Deliverable Number 6.01

System Integration and Validation Plan

WP 6 – System Integration
Task 6.01 – Definition of Integration Steps

Revision: Final

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## Statement of originality

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Acronyms

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<th>Description</th>
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<td>RAD</td>
<td>Rapid application development</td>
</tr>
<tr>
<td>HW</td>
<td>Hardware</td>
</tr>
<tr>
<td>SW</td>
<td>Software</td>
</tr>
<tr>
<td>FUN</td>
<td>Functional requirement</td>
</tr>
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<td>Non-functional requirement</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>GUI</td>
<td>Graphical User Interface</td>
</tr>
<tr>
<td>DB</td>
<td>Database</td>
</tr>
<tr>
<td>RFID</td>
<td>Radio-Frequency Identification</td>
</tr>
<tr>
<td>NIR</td>
<td>Near-infrared</td>
</tr>
<tr>
<td>RGB</td>
<td>Red Green Blue colour model</td>
</tr>
<tr>
<td>LIDAR</td>
<td>Laser Imaging Detection and Ranging (system)</td>
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<tr>
<td>UML</td>
<td>Unified Modelling Language</td>
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<tr>
<td>FP</td>
<td>Forest Planner</td>
</tr>
<tr>
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<td>Forest Operator</td>
</tr>
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<td>TO</td>
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<td>FIS</td>
<td>Forest information System</td>
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1 Introduction

A clear strategy to monitor and assess the evolution of the project in terms of hardware and software is essential to achieve a complete integration of the different parts of the SLOPE platform. The main purpose of this deliverable is to define a clear process and a set of evaluation criteria to be achieved by all the partners in charge of the development of the SLOPE forest information system and introduce a first reference schema for the system integration report (D.6.02x) and for the system techno-economic evaluation report (D.6.04x).

1.1 Integration Strategy

Software development has been part of computer science from its very beginning and during the last 50 years has experienced an evolution in terms of programming languages going from machine code to assembly language and finally to high level programming (imperative, functional, logic, etc.), and strategies for the construction of very complex application by an high number of developers. Besides some customized methodologies for software development the majority of them can be classified under two different methodologies: Heavyweight, considered as the most traditional strategies embracing rigid step-by-step planning, documentation and design and Lightweight, also known as agile methodologies involving short iterative cycles, tacit knowledge within the development team and closer communication with the customer.

The most adopted heavyweight methodologies are Waterfall, Unified Process and Spiral, briefly described below.

The **Waterfall** approach, accordingly with [1], consist in a rigid sequence of well-defined phases subdivided into a set of activities and deliverables that have to be accomplished before proceeding with the next one. Typically, the first step tries to understand what has to be done, the second one how to do it, the third one is devoted to the actual development the final ones on testing and implementation. A typical sequence is represented in Figure 1. Several variation have been envisioned during the years by adding and removing phases as well as extending the model to increase verification and validation, like in the V-model, but the main concepts remain the same.

The **Unified Process** organizes the development into workflows performed in an iterative and incremental manner as shown in Figure 2. This process makes extensive use of the unified modelling language [3] to represent software structure and behaviour into a set of abstract graphical blocks easily
understandable by non-technical users and thanks to its component based architecture allows the creation of a modular and extensible system.

Figure 1: Waterfall development process

Figure 2: Unified development process

By looking at Figure 2, it clearly appears how the effort is allocated during the development. Different phases run in parallel and the testing one has several peaks representing validation loops during the implementation.

The Spiral model, combines elements from design and prototyping in an effort to improve the waterfall model and ensure better risk assessment and planning, collecting feedbacks from customers. It can be subdivided into 4 steps that are performed at each development loop to incrementally build working prototypes that can cope with changing requirements over time: objective detection, assessment and reduction of risks, development and validation and planning.

The main peculiarities of all these heavyweight methodologies are, among the others, the advanced planning on the short and long period, extensive requirement documentation as the main reference, specific procedure for each involved actors and the adoption of tools for each task.
In contrast with the aforementioned techniques, the last decade has assisted to a new way of managing software development answering the needs of continuous maintenance and improvement, fast implementation and closer customer relations. The term AGILE Modelling indicates a set of methods in which requirements and solutions evolve through collaboration between self-organizing cross-functional teams focused on high quality software. The main principles behind this term have been summarized inside a document, called Agile “Software Development” manifesto [4], written by a number of representatives from some of the main methods available. Among the others some of the main principles are: customer satisfaction, openness to requirements changes, frequent delivery, collaboration between customer and developer, face-to-face conversation, simplicity and technical excellence in software design.

The most important agile techniques are extreme programming and scrum.

**Extreme programming**, can be seen as a way to solve the problems caused by traditional long development cycles and, as stated by [1], it is characterized by short development cycles performed through pair programming (two programmers on the same computer), simple design, incremental planning of effort together with the customer and short release time. An overall schema is shown in Figure 3.

![Extreme Programming](image)

**Figure 3: Extreme Programming**

**Scrum** (shown in Figure 4) is an iterative and incremental process of development or work management where team members are focused on flexible systems subject to constantly changing requirements. Each iteration produces a working system with increased functionalities. The scrum process is characterized by a set of practices to achieve the objectives and keep the focus on what really matters:

- *Product backlog* including a prioritized list of features to be implemented;
- *Sprints periods* where an incremental version of the product is produced;
- *Sprint planning meetings* together with customers, users, management and development team;
• **Sprint backlogs** with the list of features to be achieved within a sprint and finally;

• **Daily scrum** short meetings to keep track of the work in progress.

While a usual development approach foresees project managers directing the project and telling a team what to do, scrum relies on self-organization. Although this technique is widely adopted and has generated significant productivity improvements [5], “Clearly, Scrum is not an approach for large, complex team structures, but we found that even small, isolated teams on a large project could make use of some elements of Scrum. This is true process diversity” [6].

![Figure 4: Scrum development](image)

According to Highsmith and Cockburn [7], “what is new about agile methods is not the practices they use, but their recognition of people as the primary drivers of project success, coupled with an intense focus on effectiveness and manoeuvrability. As stated by [1] we can summarize the differences between agile methodologies and heavyweight ones in the following list:

• Oriented to people, considered the most important part of the project
• Adaptive to changes
• Focus on actual results instead of compliance with the plan
• Flexibility and planning balance
• Empirical process subject to several trials
• Decentralized approach in contrast with autocratic one
• Simplicity of the design to be ready for changes
• Collaboration with customers on a daily basis
• Small self-organizing teams

Considering the aforementioned development strategies with their positive and negative aspects and the fact that the project involves several actors and a number of development groups for hardware and software interfaces, the SLOPE project tries to combine the advantages of both strategies into an hybrid development plan based on waterfall integration and agile development, described in details in section 1.2.
1.2 Process overview

To achieve a complete integration of the different components that are part of the SLOPE platform, it is essential to have a clear plan on how to connect the different elements developed by the consortium and define a strategy for the testing of their functionalities.

As shown in Figure 5, the integration process will involve the outcomes of three main work packages (WP): WP 2, including the 3D planning for harvesting system showing the forest model reconstructed from UAV and TLS systems, enriched with routing and logistic optimization; WP 3 including the data coming from harvesting hardware like head processor and cable crane; and finally WP 5 including the common SLOPE database and online services for purchasing/invoicing, real-time operations control and optimization. Each one of them is part of the overall scenario represented in Figure 6, which involves several different actors and use cases with a multitude of requirements.

Referring to this new workflow, their actors, use cases and components, the integration process that will be followed foresees three major loops of integration and lab validation (waterfall approach), each one with a series of 3/4 iterative evolution loops (agile approach). The goal of this strategy is the achievement of high integration frequency and bug fixing in laboratory conditions, necessary to cope with the pilot tests in the real scenarios, planned after only 3 months of system integration.
The three main integration steps, matching tasks 6.2, 6.3 and 6.4, as planned in the description of work will be:

1. Forest inventory and harvesting system integration: where the SLOPE forest data model described and deployed in task 5.1 will be exposed and connected with the on field hardware instruments which in turn will be integrated into the tracking system and with the planning and visualization tools developed in work package 2.
2. Forest management integration: where results of on-the-field data collection from work package 4 will be connected with the central forest information database and used by the data analysis and synthesis services developed on top of them.
3. System validation: where the integrated system will be validated and tested.

Figure 7: Forest information System (FIS) database schema

Each one of these phases will involve a number of components foreseen within the component diagram in Figure 8 as well as a number of tables and relations of the compressed database schema of Figure 7 and described in details in the upcoming deliverable D.5.01 “inventory module of the FIS”. The following chapters will follow these three main integration steps describing, for each one of them, the following aspects:

- **Components involved within the integration** based on the component diagram and the database schema;
- **Timeline** and integration approach with Gantt diagram and deadlines;
- **Testing scenario**;
- **Involved actors among those defined in deliverable 1.03 and 1.01**;
- **Hardware and software requirements** to execute the tests;
- **Functional and non-functional requirements** to be checked;
- **Testing approach**;
It is important to notice that the research nature of the project could lead to changes in the final dates presented in the following chapters due to unexpected progresses or delays. For this reason, the proposed deadlines should be taken only as an indication of the desired timings for the achievement of the final integrated platform.

Figure 8: Forest information system (FIS) component diagram

1.3 Organization of the document

The remainder of the document is organized following the three main integration steps defined in the description of work and introduced in section 1.2. Chapter 2 will be devoted to the first integration step between the forest inventory and the harvesting system while chapter 3 will be devoted to the second integration step with the forest management system. Finally an overall validation is described in chapter 4, followed by a conclusion chapter and some references.
2 First Integration Step – Forest Inventory and Harvesting System

The first integration step involves the elements and actors defined in the contexts of work packages 2, 3 and 5. This phase is probably the most critical one representing the first step towards an integrated platform between a number of services and hardware devices. Particular attention will be paid to reduce custom data formats and simplify communication as well as promptly adapting the data model and its Web Services to the needs of the involved components and actors.

2.1 Involved Components

The picture above highlights the four components involved in the first integration phase. More in details the SLOPE FIS at the center, including the forest data model and the web service, will expose functions to update and retrieve forest data in a format, which depends on the other components and will evolve during the iterative loops. This component, accessed by the 3D Modelling for harvesting planning system, will allow tree data visualization on top of the 3D forest model, with imageries datasets collected during the UAV and TLS surveys, optimized and streamed by GraphiTech servers. In parallel with the data consumption, data submission will be possible through a number of on-the-field sensor-equipped devices, like cable crane, processor heads, RFID readers and truck emitters. Each one of these four agents will have their own set of web interfaces to add and retrieve data from the FIS inside their specific database tables (e.g. routing optimization DB schema).
2.2 Timeline and integration approach

A timeline with the main milestones for the first integration phase is shown in the following picture.

![Timeline Diagram]

**Figure 10: First integration validation and deliverables**

As it clearly appears, 4 agile-like integration sprints (on a bimonthly basis) have been planned with a monitoring telco of 1-2 hours planned every 2 weeks. More in details, the third and fourth loop will be executed in parallel with the start of the second integration phase, progressively replacing the first one. This approach differs from the standard agile one which foresees daily meetings with the development team, and a sprint length of one month, but is justified by the size of the team involved in the development and the amount of hardware and software components to be developed and integrated which makes difficult to maintain an high rate of reporting and monitoring during the entire integration process.

At the end of each integration sprint, a round of testing is planned, reproducing the testing scenario of section 2.3 following the process described in section 2.8. Each testing will highlight the achieved functionalities and bugs to be fixed contributing to the incremental shape of the first system integration report (D.6.021), whose draft template is provided in chapter 6.

In terms of components integration, an effort will be perfused to achieve the following high-level integration sequence:

1. Connection of the 3D modelling for harvesting planning developed in the context of task 2.4 with the services of the FIS, exposing the data available within the database inside the 3D forest model;
2. Connection of handheld devices (e.g. RFID UHF readers) with the FIS web interfaces to upload and download data;
3. Connection of cable crane and processor head enhanced hardware with the FIS web interfaces to upload data;
4. Connection of truck control units with the FIS web interfaces to upload road and logistic data;
5. Connection of planning and editing functionalities already available in the 3D modelling for harvesting planning system with the FIS.
2.3 Testing scenario

Recalling what already described in the deliverable D.1.1 “Definition of requirements and system analysis”, the testing scenario for the first integration phase will mainly focus on the forest surveying and harvesting activities with real-time or almost real-time update of the forest information system. More in details, a forest owner interested in selling parts of its real-estate starts an inventory phase where satellite images are used for a first screening and characterization of the forest and the surrounding areas. This data is used for planning the collection of more detailed data by means of low altitude sensors mounted on UAV and on-field laser scanners. Data generated for all sources are harmonized for the generation of a 3D forest model which is then uploaded on the web map services to be visualized by the 3D modelling for harvesting planning tool and used for the reconstruction of a canopy model and geo-reference the position of each tree in the surveyed stand. All this forestry data is then uploaded on the FIS, visualized inside the integrated SLOPE viewer and used by forest planner for “virtual marking”, identifying trees to be felled according to their position, characteristics and commercial value. The viewer will show all the available digital data, such as property limits, road network (public, forest, etc.), protected areas, soil types, etc.

After this marking process, the viewer will be used to assist the chain of harvesting operations, identifying the optimal positioning of landings and cable-ways through an advanced simulation editor. After that, a professional forester inspects the property for the final tree marking considering all the results of 3D forest model and supported/guided by a digital map and GPS. The forester may confirm the virtual marking or change it accordingly to the result of his survey. If the tree has to be felled, a visual mark is applied together with a unique RFID tag which code is linked into the FIS, otherwise a report will be issued from a handheld device to the system, reporting the reason why the tree has been discarded. Manual tree felling operations, as well as trees extraction will be also reported to the FIS providing cutting time, log tree identification and cable crane load weight while the head processor thanks to its sensors will evaluate the quality of each cut log, combining different indices to generate a qualitative classification in accordance with standard UNI EN 1927-1 2008.

Logistic operations like logs transport and storage will be optimized and monitored from the slope viewer, minimizing the risk of intermediate storage saturation (mountain landings are typically small, and once full the extraction must be interrupted). To achieve this functionality, their movements will be tracked by means of in-vehicle GPS systems and RFID readers.

The aforementioned testing scenario will be collectively simulated in laboratory condition using the same hardware and software deployed on the field in the context of work package 7.
2.4 Involved actors

The actors involved in this first integration phase can be summarized in the following list, which recalls for every actor its definition from D.1.03:

- Forest Planner (FP): involved in the decision making processes for managing harvesting on forest areas;
- Forest Operators (FO): representing the persons involved directly on field forest operations, like the coordinator of operations for the harvesting company;
- On-field Harvesting Operator (HO): representing the persons involved on the harvesting operations, like the harvesting machine pilot;
- Forestry expert (FE): representing all the figures that are involved in a directly analysis of the forest, from forestry to silvicultural aspects, with the aim of environmental conservation and protection or wood product optimization;
- Cableway Operator (CO): representing the persons managing and controlling the cable crane system

2.5 Hardware and software requirements

The list of hardware and software required for the execution of the first testing scenario is the following:

- Hardware
  - RFID Handheld (Tablet / Smartphone)
  - GPS Sensor (integrated inside the handheld or external)
  - Industrial PC installed inside the harvesting machine
  - CompactRIO Custom system
  - Desktop Computer
  - Wifi/3G connectivity

- Software
  - 3D Planning for Harvesting software
  - Forest Information System (Web Services and Database)
  - Web Mapping Service (GeoServer)

It is important to notice that the aforementioned list is not exhaustive and may be change in the future in accordance with the needs emerging during the project and the iteration loops.
2.6 Functional Requirements

The functional requirements that can be foreseen for the first integration phase are summarized in the following list:

Table 2-1: First integration step functional requirements

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<tr>
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<td>Authentication</td>
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<tr>
<td>1.1</td>
<td>Create a new account</td>
<td>LOW</td>
</tr>
<tr>
<td>1.2</td>
<td>Login to the system</td>
<td>LOW</td>
</tr>
<tr>
<td>1.3</td>
<td>Logout from the system</td>
<td>LOW</td>
</tr>
<tr>
<td>2</td>
<td>Navigation</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Navigate the forest map (Pan, Zoom, Tilt)</td>
<td>HIGH</td>
</tr>
<tr>
<td>2.2</td>
<td>Flight to a specific area</td>
<td>HIGH</td>
</tr>
<tr>
<td>2.3</td>
<td>Switch between different map data</td>
<td>HIGH</td>
</tr>
<tr>
<td>3</td>
<td>Analytics</td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>Show satellite imagery</td>
<td>HIGH</td>
</tr>
<tr>
<td>3.2</td>
<td>Toggle aerial imagery visualization of the stand</td>
<td>HIGH</td>
</tr>
<tr>
<td>3.3</td>
<td>Toggle NIR imagery visualization of the stand</td>
<td>HIGH</td>
</tr>
<tr>
<td>3.4</td>
<td>Toggle open data visualization</td>
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<td>3.5</td>
<td>Toggle digital surface model visualization</td>
<td>HIGH</td>
</tr>
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<td>3.6</td>
<td>Distance measurement</td>
<td>HIGH</td>
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<td>3.7</td>
<td>Area measurement</td>
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</tr>
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<td>3.8</td>
<td>Terrain profiling</td>
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<td>3.9</td>
<td>Point of interest visualization</td>
<td>MEDIUM</td>
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<td>4</td>
<td>Operation</td>
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<td>4.1</td>
<td>Cableway planning</td>
<td>HIGH</td>
</tr>
<tr>
<td>4.1.1</td>
<td>Add/Remove pillars</td>
<td>HIGH</td>
</tr>
<tr>
<td>4.1.2</td>
<td>Show harvesting area</td>
<td>HIGH</td>
</tr>
<tr>
<td>4.1.3</td>
<td>Show cable information (angles, height from terrain, length)</td>
<td>HIGH</td>
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<td>4.1.4</td>
<td>Show cable line profile</td>
<td>MEDIUM</td>
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<td>Working area setup</td>
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<td>4.2.1</td>
<td>Draw working area</td>
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<tr>
<td>4.2.2</td>
<td>Place harvesting machines</td>
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<tr>
<td>4.2.3</td>
<td>Place other resources</td>
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<td>4.2.4</td>
<td>Plan routes</td>
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<td>4.3</td>
<td>Track felling activities</td>
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<td>4.4</td>
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4.5  **Track logistics**  MEDIUM
4.5.1 Show truck movements  MEDIUM
4.5.2 Track wood storage areas  MEDIUM
4.5.3 Track sawmills  MEDIUM
4.5.4 Show logs inventory  MEDIUM
4.6  **Track harvesting progress**  HIGH
4.6.1 Real-time updates and statistics  MEDIUM
4.7  **Show weather conditions and forecast**  HIGH

5  **Forest**
5.1  **Toggle stand visualization**  HIGH
5.2  **Toggle simple tree models visualization (from UAV)**  HIGH
5.3  **Toggle complex tree models visualization (from TLS)**  HIGH
5.4  **Single tree selection and inspection**  HIGH
5.5  **Single tree virtual marking**  HIGH
5.5.1 Issue a report  MEDIUM
5.5.2 Update tree properties (Quality indices, status, etc.)  HIGH
5.6  **Retrieve forest area information**  MEDIUM

6  **Other**
6.1  **Save harvesting plan**  MEDIUM
6.2  **Load harvesting plan**  MEDIUM

### 2.7 Non-functional requirements

The non-functional requirements that can be foreseen for the first integration phase are summarized in the following list:

<table>
<thead>
<tr>
<th>ID</th>
<th>Description</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Forest Information System (FIS)</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>User friendliness</td>
<td>HIGH</td>
</tr>
<tr>
<td>2</td>
<td>Compatibility with all the desktop browsers</td>
<td>HIGH</td>
</tr>
<tr>
<td>3</td>
<td>Compatibility with mobile browsers</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>4</td>
<td>Cross platform</td>
<td>HIGH</td>
</tr>
<tr>
<td>5</td>
<td>Dynamic interface</td>
<td>MEDIUM</td>
</tr>
</tbody>
</table>

#### Mobile scenario

<table>
<thead>
<tr>
<th>ID</th>
<th>Description</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Easy identification of virtually marked trees on the field</td>
<td>HIGH</td>
</tr>
<tr>
<td>7</td>
<td>GPS signal should work in the forest</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>8</td>
<td>Offline fault tolerance</td>
<td>MEDIUM</td>
</tr>
</tbody>
</table>
In-vehicle scenario

8 Offline fault tolerance MEDIUM

2.8 Testing approach

The testing of the aforementioned requirements will be performed on a bimonthly basis after each integration loop. Depending on the complexity of the integrated components one or two days will be devoted to test each requirement in laboratory conditions. The testing results will be reported on an incremental document based on the requirements table with a list of detailed functional tests.

A functional test will be structured following the schema reported in Table 2-1, consisting of a progressive number, a description of the test situation, a description of the expected results, the gained results and, if any, the detected anomaly.

<table>
<thead>
<tr>
<th>Test N°</th>
<th>Test case Description</th>
<th>Expected result</th>
<th>Obtained Result</th>
<th>Anomaly</th>
<th>Performed</th>
<th>Passed</th>
</tr>
</thead>
</table>

The threshold of working functionalities to be reached within this integration step is 70%.
3 Second Integration Step – Forest Management

The second integration step introduces the elements and actors defined in the contexts of work packages 4 and part of work package 5 together with the elements described in chapter 2. This phase enriches the previous one with the addition of qualitative and quantitative analysis to develop dedicated simulations models for evaluating productivity and costs under different scenarios, identifying bottlenecks and critical elements to be solved.

3.1 Involved Components

Figure 11: Second integration step involved components

Figure 11 highlights the components involved in this integration phase. What is new from section 2.1 is a major focus on the services components of the project that are responsible for the setup of online control of operations (Treemetrics services) and online purchasing/invoicing system (MHG System). Both systems are strictly dependent with the results gained within work package 4 to define prices and take decisions about type and quantity of wood to be harvested, stored and delivered to the marked. For this reason, a crucial role will be the development of specific spatial queries for the FIS to be exposed to the slope viewer and to the system already working on MHG and Treemetrics premises. Additionally an effort is planned for the introduction of logistic software optimizations based on the outcomes of deliverable D.2.5 “Road and logistic simulation module”.

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3.2 Timeline and integration approach

A timeline with the main milestones for the first integration phase is shown in the following picture.

![Timeline](image)

**Figure 12: Second integration validation and deliverables**

As shown, 4 agile-like integration sprints (on a bimonthly basis) have been planned with a monitoring telco of 1-2 hours planned every 2 weeks. More in details, all the loops will be executed in parallel between the end of the first integration phase and the start of the final one, contributing to the finalization of the first system integration report (D.6.021).

At the end of each integration sprint, a round of testing is planned, reproducing the testing scenario of section 3.3 following the process described in section 3.8. Each testing will highlight the achieved functionalities and bugs to be fixed contributing to the incremental shape of the second system integration report (D.6.022).

In terms of components integration, an effort will be perfused to achieve the following high-level integration sequence:

1. Refinement of already existing Webservices to access the FIS;
2. Development of new Webservices functions to cope with online purchasing/invoicing, real-time operation control and logistic optimization;
3. Connection of purchasing/invoicing system with the FIS;
4. Connection of real-time operation control system with the FIS;

3.3 Testing scenario

In accordance with the description provided inside the deliverables D.1.1, the second integration phase will refine the first phase, focusing on real-time data provisioning especially from the grading system. All involved machines, sending real time / daily data on their activity and the products generated, enable the real-time enterprise resource planning (ERP) platform. This platform, connected
with the FIS provides monitoring tools to the forest planners, allowing optimization of the logistic operations, minimizing the risk of intermediate storage saturation with an efficient management of the transport fleet. The second components to be integrated thanks to incoming on the field data, is the online auction system where logs (as well as biomass) are sold while being extracted. This system allows end users to directly purchase the desired wood assortments, already sorted in quality classes within the forest to avoid the intermediate storage costs, minimize the transport and yard costs and excludes the delivery of undesired assortments.

3.4 Involved actors

The main actors involved in this second integration phase can be summarized in the following list, which recalls for every actor its definition from D.1.03:

- Forest Planner (FP): involved in the decision making processes for managing harvesting on forest areas;
- Forestry expert (FE): representing all the figures that are involved in a directly analysis of the forest, from forestry to silvicultural aspects, with the aim of environmental conservation and protection or wood product optimization;
- Truck operator (TO): representing all the figures involved in the in-vehicle operations;

3.5 Hardware and software requirements

The execution of the second testing scenario requires the same hardware and software of the first integration step with the addition of:

- Hardware
  - In-vehicle GPS system
- Software
  - Real-time enterprise resource planning system
  - Online selling and auction system
  - MHG Mobile app

3.6 Functional Requirements

The functional requirements that can be foreseen for the second integration phase are summarized in the following list and should be considered as an integration of the list provided in section 2.6:
Table 3-1: Second integration step functional requirements

<table>
<thead>
<tr>
<th></th>
<th>Operation</th>
<th>Purchasing</th>
<th>Business Analytics</th>
<th>Resource inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td><strong>Schedule operations and give work orders</strong></td>
<td><strong>Online auction</strong></td>
<td><strong>Harvesting cost estimation</strong></td>
<td><strong>Staff monitoring</strong></td>
</tr>
<tr>
<td>4.8</td>
<td><strong>Schedule operations and give work orders</strong></td>
<td><strong>Direct selling</strong></td>
<td><strong>Income estimation</strong></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td><strong>Schedule operations and give work orders</strong></td>
<td><strong>Forecasting</strong></td>
<td><strong>Harvesting cost estimation</strong></td>
<td><strong>Forecasting</strong></td>
</tr>
<tr>
<td>7.1</td>
<td><strong>Schedule operations and give work orders</strong></td>
<td><strong>Forecasting</strong></td>
<td><strong>Income estimation</strong></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td><strong>Forecasting</strong></td>
<td><strong>Forecasting</strong></td>
<td><strong>Income estimation</strong></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td><strong>Forecasting</strong></td>
<td><strong>Forecasting</strong></td>
<td><strong>Income estimation</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Non-functional requirements**

The non-functional requirements foreseen for the second integration phase are the same as section 3.7.

**Testing approach**

The testing of the aforementioned requirements will be performed on a bimonthly basis after each integration loop. Depending on the complexity of the integrated components one or two days will be devoted to test each requirement in laboratory conditions. The testing results will be reported on an incremental document based on the requirements table with a list of detailed functional tests.

A functional test will be structured following the schema reported in Table 2-1, consisting of a progressive number, a description of the test situation, a description of the expected results, the gained results and, if any, the detected anomaly. The threshold of working functionalities to be reached in this integration step is 80% of the overall requirements list, including the first integration step.
4 Third integration – System validation

The third and final integration step will validate the entire SLOPE workflow in laboratory conditions, consolidating core functionalities and covering the secondary aspects that were not included in the previous phases, like the upload of aerial and terrestrial forest surveys data on online web mapping services or mobile applications like the forest management plan creator provided by MHG. This phase will involve elements and actors from the 2nd to 5th work packages.

4.1 Involved Components

Figure 13: Third integration step involved components

The last integration step, as shown in Figure 13 will extensively test all the components of the SLOPE system and their communication with the FIS services to ensure stability and fault tolerance against normal on the field conditions expected during the WP7 pilot tests.
4.2 Timeline and integration approach

A timeline with the main milestones for the first integration phase is shown in the following picture.

![Timeline and integration approach](image)

**Figure 14: Third validation and deliverables**

In this last phase, the same number of agile-like integration sprints of section 3.2 and 2.2, have been planned with a monitoring telco of 1-2 hours every 2 weeks. The first two loops will be executed in parallel with the end of the second integration phase contributing to the finalization of the second system integration report (D.6.022).

At the end of each integration sprint, a round of testing is planned, reproducing the testing scenario of section 4.3 following the process described in section 4.8. Each testing will highlight the achieved functionalities and bugs to be fixed contributing to the incremental shape of the first system integration report (D.6.023).

4.3 Testing scenario

The testing scenario for the final validation step involves the full SLOPE workflow described in section 2.3 and 3.3.

4.4 Involved actors

The actors involved in this last step all the actors involved in the previous steps, namely: forest planner, forest operator, on-field harvesting operator, forestry expert, cableway operator and truck operator.

4.5 Hardware and software requirements

The execution of this final testing and validation phase requires the same hardware and software of the first and second integration and validations steps.
4.6 Functional Requirements

The functional requirements that can be foreseen for the final integration phase are the combination between the list provided in section 2.6 and 3.6.

4.7 Non-functional requirements

The non-functional requirements foreseen for the final integration phase are the same as section 3.7.

4.8 Testing approach

The testing of the aforementioned requirements will be performed on a bimonthly basis after each integration loop. Depending on the complexity of the integrated components one or two days will be devoted to test each requirement in laboratory conditions. The testing results will be reported on an incremental document based on the requirements table with a list of detailed functional tests.

A functional test will be structured following the schema reported in Table 2-1, consisting of a progressive number, a description of the test situation, a description of the expected results, the gained results and, if any, the detected anomaly. The threshold of working functionalities to be reached in this integration step is 90% of the overall requirements list, including the first and the second integration steps.
5 Conclusions

The current document establishes the major guidelines for an efficient and continuous integration of the SLOPE forest information system, with regular monitoring meetings and incremental testing phases. Particular attention has been taken to find an integration and development approach to cope with a well-defined set of use cases with changing requirements and a number of development teams working on the same platform, choosing a mixed waterfall/agile like approach. Each integration and validation phase has its own set of components, actors, hardware and software requirements as well as functional requirements that will be further expanded and accurately tested with detailed procedures reported in the upcoming reports.
6 References


