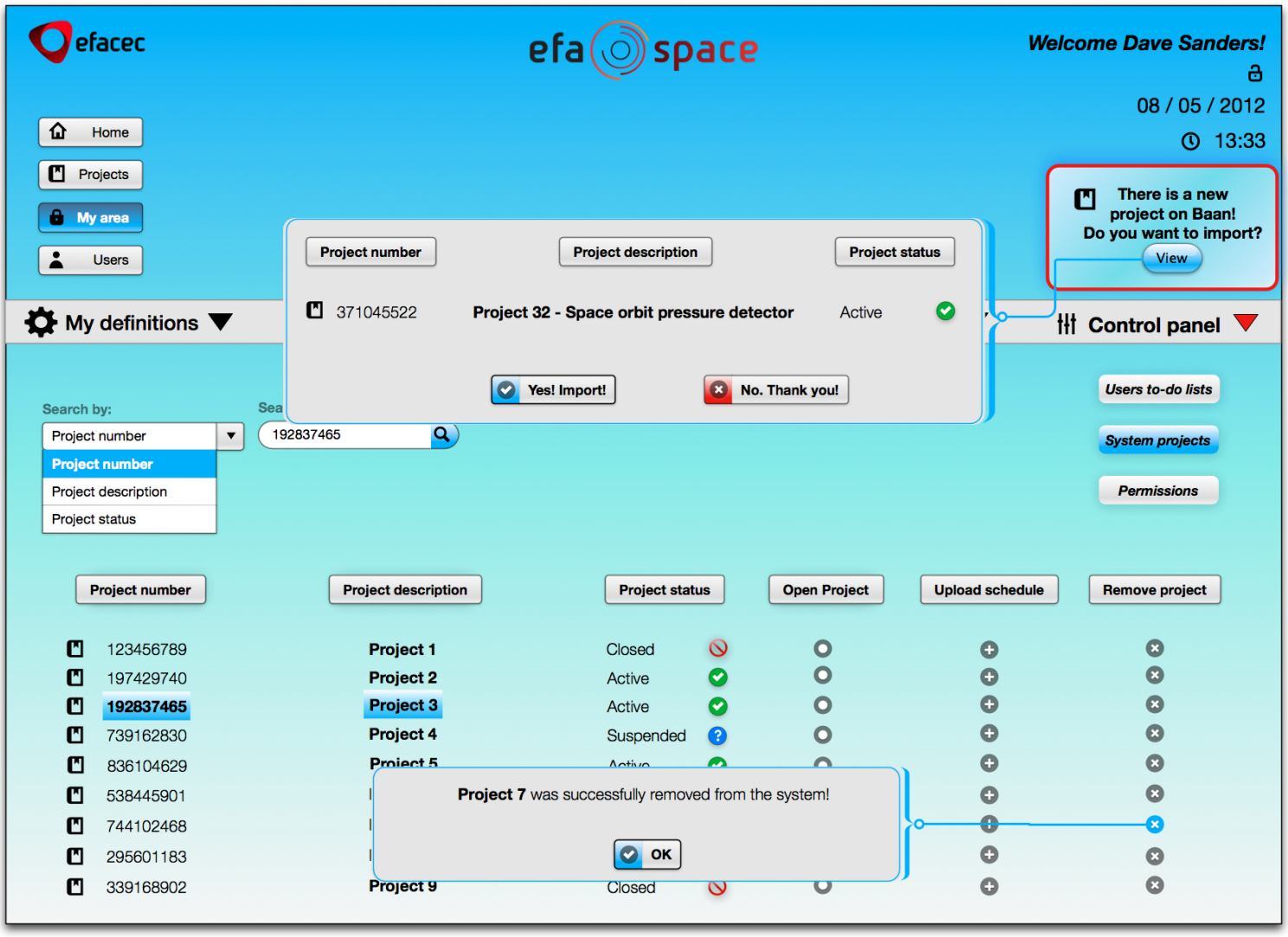


Figure 5.59: System projects - Project removal confirmation and Project submission

On this screen also, the project manager can submit a schedule for each project by clicking on the upload schedule icon (figures 5.60 and 5.61).

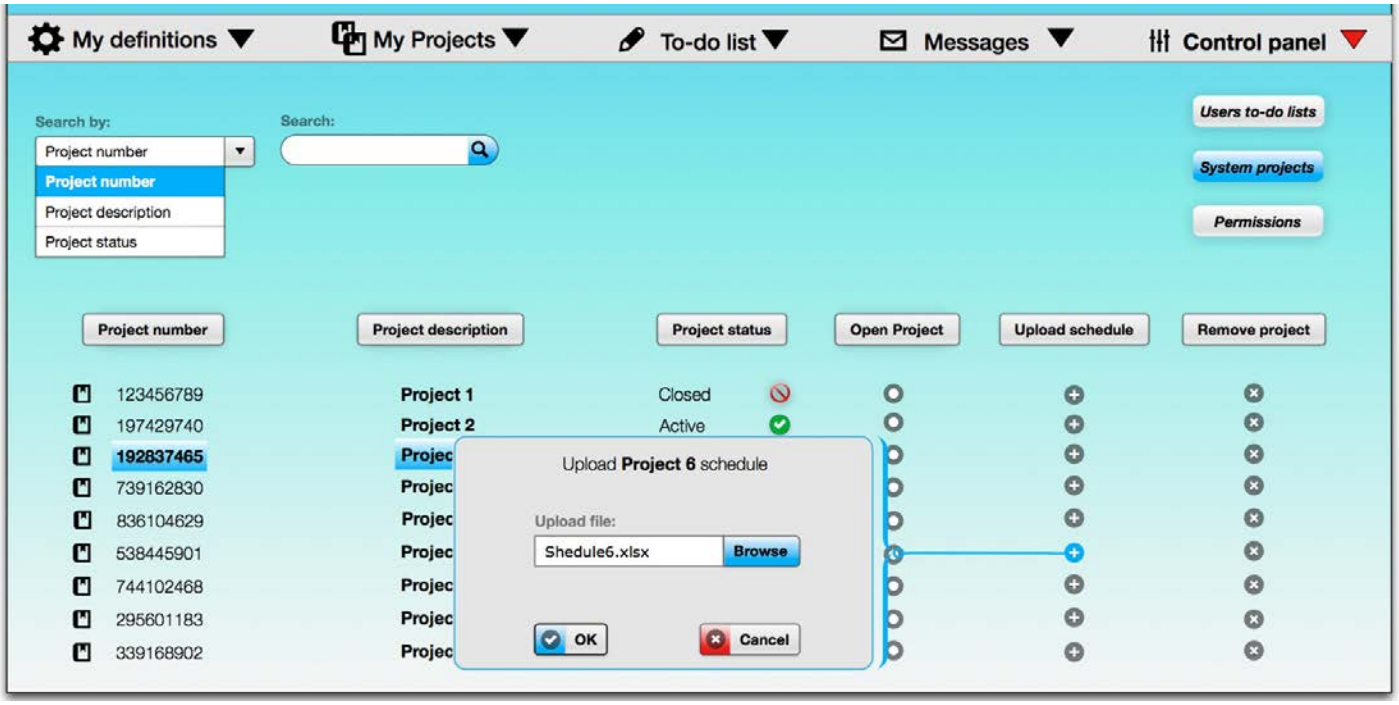


Figure 5.60: System projects - Schedule submission

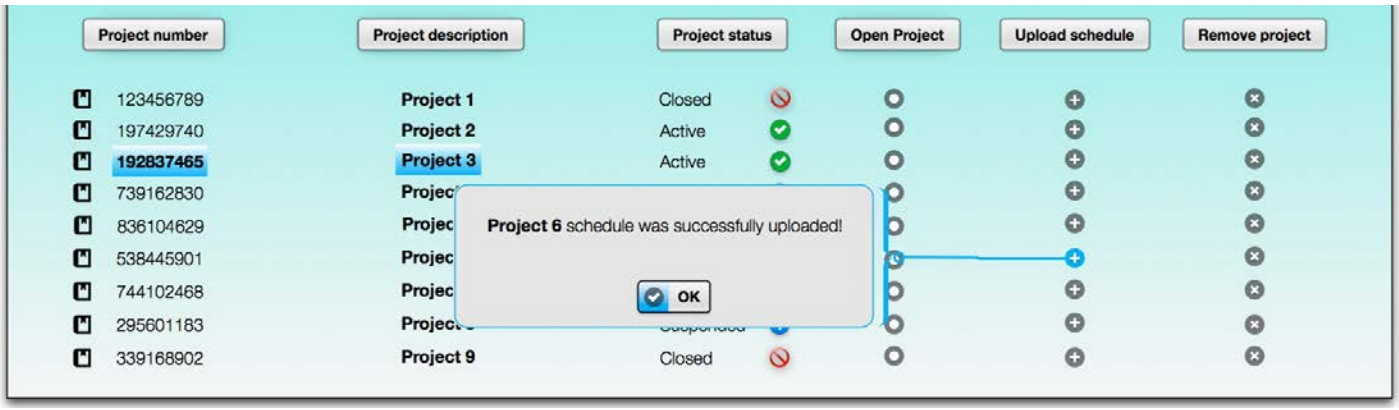


Figure 5.61: System projects - Schedule submission confirmation

The last button on the "Control panel" tab, the "Permissions" button, gives the project manager access to an area where he can manage the system's registration requests allowing or denying each request (figure 5.62), and give permission to an external user to consult a contract on the financial area of a project . To this, the project manager must fill the name of the external user, e-mail and associate the contract and respective project to be consulted, the user number is given automatically by the system as shown in the figure 5.63.

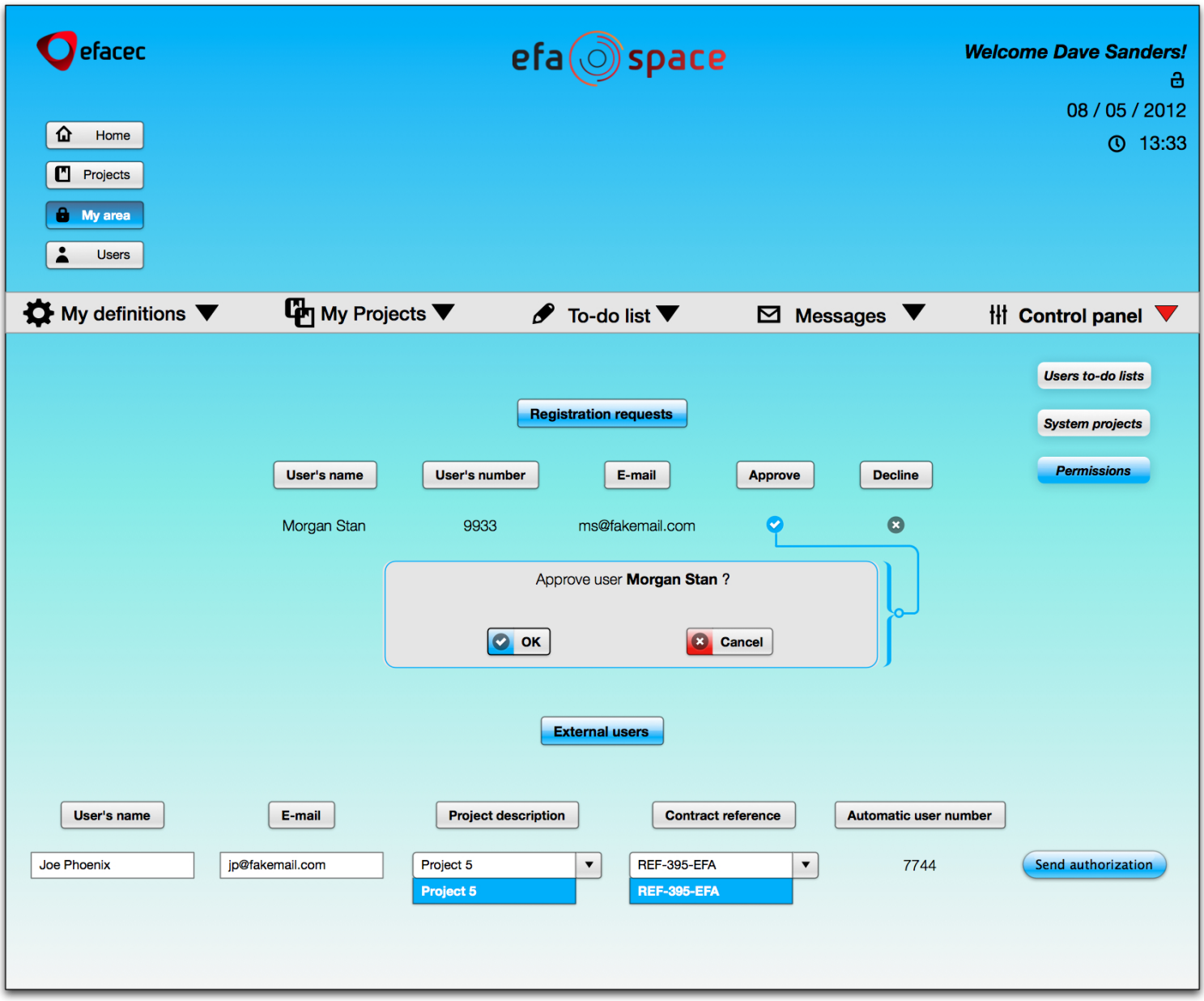


Figure 5.62: Permissions - User registration request and External user permission

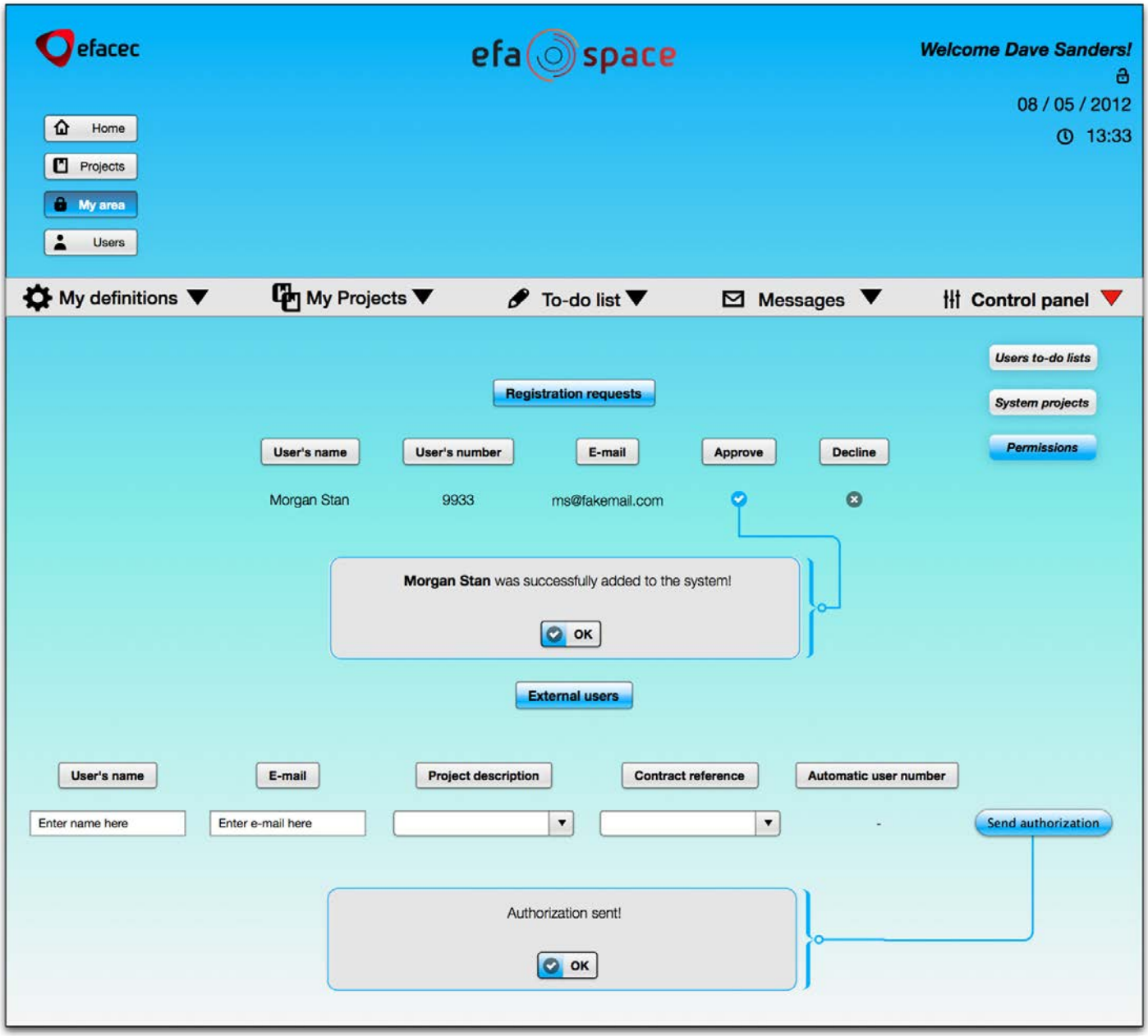


Figure 5.63: Permisions - New user added to the system and Authorization sent

5.1.5 Users

Finally, the last area on the EFASpace platform is the "Users" area. This area is very simple, it intends to present all the registered users on the system and allow any user to locate other user by his name or number. By clicking on the icon in front of each user the system presents that user's photo, name, number and e-mail, here the user can also send a direct message to the selected user by clicking on the send message icon (figure 5.64).

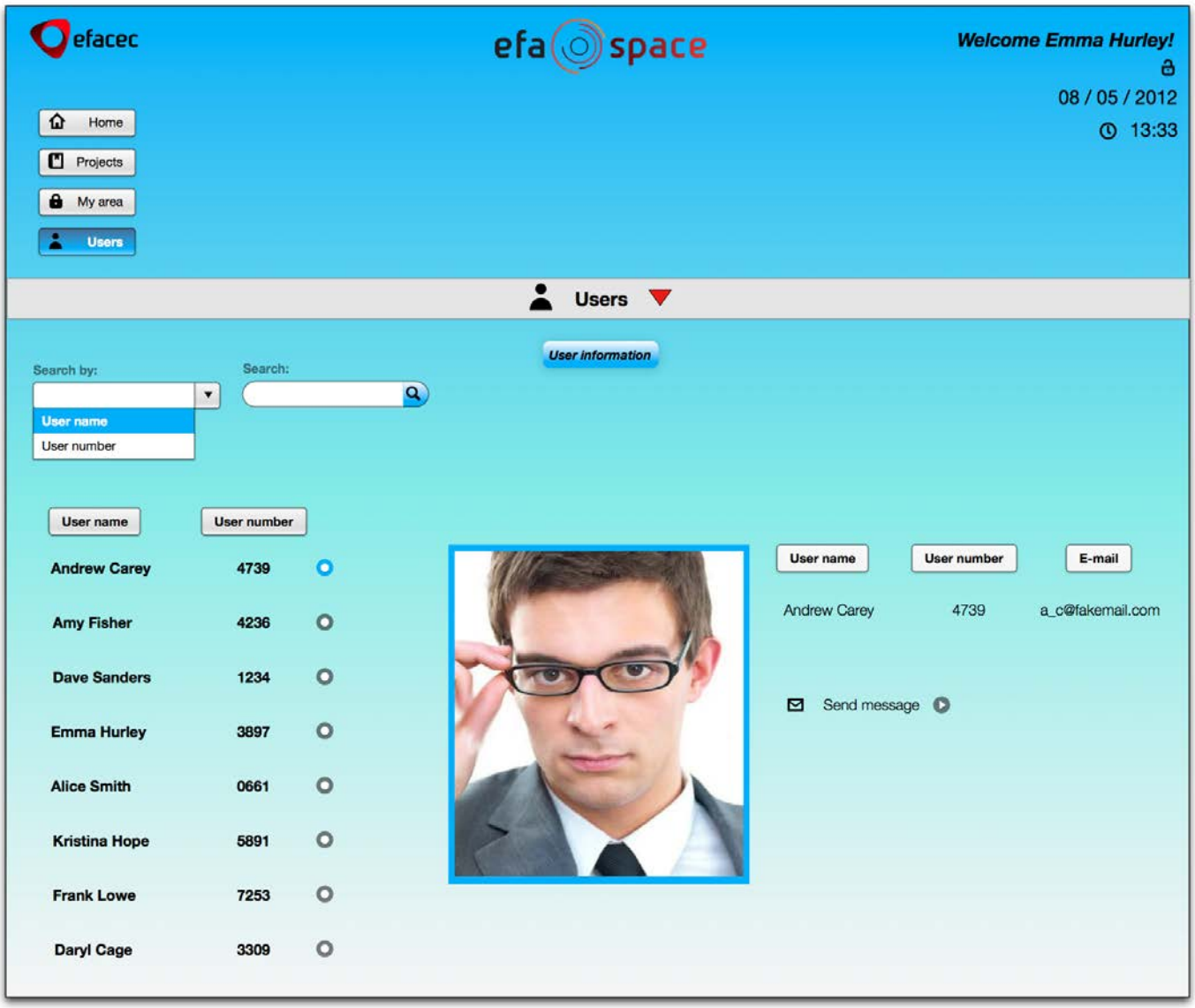


Figure 5.64: Users

5.2 Use cases

All systems can be decomposed into use cases [31],[32] diagrams [33], that reflect the functionalities and areas in which the actors operate. For the "Home" area the figure 5.65 shows that the users can access the system alerts as well as their personal alerts, the project manager also has this privileges but he can also add a new project into the system. Note that the detection of a new project alert is shown on the screens giving the project manager the option to view and act right a way but it is also stored as any other alert on his "My alerts" area, with the difference that this alert is only shown to the project manager.

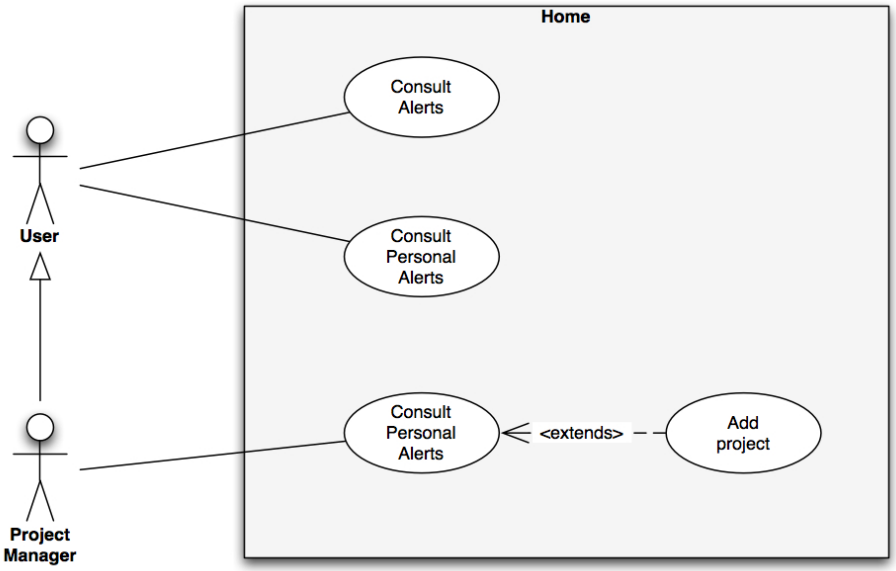


Figure 5.65: Home - Actors and functionalities

The "Projects" area, as seen, is the biggest area on the system, here the user access almost to all system's functionalities, the figure 5.66 defines all of these functionalities and shows that both the project manager and a normal user (such as a member of the project developing team) have the same access permissions.

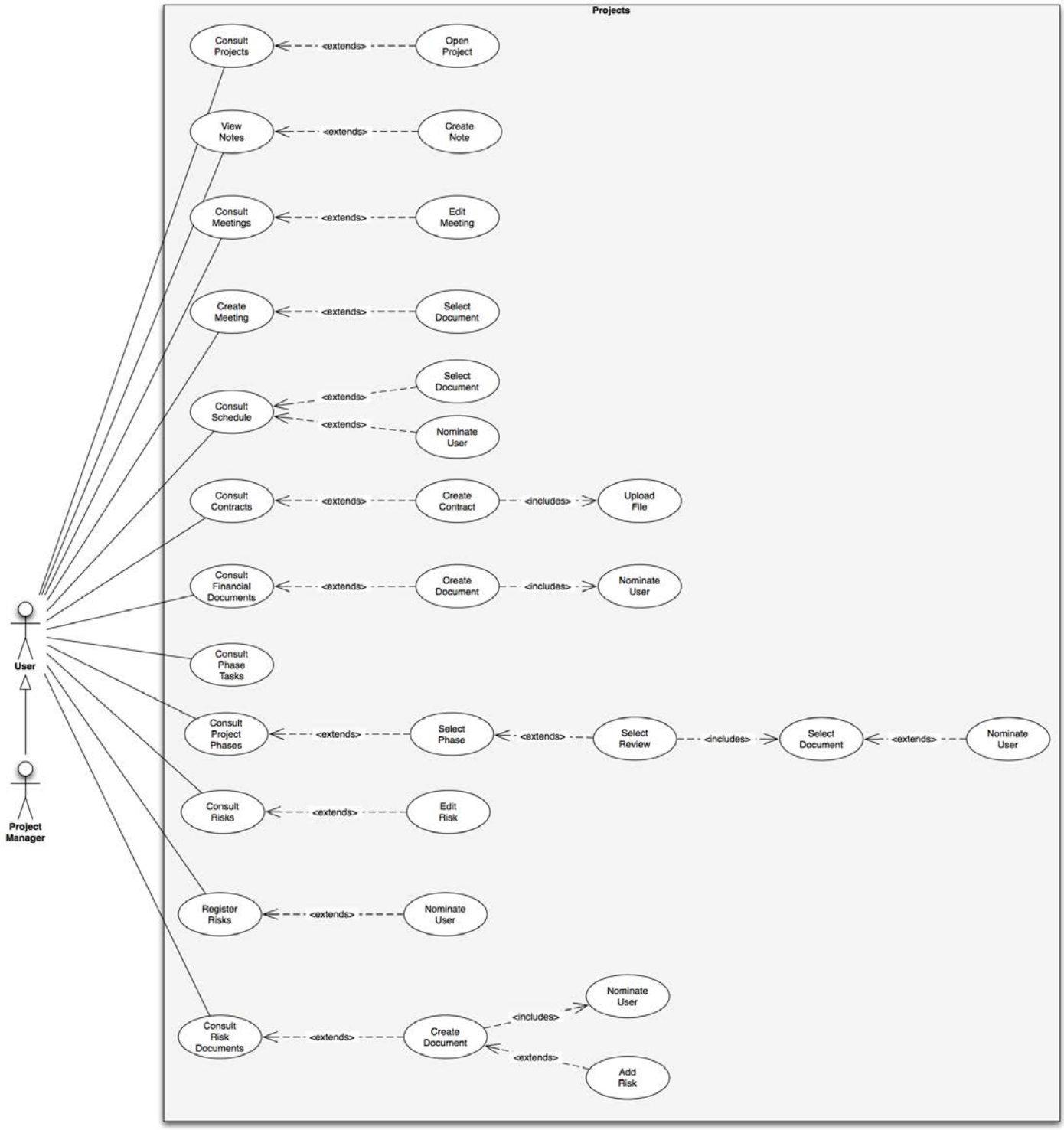


Figure 5.66: Projects - Actors and functionalities

Also defined previously, the users can manage their definitions, to-do list, messages and projects within a area called "My area". This area is where the users go to manage their assignments within a specific project, the figure 5.67 illustrates the major functionalities available to

the users on this area. Note that, the difference between a considered normal user and the project manager is also defined on this area, here the project manager has, besides all of the functionalities defined for the users, the access to the control panel presented previously on this chapter.

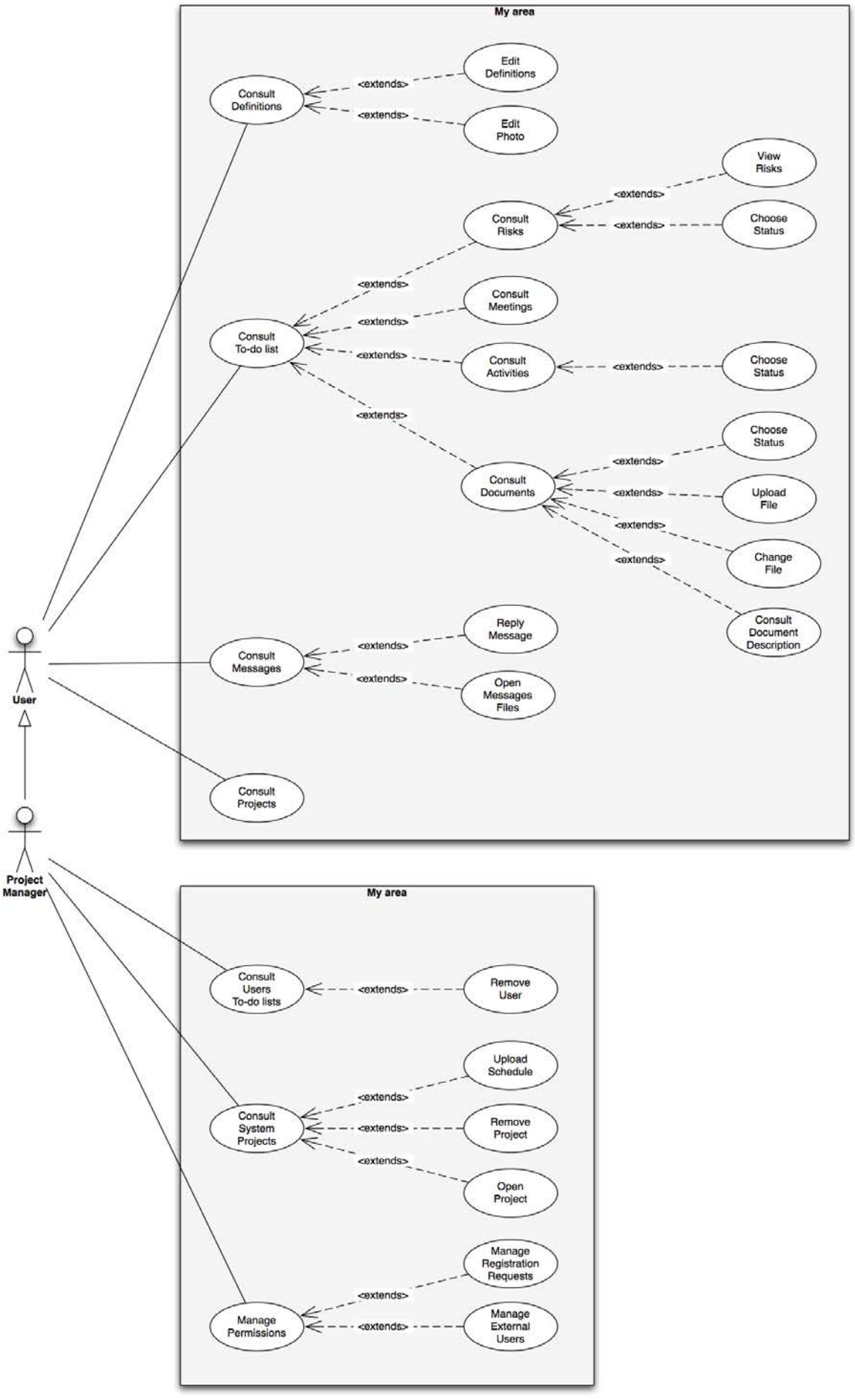


Figure 5.67: My area - Actors and functionalities

At last the "Users" area on the system is a simple one so is the diagram in the figure 5.68 that shows the interaction between the user and this area.

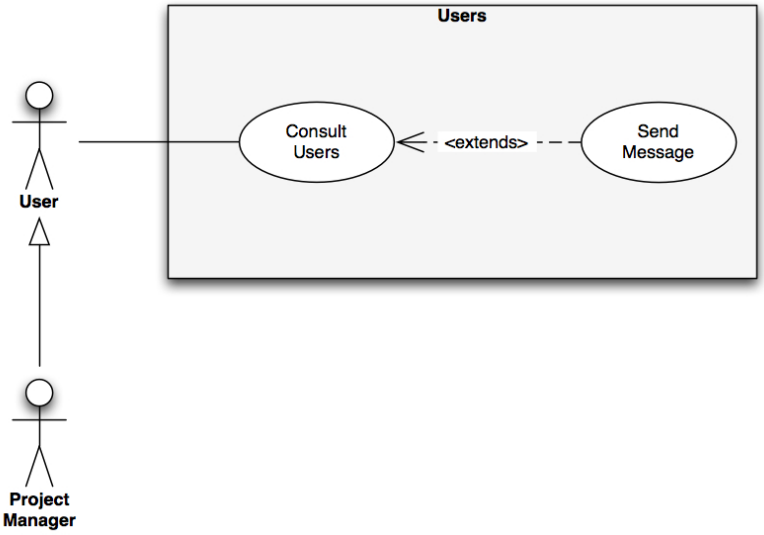


Figure 5.68: Users - Actors and functionalities

5.2.1 Create meeting - use case

An easy and effective way of defining a use case is by using a table [34] where the use case name and number are presented, the involved actors and pre-conditions are identified and the use case steps are defined. The create meeting use case was chosen due to the fact that it is one of the few operations, within the system, that are only considered completed after a series of steps have been taken. The figure 5.69 shows the create meeting use case and its steps. Note that only a normal user or the project manager can execute this operation.

Use case name:	**Create meeting**
Identification number:	UC1
Actors:	User; Project manager;
Pre-conditions:	It is necessary to be logged in into the system.
Use case description:	This use case defines all the steps that a user must take to create a meeting within a project.
Numerated sequential description:	
1. Click on the projects button on the main menu; **2.** Choose the project where the meeting will be created; **3.** Click on the meetings tab; **4.** Click on the create meeting button below the meetings tab; **5.** Set meeting date and time; **6.** Nominate users for the meeting; **7.** Describe the meeting main objectives; **8.** Choose the type of meeting; **9.** Click on the create meeting button.	

Figure 5.69: Create meeting use case

5.2.2 Register risk - use case

Following the same logic of the previous use case, the risk registration operation involves different steps that together allow a user to register a new detected risk on a project. The figure 5.70 indicates that only a user or the project manager can execute this operation, again, the external user does not have any access to this area on any project.

Use case name:	**Register risk**
Identification number:	UC2
Actors:	User; Project manager;
Pre-conditions:	It is necessary to be logged in into the system.
Use case description:	This use case defines all the steps that a user must take to register a risk within a project.
Numerated sequential description:	
1. Click on the projects button on the main menu; **2.** Choose the project where the risk will be register; **3.** Click on the risks tab; **4.** Click on the risk registration button below the risks tab; **5.** Describe risk; **6.** Choose the risk likelihood score; **7.** Choose the risk severity score; **8.** Click on the generate risk index button; **9.** Choose the type of action to be taken when assessing the risk; **10.** Describe the proposed actions; **11.** Associate users to the proposed actions; **12.** Click on the register button.	

Figure 5.70: Register risk use case

5.2.3 Add external user - use case

To add an external user to the system and associate him to a specific project where he can consult a contract, the project manager, and only him, has to give permission and access to the user. To do this, the project manager must follow a few steps that are defined on the add external user use case represented in the figure 5.71.

Use case name:	**Add external user**
Identification number:	UC3
Actors:	Project manager;
Pre-conditions:	It is necessary to be logged in into the system.
Use case description:	This use case defines all the steps that the project manager must take to give permission to an external user to access the system contracts consult area.
Numerated sequential description:	
1. Click on the My area button on the main menu; **2.** Click on the control panel tab; **3.** Click permissions button below the control panel tab; **4.** Enter the external user name on the user's name field; **5.** Enter the external user e-mail on the e-mail field; **6.** Choose the project to be giving access to; **7.** Choose the contract to be giving access to; **8.** Click on the send authorization button.	

Figure 5.71: Add external user use case

5.3 Conclusions

On this chapter the system's interfaces and screens were presented and explained in order to prove the system's effectiveness on translating the initial needs into features and functionalities that make this platform a powerful work management for space projects. All project development team members would have a platform where they could manage their activities and documents, where it was possible to schedule meetings and keep record of all documents within a project's life cycle.

Also the project manager would be given a useful tool for keeping track of the progress and work development not only made by each user but on the project itself. Risk management would also be more clear and effective by keeping record of all detected risks within a project as well as to have available a place where the risk management documents would be stored and accessible to all users.

Chapter 6

Conclusions and Future work

The final chapter of this document is dedicated to the conclusions about the work developed for this system specification. The specification presented was a compilation of many stages of work divided here into categories defined by the document's chapters. The conclusions to be drawn are presented into two sections, the first section is dedicated to the analysis of the objectives achievement purposed for this work, and the second section presents some additional work that could be done in the future that would add value to the platform.

6.1 Objectives achievement

The specification of the projects management platform presented on this document had a series of objectives to achieve during the course of the work development, the organization of these goals was set through time milestones. The first goal set to this specification was the ECSS management standards for space projects analyses, the main objective of this analysis was to understand all principles and requirements defined on each standard and retrieve the necessary information to be applied within the platform. Since documentation reporting is an essential part when developing spacial projects under ESA's supervision the management platform should include all documents set as normative by the standards within the according areas within a project.

Upon reaching the first objective, the needs assessment was the following goal. These needs would be from three sources, the needs identified by the project manager, members of development team and ultimately the needs that emerged from the analysis and study of the ECSS standards. It was extremely important to effectively define these needs because it is from these that the system requirements were defined. With this it was set as completed the second major objective of this specification.

The third goal of this specification would be the transformation of needs identified in objective requirements that the system should be able to meet. These requirements were grouped according to areas of interest that aimed to meet the needs identified above and form a solid basis for defining the structure of the system.
The next objective was aimed to define the system's structure. This definition was composed of several phases, the first was dedicated to translating the requirements defined into packages grouped within the different fields of action of the system where their main characteristics were identified. The second phase of defining the structure of the system aimed to identify the different types of users of the platform and set permission levels assigned to each one of them. At last, the third stage of defining the structure of the system was devoted to the database structuring required to support system definition, its characteristics and functionalities.

The last major goal for this specification was the design of interfaces and screens for the platform. These interfaces were designed according to the structure defined for the system and demonstrate the interaction between the users and the platform as well as the features included on each screen of the system.
The great challenge of this work was to combine all these stages of the system specification and generate user-friendly interfaces respecting the definition identified but keeping in mind that the platform is for users and therefore should be as intuitive as possible.

6.2 Future work

The platform presented in this document has the potential to grow further in several aspects. One of these aspects is the ability to integrate the platform with other platforms used within the company, namely the platform dedicated to the non-accordance management within the company and on the projects developed, where each user can manage the ones assigned to him.
So the specified platform could, for each user, integrate the management of non-accordances on its system. While the specified platform already has an integration with the Baan platform, this one is considered very simple and it could be extended to obtain more contractual and financial informations about each project and to also allow management of partnerships with suppliers and clients.
The Baan system gathers, within a unique platform, all information relating to a project that can create value, if added, to the platform specified herein.

In addition to the possibilities of integration for this platform this one also has other capabilities such as the possibility of not only the management standards dedicated to space projects to be included on system but also the other two branches, the branch of space engineering standards and the space product assurance standards. These branches have similar structures to the standards included in this document where the principles and requirements are presented and all normative

documents are defined. It would be a valuable addition to this platform to cover all ECSS standards for space projects.
Another interesting feature that would add value to the platform would be auto-fill fields for issuing the required documents within the platform. With this the users would safe time and issue documents in a fastest and efficient way but always complying with the guidelines present in the ECSS standards.
For all that was described in this document it is possible to conclude that a system like the one specified, can be developed for many other areas of project management, representing, due to its usability, added value for any company on this kind of projects.

Annex A - Login and Home screens



Figure 1: Registration request

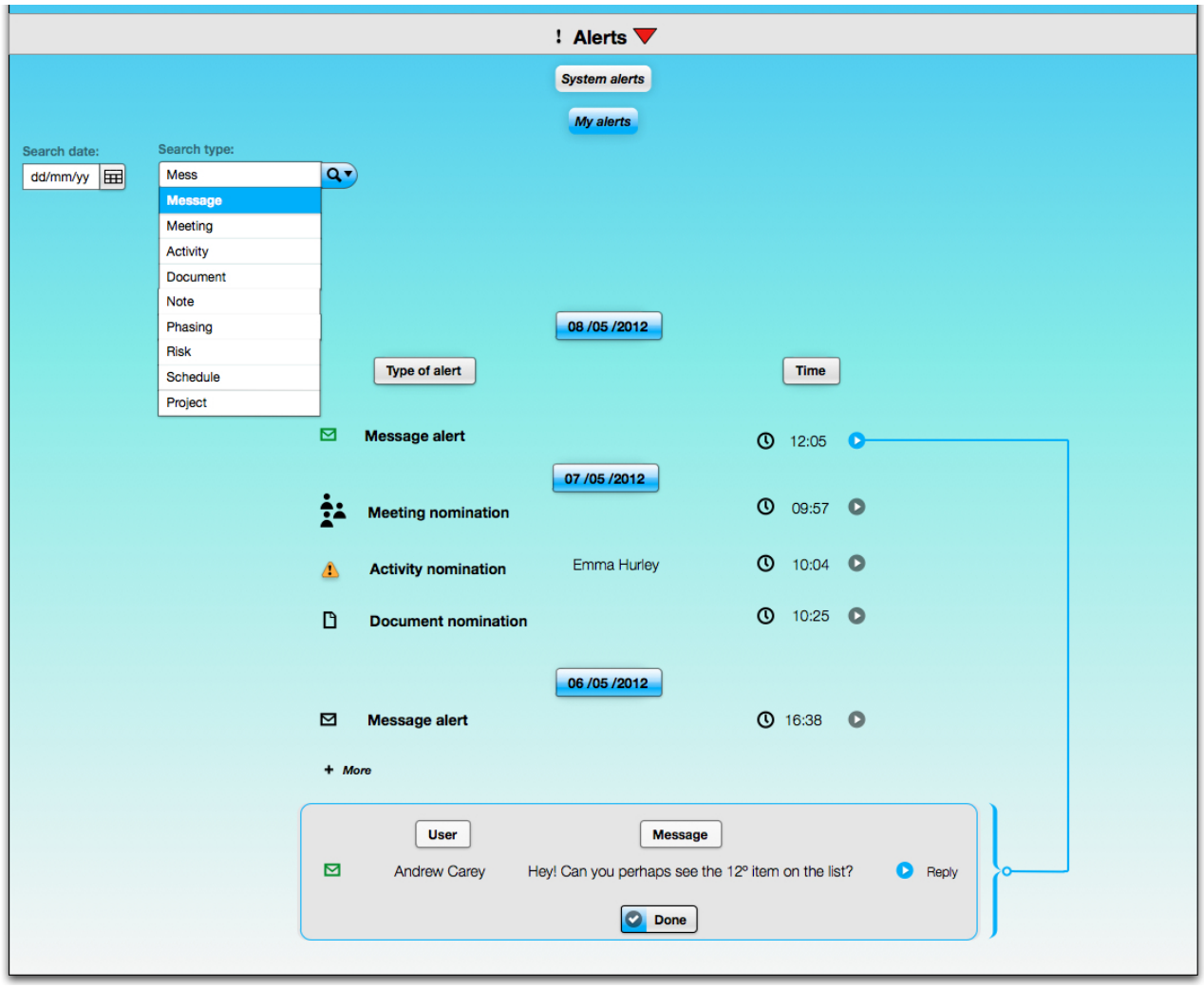


Figure 2: Home - My alerts

Annex B - Create meeting and document selection processes

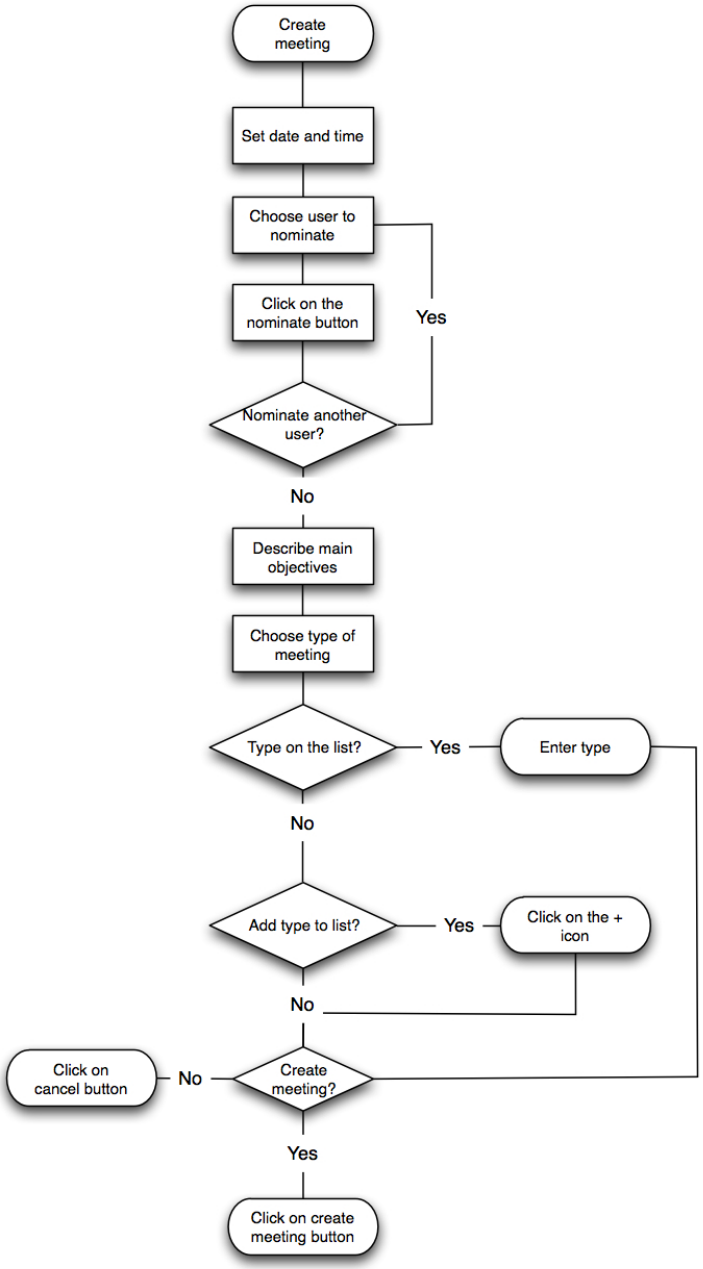


Figure 3: Meetings - Create meeting process

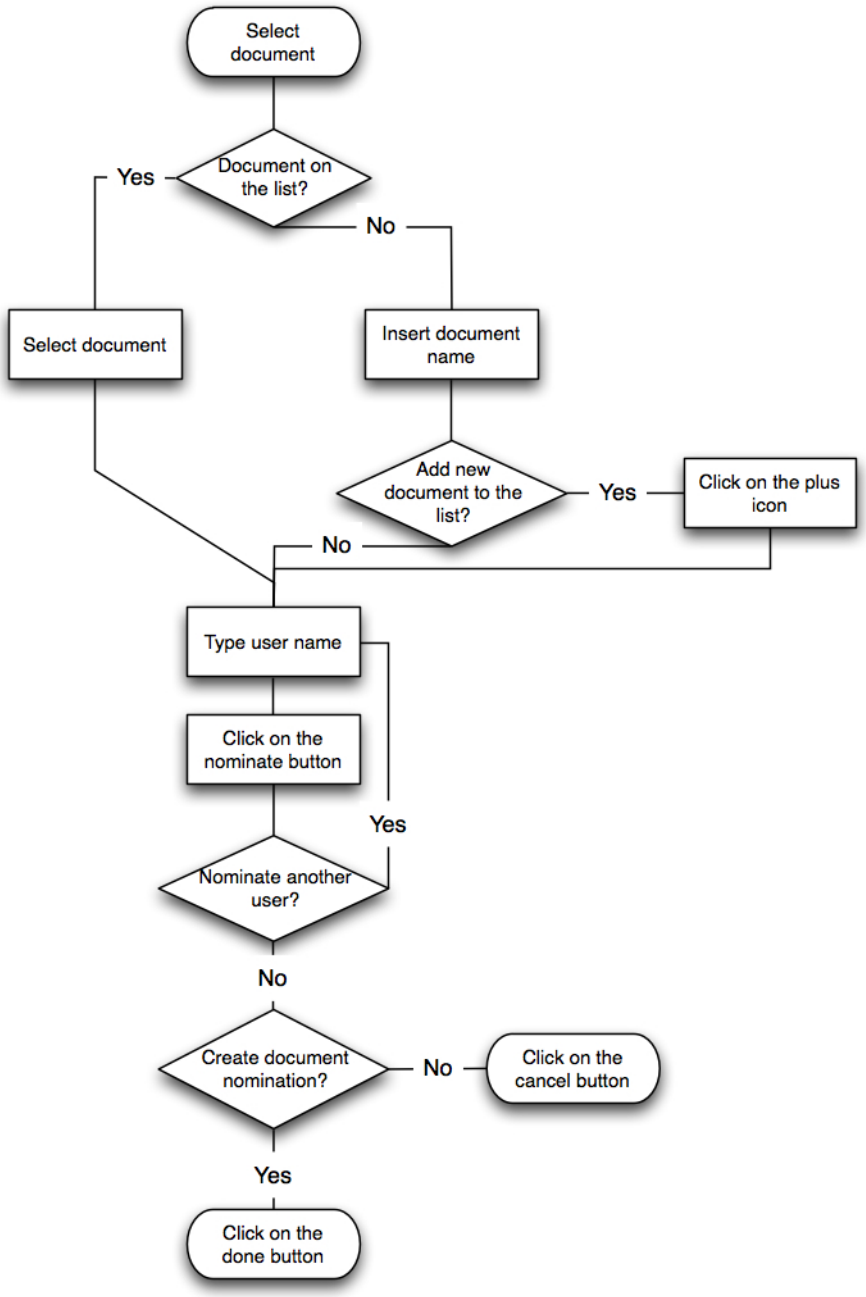


Figure 4: Meetings - document selection process

Annex C - Financial contracts screen

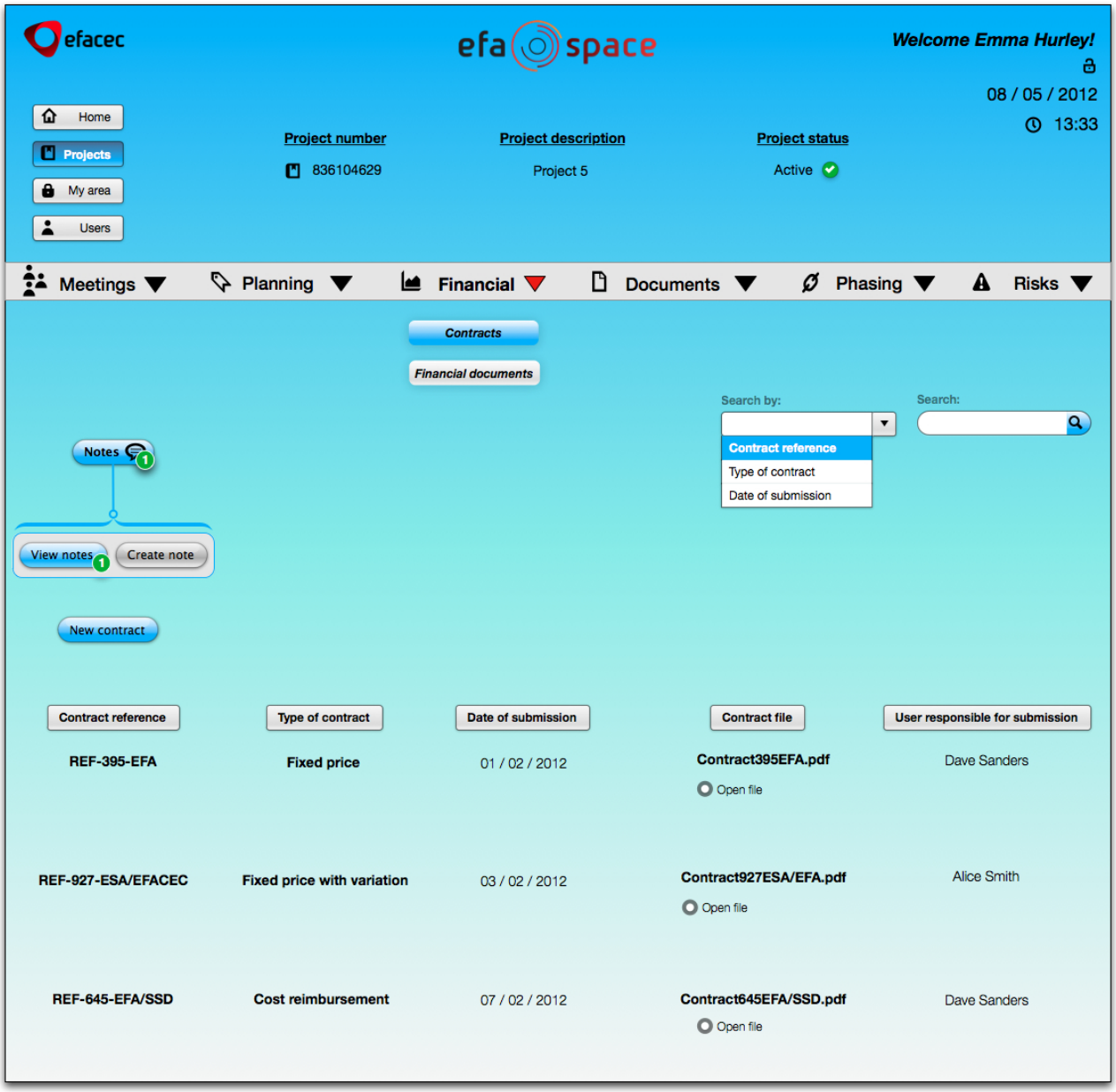


Figure 5: Financial - Contracts

Annex D - Documents area screens

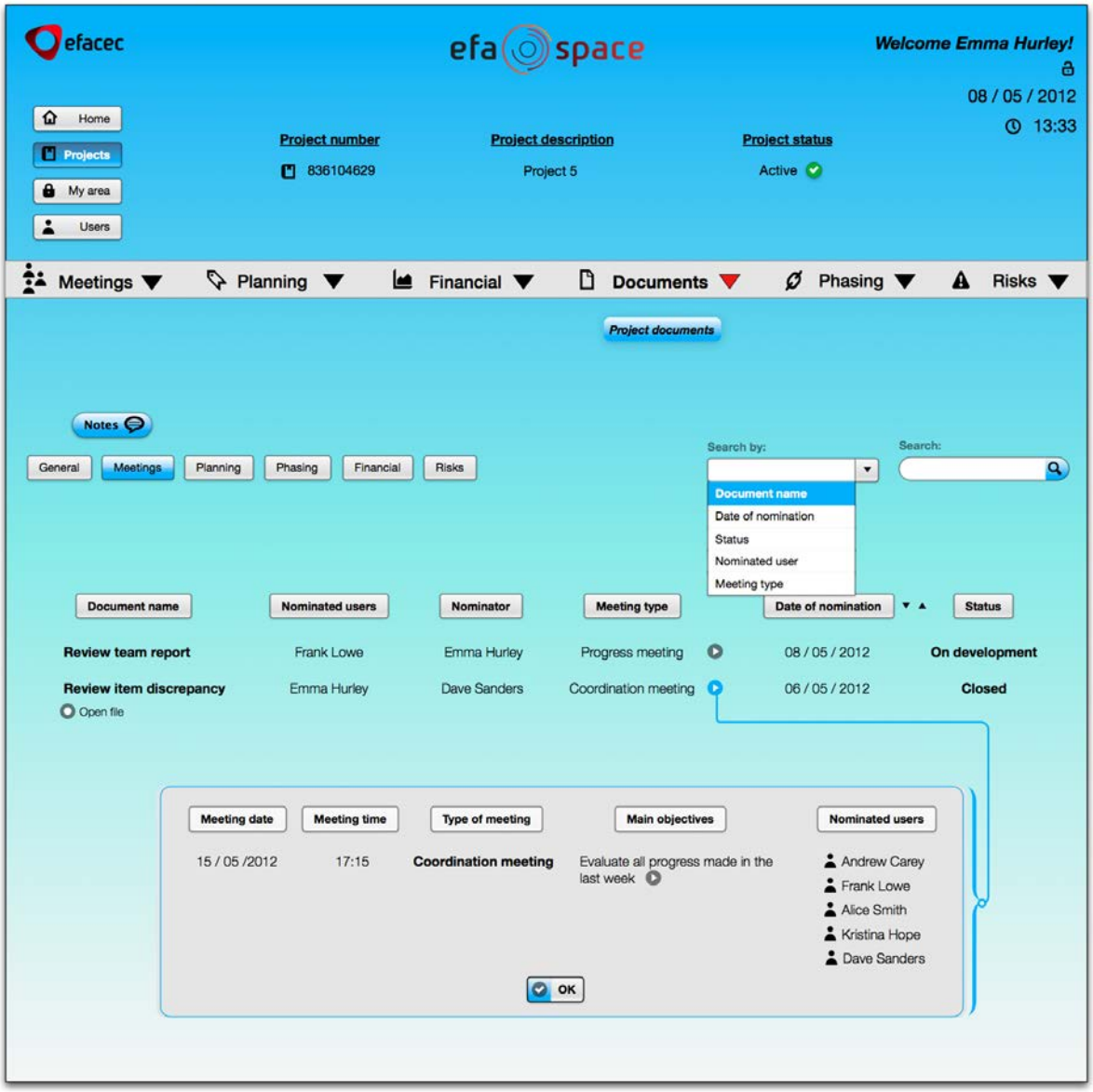


Figure 6: Documents - Meetings

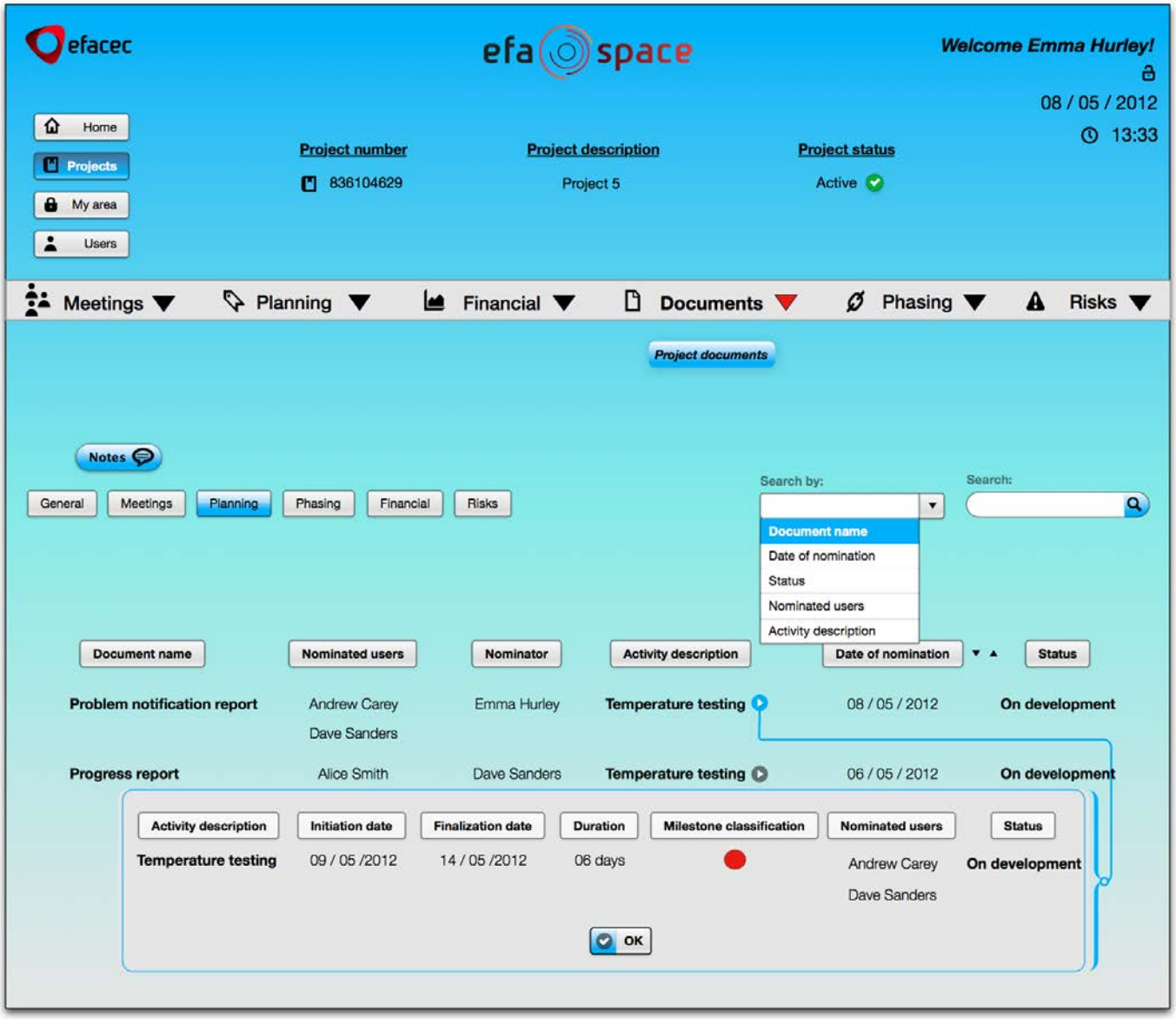


Figure 7: Documents - Planning

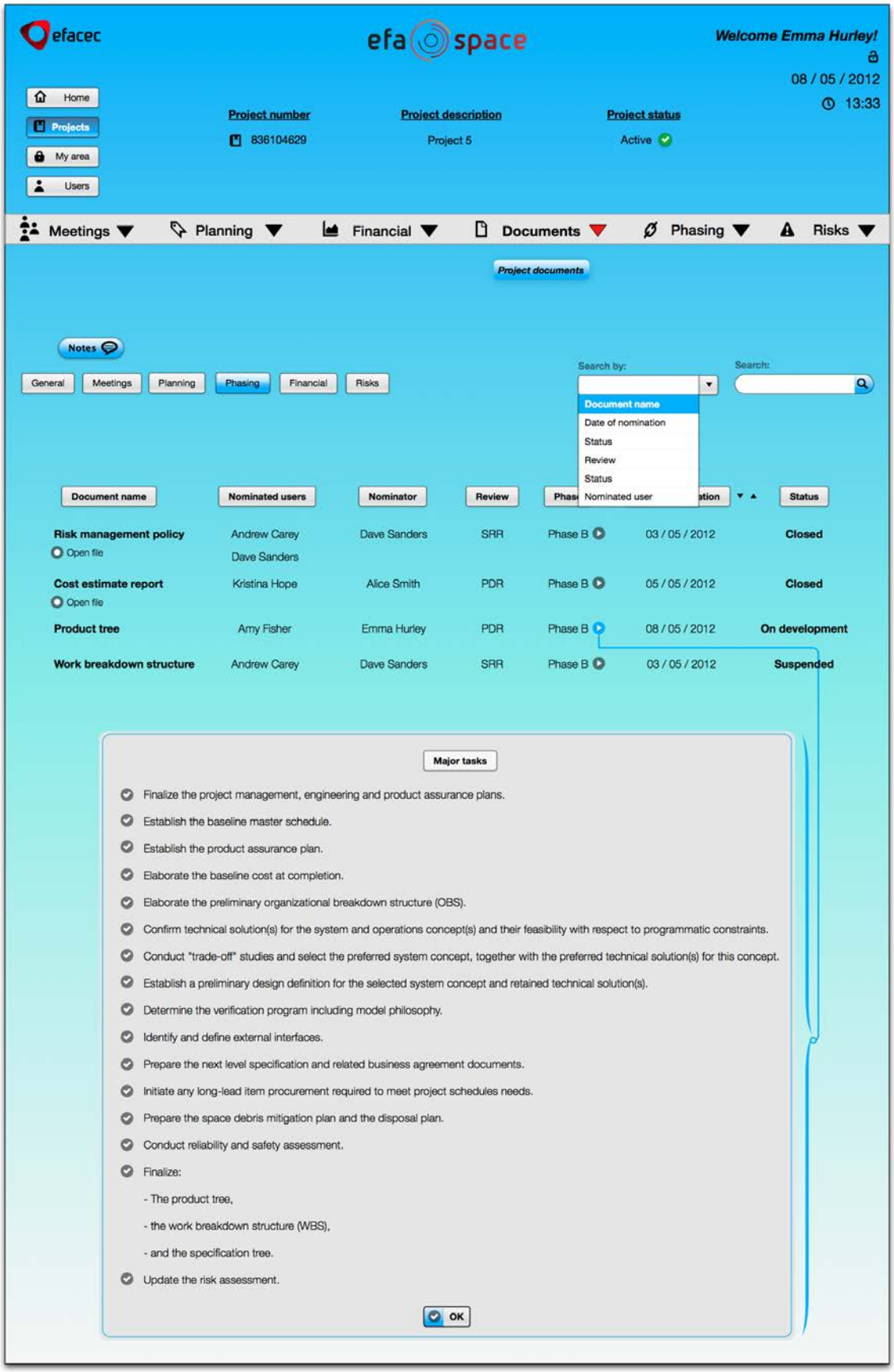


Figure 8: Documents - Phasing

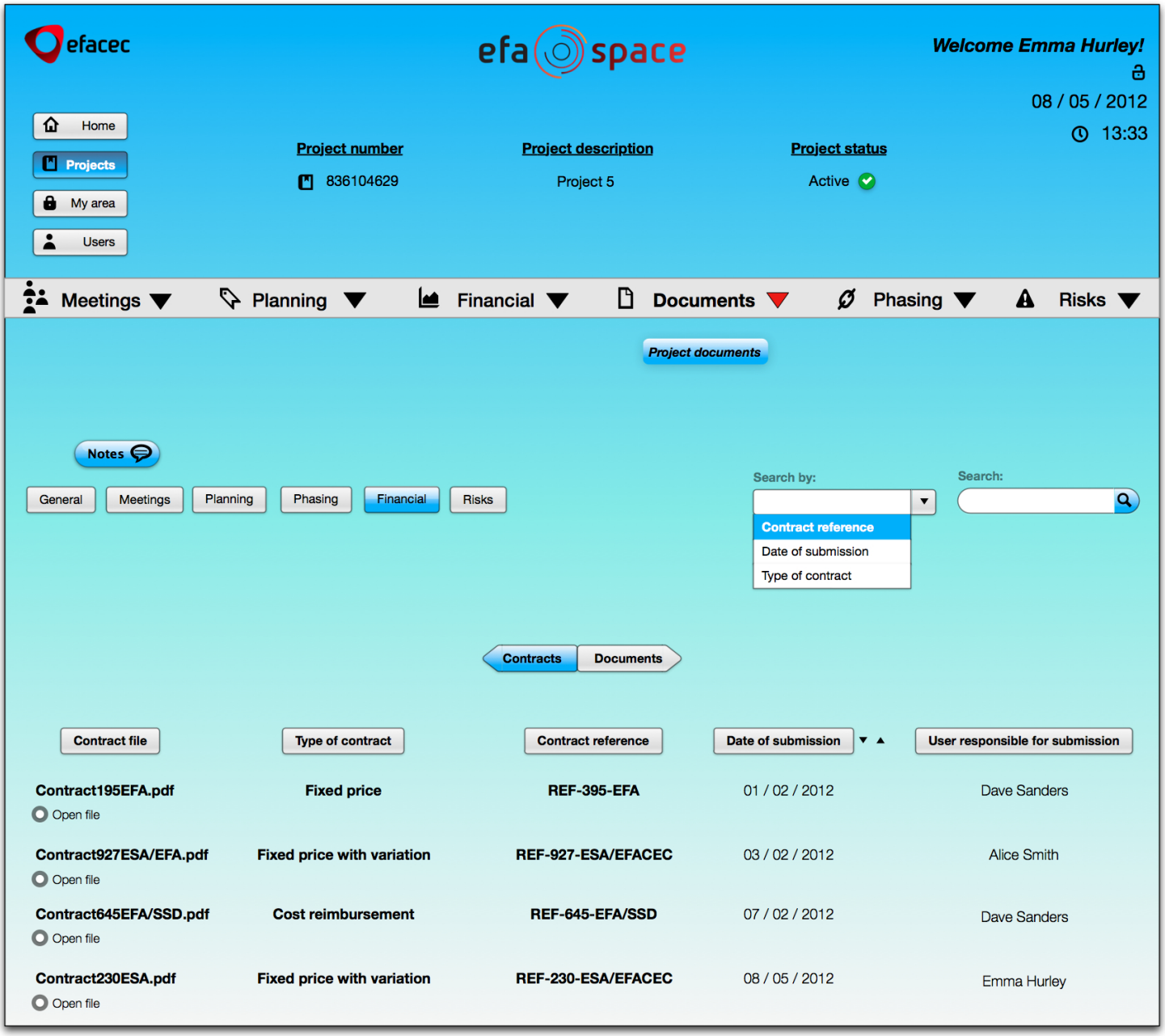


Figure 9: Documents - Financial contracts

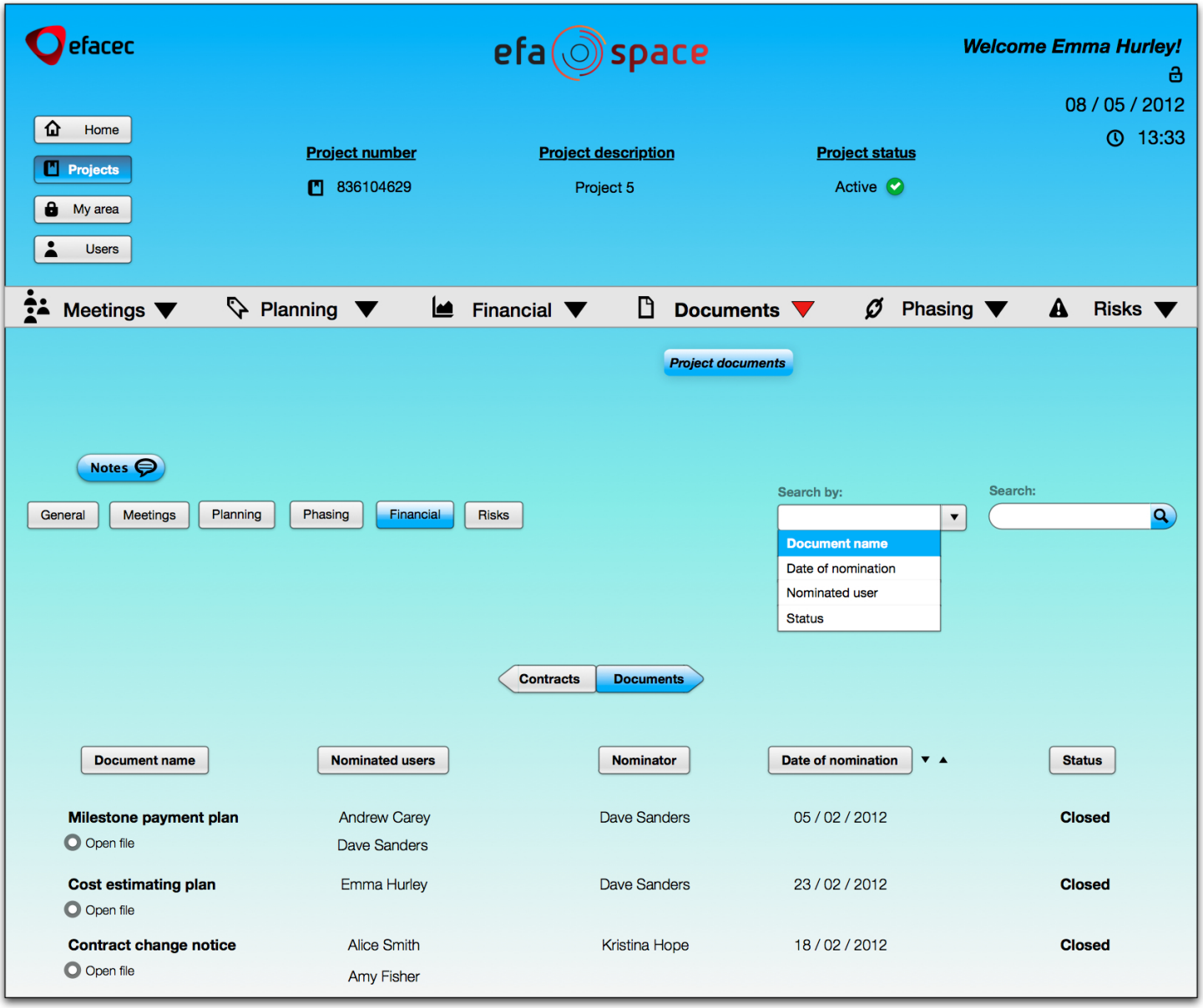


Figure 10: Documents - Financial documents

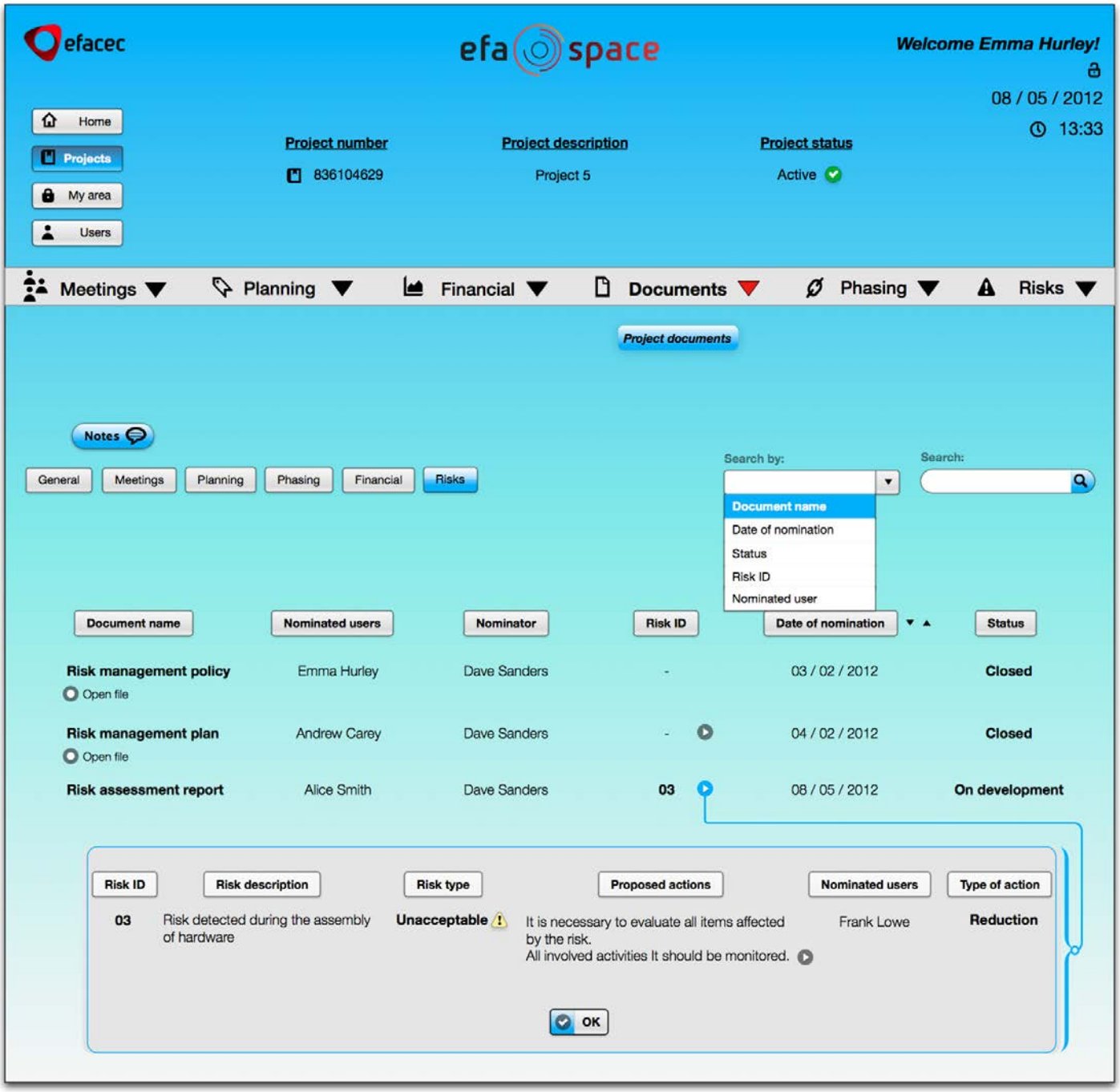


Figure 11: Documents - Risks

Annex E - Phasing area screens

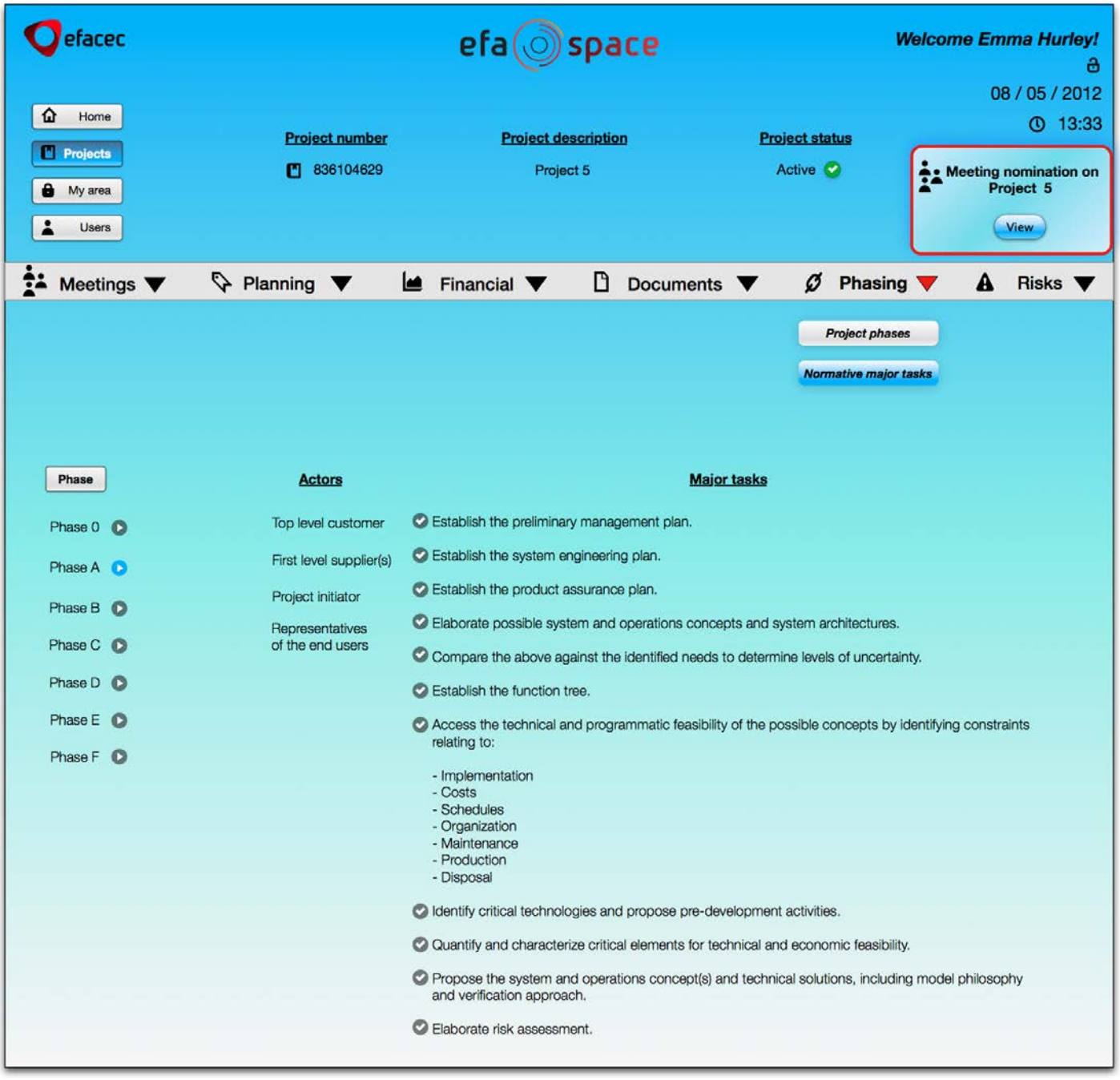


Figure 12: Phasing - Phase A

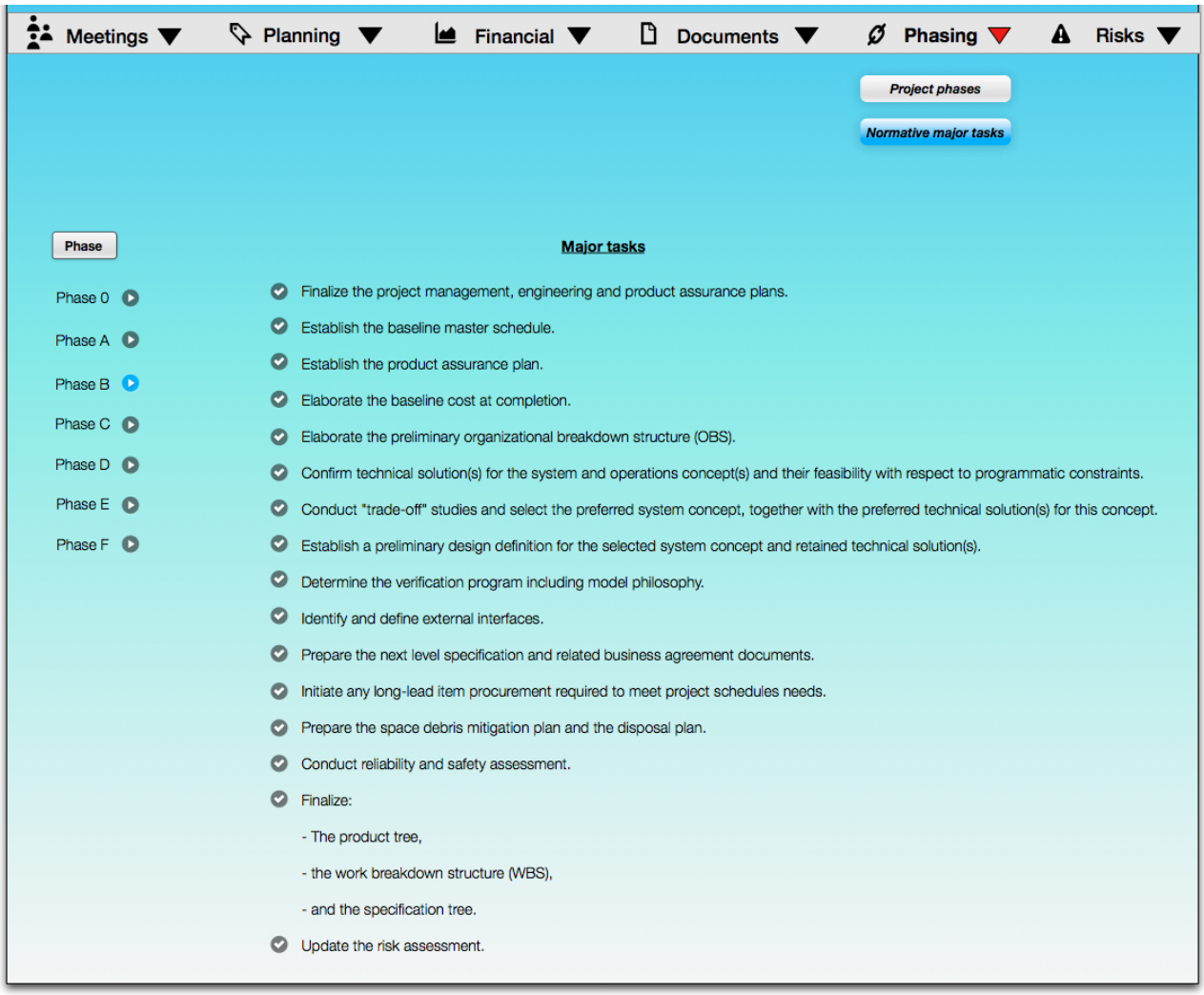


Figure 13: Phasing - Phase B

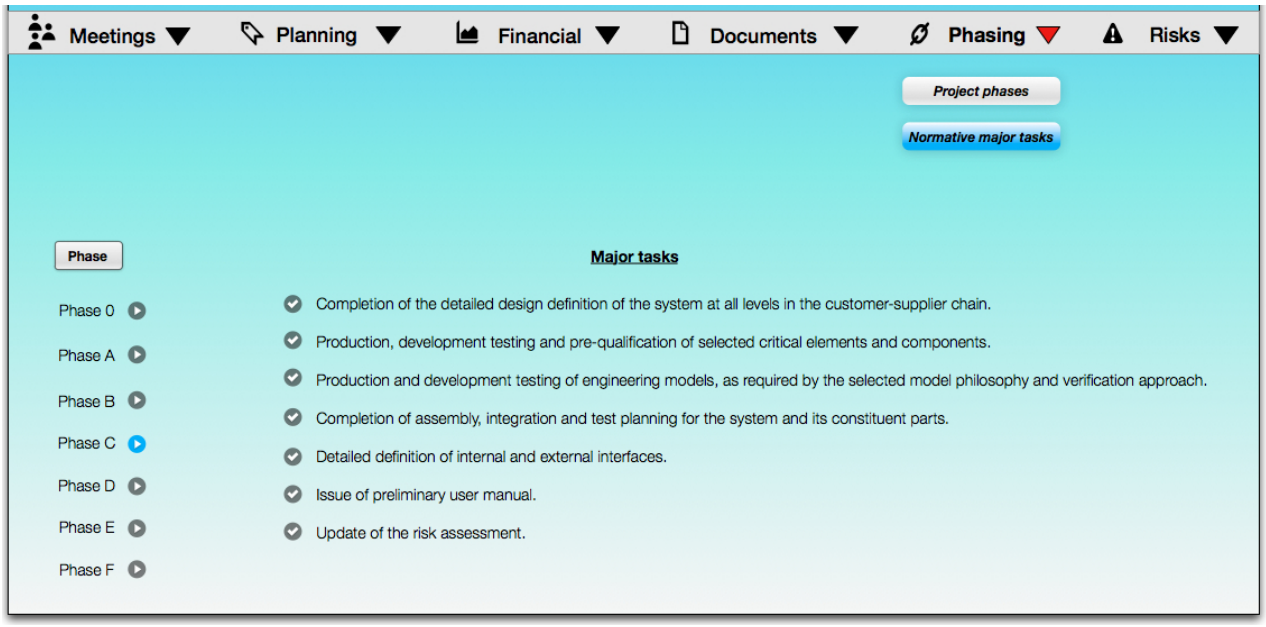


Figure 14: Phasing - Phase C

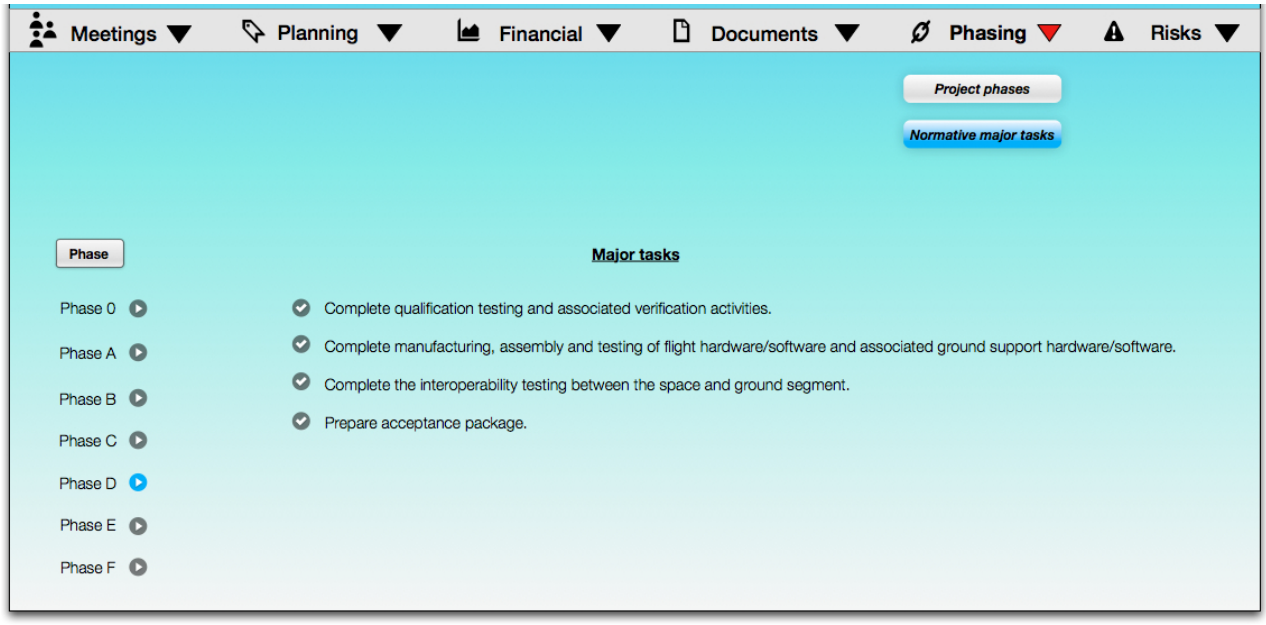


Figure 15: Phasing - Phase D

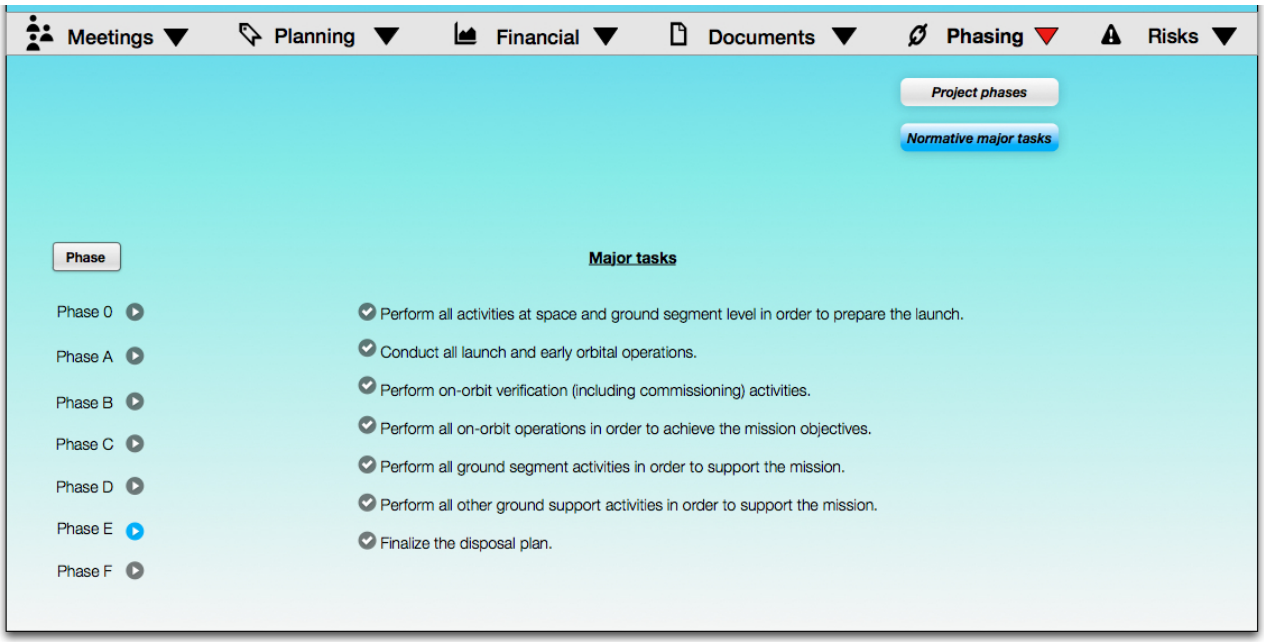


Figure 16: Phasing - Phase E

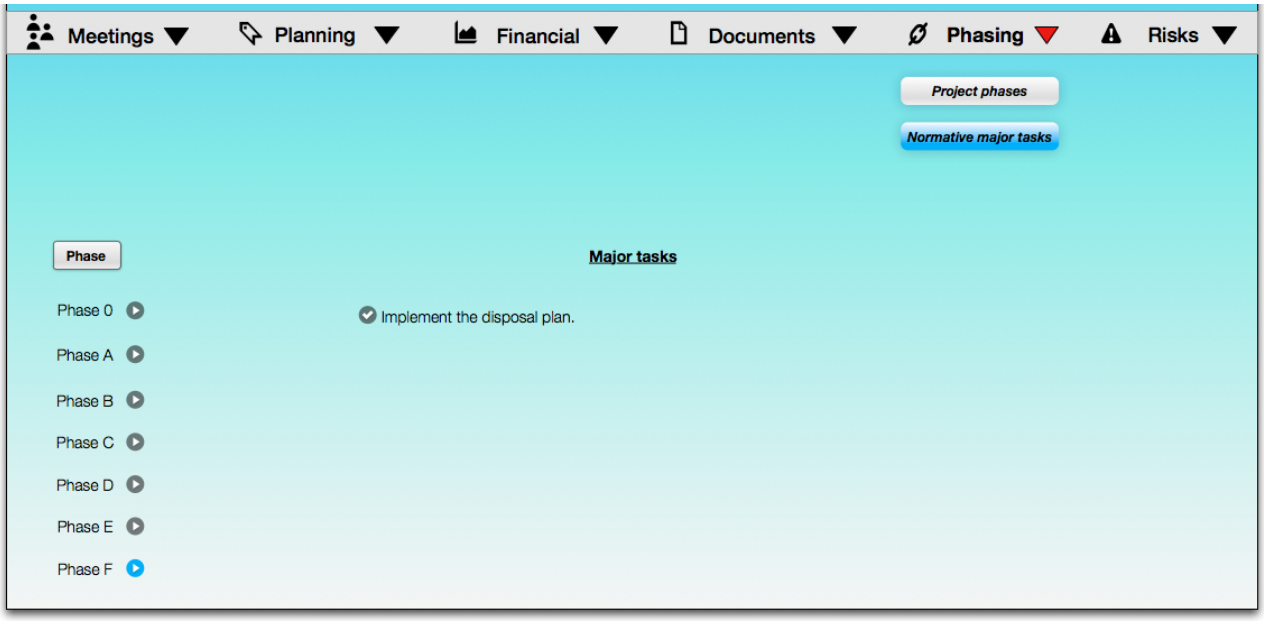


Figure 17: Phasing - Phase F

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