EUROPEAN
SPALLATION
SOURCE

Estia - Work Package Specification

Version 1.3

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Contents

1 Introduction

1.1 Purpose of the document

The Work Package Specification Description of the ESTIA instrument describes the work package definition as well as the associated staging plan. The corresponding hardware and software descriptions result from the design work based on the functional requirements (1) as well as the constraint requirements that have been identified at this point. The purpose of this document, together with the Prelementary System design is to:

- Provide a documented description of the work packages of the instrument that can be reviewed and approved by the stakeholders in a Tollgate review
- Provide a description of the work packages in enough detail that reasonable and assessable milestones can be defined and used for for the project management work.

1.2 Definitions, acronyms and abbreviations

Abbreviation	**Explanation of abbreviation**
AP	Approval package
BTCS	Beam transport and conditioning system
COM	Milestone: Commissioning
DES	Milestone: Design
INST	Milestone: Installation
NOSG	ESS neutron optics and shielding group
PBS	Product breakdown structure
PM	Project management
PNR	Polarized Neutron Reflectometry
SCS	Scattering characterization system
SES	Sample exposure system
SSM	Strålsäkerhetsmyndigheten (Swedish Radiation Safety Authority)
SP	Subproject
VS	Virtual Source
WBS	Work breakdown structure
WP	Work package

Specific to neutron guides:	
Abbreviation	**Explanation of abbreviation**
segment	A single physical piece of a neutron guide as produced by the vendor.
mirror	A collection of segments that belong to the same geometrical shape or serve the same physical purpose. An example would be an elliptical mirror, which describes one reflector with elliptic shape that is implemented using several segments.
guide	One or more mirrors that share the same location on the beam axis and form one component of the beam delivery system. An example would be an elliptical guide that is a collection of four elliptical mirrors, two opposite mirrors for horizontal and vertical direction, each.
guide system	The collection of neutron guides that form the full beam delivery system from source to sample.

1.3 Project Goal

The goal of the project is to deliver a complete Small Sample Reflectometer ready for hot commissioning with spallation neutrons from the ESS target station. The overarching goal is that this instrument will provide the best possible scientific performance that will allow neutron scattering to be applied to more challenging and relevant systems in the field of hard condensed matter. It will be designed as complimentary instrument to the horizontal sample reflectometer FREIA, providing a larger q-range and sample environment for diverse magnetic experimentsto ESS. A scematic overview of the instrument can be found in figure 1.1. For more details about the design see the documents Estia System Requirements and Estia Prelemenary System Design.

1.4 General Project Strategy

The general strategy to achieve the objectives is that the Core Instrument Team (Instrument Scientist, Instrument Engineer) set the requirements for various subsystems and the ESS technical groups or in kind partners in the corresponding technical area provide technical solutions that fulfil these requirements. Together with the core instrument team they design, procure or fabricate, install and test the technical components of the instrument. The instrument infrastructure supports the technical components, provides the necessary utilities and shields against radiation. This infrastructure will be designed by the core instrument

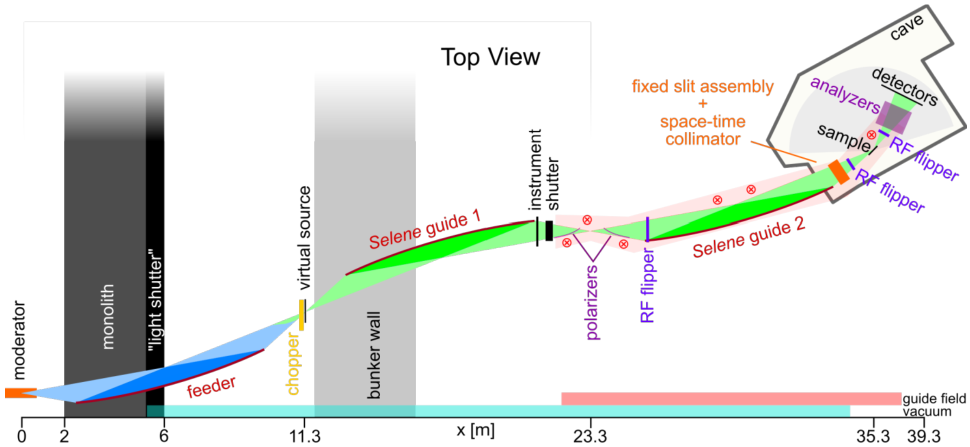

Figure 1.1: ESTIA Concept

team together with the relevant technical groups and procurement and installation will be coordinated within the instrument construction tasks. The high level WBS structure can be seen in the figure 1.2.

1.5 Staging Plan

In order to be ready for user-operation in 2023, the installation-schedule for the *Estia*-instrument must be optimized to meet the infrastructure-installation schedule and to streamline the instrument installation work. The result is the requirement to make early procurements with a plurality of instrument components. *Estia*'s guide system consists of separated guides which have to be connected with flight-tubes, those are natural system boundaries with little interfaces, thus they can be considered separately as work packages which can be designed and procured staggered over time. For a better integration with ESS and a more efficient approval process than what would be in place by separately evaluating every single early procurement item, these natural system boundaries are exploited in the *Estia* staging plan to define approval packages, which consist of a combination of work packages with many internal, but only few system boundaries to the rest of the instrument. This extension to the general ESS toll gate 3 process makes sure the same high standards are applied for the *Estia* project as for other parts of the ESS construction while generating enough flexibility to finish the instrument as soon as possible under the given boundary conditions.

1.5.1 Approval Package 0 - R&D Project

The initial scope of the R&D project has to be completed to move to the design of the actual Selene Gudes as the R&D is part of the guide-design process. Therefore it is critical to procure the corresponding components asap.

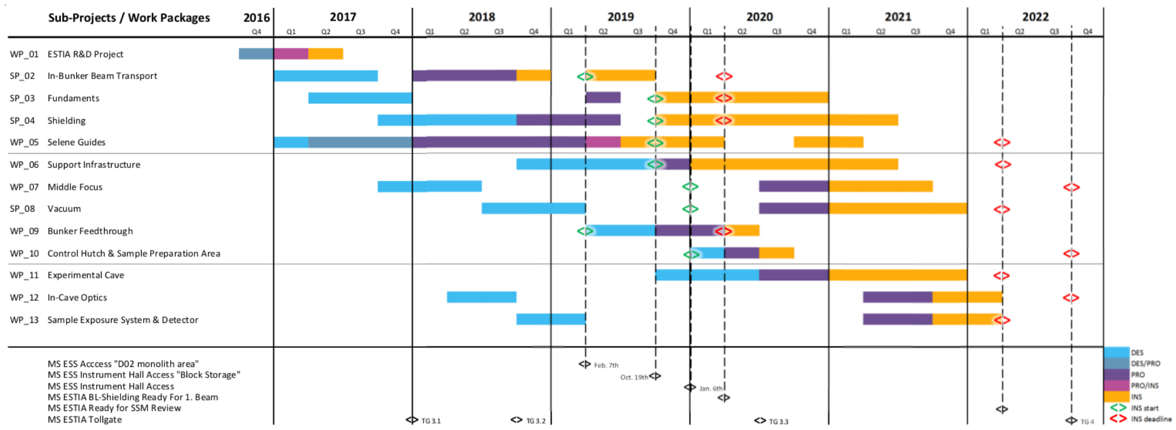

Figure 1.2: ESTIA High Level WBS

1.5.2 Approval Package 1 - In-Bunker & Long Procurement Items

The in-bunker- and close to the bunker components shall be fully installed when the test beam is switched on in Q2 2020. The Selene Guides have to be procured early as both the carriers and the super-mirrors have long delivery times.

TG3.1 - Deadline: December 31th, 2017

The Approval Package 1 includes the following work packages:

- SP_02 In-Bunker Beam Transport
- WP_03.1 Selene Guide 1 & BL Shielding Foundation
- WP_05 Selene Guides
- WP_09 Bunker Feedthrough

1.5.3 Approval Package 2 - Fundaments & Shielding

The Shielding components which are not relevant for the first beam on target can be designed subsequent. The Approval Package 2 has two system boundaries to the already designed system:

- Shielding:
  AP 1 and AP 2 have a system boundary within the bunker wall feedthrough, which has to already have a defined connection to the beamline shielding.
- Beamline:
  The AP 1 and AP 2 system boundaries are defined by a standard vacuum flight-tube ∅ 200

TG3.2 - Deadline: October 31^{th}, 2018

The Approval Package 2 includes the following work packages:

- WP_03.2 Selene Guide 2 & Optical Cave Foundation
- WP_04.1 Heavy Collimation Shielding
- WP_04.2 Beam Line Shielding & Instrument Shutter
- WP_04.3 Optical Cave Shielding
- WP_06 Support Infrastructure
- WP_08.1 Selene Guide Vacuum System

1.5.4 Approval Package 3 - Beam Line & Experimental Cave

The Experimental Cave- and Middle Focus components can be designed with little interfaces to the pre-built work-packages and are seen as components with delivery times no more than 1 year. In addition, the maximum rotation of the detector and with that the Experimental Cave size can still be adapted at this stage, if budgetary pressure necessitates it, as most costs are already fixed. These components do also profit from an already existing hall crane for their installation.

TG3.3 - Deadline: July 31^{th}, 2020

The Approval Package 3 includes the following work packages:

- WP_03.3 Experimental Cave Foundation
- WP_07 Middle Focus
- WP_08.2 General Vacuum System
- Control Hutch & Sample Preparation Area
- SP_11 Experimental Cave
- WP_12 In-Cave Optics
- WP_13 Sample Exposure System & Detector

1.6 Connection to other Projects or Assignments

Detector technology fulfilling the instrument requirements is currently not available, so the ESS Detector Group is performing research and development activities to provide such detectors for instruments with similar requirements.

The software tools for time of flight Laue data processing are not yet mature, so the ESS DMSC will ensure as part of its scope that appropriate software will be available when the instrument enters hot commissioning.

2 Work Breakdown

WBS Strategy

The ESTIA WBS strategy is to define sub projects and work packages which are based on engineering- and environmental constraints. The work packages do not follow the PBS but an assembly oriented structure. Therefore one product can be spread over various work packages, thus the affected products are listed in the work package specifications. Furthermore one work package contains all phases from design to commissioning unless specified differently.

The underlying criteria for the ESTIA WBS concept are listed subsequent, they do not follow a prioritization:

- Follow the assembly structure so components which have strong interaction or dependencies from a engineering point of view will be designed together.
- Parts of the instrument which have special environmental impacts and therefore require a collaboration with experts or a coordinated high level design.
- The installation of the products underlying a work package can be done independent and with simple system boundaries.

Superior Milestones

The ESTIA WBS is streamlined to meet the requirement to be a day one instrument. Therefore a few superior milestones are crucial to fulfill this demand, they are the following:

Milestones	
Access to D02 monolith area	Feb. 7^{th} 2019
Access to the east hall instrument hall *Block storage area*	Oct. 19^{th} 2019
Access to the east hall instrument hall	Jan. 6^{th} 2020
Instrument in-bunker components ready for beam on target	Mar. 31^{th} 2020
Instrument is ready for SSM assessment	Mar. 31^{th} 2022

2.1 WP_01 R&D Project

Task

The R&D Project contains the development, construction and testing of the full functionalyity of the Selene Guides including MC and Vacuum. Therefore a fully equipped Selene Guide shall be built in life-size with original parts and the length of two segments (960mm). The aim of the construction is to test and optimize the following functionality to meet the SR:

- Comparing different actuator concepts and optimizing the motion required for the in vacuum alignment
- Testing the metrology-cart segment measuring
- Testing the metrology cart positioning concept
- Analysis of structural behavour of the carrier combined with the vacuum feet, including the analysis vribration dumpening and the influence of temperature fluctuations
- Analysis of vacuum to the guide system

Boundary Conditions	
Labor	1560 h
Non-labor	209.5 k€
Resp.	IE

Milestones		
COM	R&D Project Complete	Q2 2017

2.2 SP_02 In-Bunker Beam Transport System

Task

The sub project In-Bunker Beam Transport System is defined as the whole instrument section from the beginning of the monolith insert to the Virtual Source Heavy Collimation System as shown in figure 2.1. The components of this SP have the following similarities:

- All components are in a high radiation environment
- All components are part of the heavy collimation concept which leads to the first time line of sight
- All components are in the same vacuum section and they have to be remote handleable according to the remote-handling concept provided by ESS.

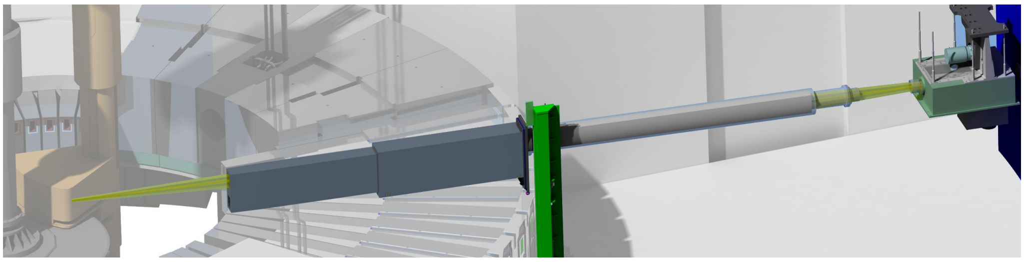

Figure 2.1: In-Bunker Components

- All motion control components shall be approved for high radiation environment. Furthermore the cabling through the bunker-wall shall be coordinated for all in-bunker components

Boundary Conditions		Milestones	
Labor	5254 h	DES	Q3 2017
Non-labor	814 k€	COM	Q3 2019
Resp.	IE		

Remarks

This sub project has well known system requirements on the instrument side and a clear defined environment (state: August 2016). Associated with the man-power stream-lining and work minimization it is crucial to have the SP_02 completed before the bunker will be closed for the 1^{th} Beam, Q2 2019.

Affected Products

13.6.9.1.1.1,13.6.9.1.3,13.6.9.1.4.3.1,13.6.9.1.6.2,13.6.9.1.9.2,13.6.9.10.1.4

2.2.1 WP_02.1 Beam Extraction System

Task

The Beam Extraction System shall contain a split feeder. The first part shall be mounted within the monolith insert. The monolith insert shall also contain a ≈2m long piece of copper which blocks the direct view through the center of the elliptical feeder guide. The second feeder-part shall be placed in the in-bunker section and be moveable in beam direction. Thus when the gamma shutter has to be closed, the vacuum in the In-Bunker section shall be broken and the feeder mirror shall be translated downstream towards the chopper. A bellow shall compensate the shortening of the flight-tube. The system boundary of the WP is at the vacuum vessle of the Chopper Pit (WP_02.2). The In-Bunker Vacuum shall reach from the monolith window to the chopper pit and execute the required length compensation.

Milestones	
DES	Q3 2017
COM	Q3 2019

2.2.2 WP_02.2 Chopper Pit

Task

The Chopper Pit WP is defined by the vacuum vessel wrapping the discussed assembly and by the required foundation. The core pieces are a 14Hz bandwidth chopper and the virtual source. These shall be mechanically decoupled from each other to avoid vibration stimulation of the latter. The two components shall be mounted on the same remote handling access point (PSD, Chapter 4.3). Furthermore does the coper pit consist of in-bunker shielding which is applied as heavy collimation before the chopper and after the virtual source, such as a shielding of the virtual source MC components. The system boundary upstream is defined in WP_02.1 and downstream it is at the vacuum-connection of the vessel or the the last piece of heavy collimation, depending on the construction.

Milestones	
DES	Q3 2017
COM	Q3 2019

2.3 SP_03 Foundation

Task

The sub project contains all foundation outside of the bunker wall, it is divided in different work packages to meet requirements of the staging plan.

Boundary Conditions	
Labor	428 h
Non-labor	86 k€
Resp.	IE

Milestones	
COM	Q2 2021

Affected Products

13.6.9.1.2.1,13.6.9.1.2.2

2.3.1 WP_03.1 Selene Guide 1 & BL Shielding Foundation

Task

The foundation for the selene guide 1 shall have a high stability over temperature and also minimize the vribration transfer from the instrument hall to the selene guides. Further the foundation for the beam line shielding is included in the WP as the two tasks have the same deadline and required knowledge.

Milestones	
DES	Q4 2017
COM	Q2 2019

2.3.2 WP_03.2 Selene Guide 2 & Optical Cave Foundation

Task

The foundation for the selene guide 2 shall have a high stability over temperature and also minimize the vribration transfer from the instrument hall to the selene guides. Further the foundation for the optical cave is included in the WP as the two tasks have the same deadline and required knowledge.

Milestones	
DES	Q4 2017
COM	Q2 2019

2.3.3 WP_03.3 Experimental Cave Foundation

Task

The WP contains the foundation for the experimental cave. The whole floor level of the experimental cave will be slightly elevated to achieve a convenient beam height at the sample position.

Milestones	
DES	Q1 2020
COM	Q4 2020

2.4 SP_04 Shielding

Task

The sub project contains all shielding tasks of the Instrument except the in-bunker shielding and the instrument specific bunker feed through.

Boundary Conditions	
Labor	5705 h
Non-labor	1125 k€
Resp.	IE

Milestones		
COM	Ready for 1. Beam	Q3 2019
COM	Ready for SSM	Q2 2021

Affected Products

13.6.9.1.10.1,13.6.9.1.10.2,13.6.9.1.10.3

2.4.1 WP_04.1 Heavy Collimation Shielding

Task

The WP includes all heavy collimation systems after the virtual source except the heavy collimation included in the WP_02.2 Chopper Pit.

Milestones	
DES	Q4 2018
COM	Q1 2020

2.4.2 WP_04.2 Beam Line Shielding & Instrument Shutter

Milestones	
DES	Q3 2018
COM	Q4 2020

2.4.3 WP_04.3 Optical Cave Shielding

Task

The WP contains the optical cave shielding.

Milestones		
DES		Q3 2018
COM		Q1 2020

2.5 WP_05 Selene Guides

Task

The WP includes the complete Selene Guide 1 and 2 including all mirror-segments, actuators, feet and alignment systems. Excluded is only the vacuum tank, this task shall be performed in WP_08.1 Selene Guide Vacuum System.

Boundary Conditions	
Labor	8143 h
Non-labor	1633 k€
Resp.	IE

Milestones		
DES	Segments	Q4 2017
DES	Guides	Q4 2017
COM		Q1 2021

Affected Products

13.6.9.1.2.1,13.6.9.1.2.2

2.6 WP_06 Support Infrastructure

Task

The instrument infrastructure consists of all the conventional construction and utilities (power, cooling water, vacuum, etc.) required to house and operate the technical components. Useful system boundaries shall be defined interactively with the corresponding components.

Boundary Conditions	
PSI labor	1312 h
Non-labor	208 k€
Resp.	IE

Milestones		
DES	In-Bunker	Q4 2017
DES	Selene Guide 1 & BL Shielding	Q3 2019
DES	Complete	Q1 2019
COM	In-Bunker & Selene Guide 1	Q3 2019
COM	Opt. Cave & Selene Guide 2	Q9 2020
COM	Complete	Q4 2020

Affected Products

13.6.9.8.1.1,13.6.9.8.1.2,13.6.9.8.1.3,13.6.9.9.1.1,13.6.9.9.1.2,13.6.9.9.1.3,13.6.9.9.1.4

2.7 WP_07 Middle Focus

Task

A Set of horizontal and vertical slits as well as pin-holes shall be installed at the position of the focus between the two Selene Guides. Changing between different apertures shall be done with a rotating holder mounted on a motorized XZ-stage for precise alignment to the focus position. The middle focus assembly shall have an additional hydrostatic monitor to measure the relative alignment to the two Selene guide granite pieces.

Two transmission polarizing super mirrors shall be installed before and after the middle focus. Uncoated silicon pieces with the same shape as the polarizes shall be mounted within the same frame to be used as frame overlap filters for unpolarized measurements. A translation stage shall be used to switch between the two operation modes.

The vacuum housing of the components is processed in the SP_08 Vacuum and the corresponding work packages shall accordingly be coordinated.

Boundary Conditions	
Labor	2172 h
Non-labor	385 k€
Resp.	IE

Milestones		
DES		Q2 2018
COM		Q4 2020

Affected Products

13.6.9.1.5.2,13.6.9.1.5.3,13.6.9.1.6.1,13.6.9.1.6.2

2.8 SP_08 Vacuum

Task

The Estia instrument shall have an instrument vacuum system which consists of a continuous vacuum from the monolith window to the beginning of the sample environment. Therefore the system shall have two vacuum-windows; one facing the monolith and one facing the sample. The vacuum system shall be divided into sectors and equipped with vacuum gate valves, which can be closed when the beam is of. Each sector shall be equipped with a separate pumping station that allows quick and stable evacuation as well as local ventilation.

Boundary Conditions	
Labor	1822 h
Non-labor	406 k€
Resp.	IE

Milestones		
DES		Q1 2019
COM	Up to Selene Guide 1	Q4 2021
COM	Complete	Q4 2021

Affected Products

13.6.9.1.9.1,13.6.9.1.9.4,13.6.9.10.1.5

2.8.1 WP_08.1 Selene Guide Vacuum System

Task

The Selenge Guides shall have separate vacuum tanks with flanges for the gate valves. The design of the vacuum system shall be coordinated with the WP_05 considering the amount of actuator cables and optical fibers used. Furthermore it shall provide a proactive solution for broadly based expansion options of the selene guides.

	Milestones	
DES	Engineering Concept	Q1 2017
DES	Complete	Q4 2017
COM	S1 Complete, S2 Bottom-Vessel	Q1 2020
COM	Complete	Q3 2021

2.8.2 WP_08.1 General Vacuum System

Task

The general vacuum system shall start at the connection to the SP_02 In-Bunker Beam Transport System and end with the vacuum-window at the sample-position. Four vacuum gate valves shall separate the sections according to the PSD.

	Milestones	
DES		Q2 2018
COM	Up To Selene Guide 2	Q2 2021
COM	Complete	Q4 2021

2.9 WP_09 Bunker Feed Through

Task

The bunker feed through shall be designed and optimized according to the ESS bunker concept. The feed through design shall be coordinated with the WP_04.1 Heavy Collimation as the bunker feed through can be used as foundation. The feed through implementation shall comply with the NOSG Handbooks ESS-0039408 and ESS-0052625.

Boundary Conditions	
Labor	523 h
Non-labor	80 k€
Resp.	IE

Milestones	
COM	Q1 2020

Affected Products

13.6.9.1.10.1

2.10 WP_10 Control Hutch & Sample Preparation Area

Task

An instrument control hutch with enough space to allow two user groups working simultaneously shall be built downstream of the experimental cave. It shall contain the control racks for the equipment installed in the experimental cave build into one wall (avoiding exhaust heat and noise from the equipment to enter the room) and separate control and data analysis terminals. A dedicated workbench close to the experimental cave entrance shall be the sample preparation area.

Boundary Conditions	
Labor	7087 h
Non-labor	228 k€
Resp.	IE

Milestones	
DES	Q1 2020
COM	Q3 2020

Affected Products

13.6.9.10.1.1, 13.6.9.10.1.2, 13.6.9.10.1.3, 13.6.9.10.1.7, 13.6.9.10.1.8, 13.6.9.6.1.1, 13.6.9.6.1.2, 13.6.9.6.1.3, 13.6.9.6.1.4, 13.6.9.6.1.5, 13.6.9.6.1.7, 13.6.9.6.2, 13.6.9.7.1.1, 13.6.9.7.1.3, 13.6.9.7.4

2.11 WP_11 Experimental Cave

Task

The experimental cave shall be entered through PSS controlled door behind a chicane on the down stream side. The whole floor level of the experimental cave shall be slightly elevated to achieve a convenient beam height at the sample position. A polished dance floor shall be installed covering the whole detector rotation area as well as the sample and in-cave optics table region of the cave. To allow independent installation of SE equipment the cave ceiling shall have roof access and a 2x2m^2 access door above the sample area. A local crane shall be installed with enough reach to move equipment from in front of the cave entrance to the access door. In addition to all utilities and control systems necessary to support the installed components (motion control, vacuum, gas and cooling water connectors, power) the cave shall be equipped with PSS equipment for access control, emergency buttons, fire protection and oxygen level monitoring.

Boundary Conditions		Milestones	
Labor	4748 h	DES	Q2 2020
Non-labor	832 k€	INST	Q2 2021
Resp.	IE	COM	Q4 2021

Affected Products

13.6.9.1.8.1, 13.6.9.1.8.6, 13.6.9.5.1, 13.6.9.5.2.1, 13.6.9.5.2.2, 13.6.9.5.2.3, 13.6.9.5.3.10, 13.6.9.5.3.2, 13.6.9.5.3.3, 13.6.9.5.3.4, 13.6.9.5.3.5, 13.6.9.5.3.6, 13.6.9.5.3.7, 13.6.9.5.3.9, 13.6.9.5.4, 13.6.9.5.5

2.12 WP_12 In Cave Optics

Task

After the exit of the second selene guide, separated from the rest of the beamline by a vacuum valve from WP_8.01 General Vacuum System, a box for in-vacuum optical components shall be implemented. The Box shall contain a beam shaping slit system and a space-time collimator.

Boundary Conditions		Milestones	
Labor	2581 h	DES	Q3 2021
Non-labor	192 k€	COM	Q1 2022
Resp.	IE		

Affected Products

13.6.9.1.4.3.2,13.6.9.1.5.4,13.6.9.1.6.2,13.6.9.1.8.5

2.13 WP_13 Sample Exposure System & Detector

Task

At the bottom of the sample stage a heavy duty goniometer with optical encoder shall be mounted on a frame with air-feet, which enables initial positioning of the rotation axis with respect to the neutron beam. This stage shall be able to accommodate any ESS pool sample environment equipment of class L and relevant XL class items with a kinematic mount if needed. The default instrument specific SE shall be placed with a separate frame on the kinematic mount. The frame shall house a manually adjustable table holding the magnet and alignment system and a hexapod positioning stage for the cryostat or room temperature sample holder.

The detector shall be mounted on a detectortable which rotates around the sample position on a 4m radius. The detector arm will be designed for the attachment of the detectors, analyzer modules and flight tube elements and will be placed on air feet.

Boundary Conditions		**Milestones**	
Labor	5870 h	DES	Q3 2021
Non-labor	1002 k€	COM	Q1 2022
Resp.	IE		

Affected Products

13.6.9.1.5.4,13.6.9.2.1,13.6.9.2.3,13.6.9.3.2.1,13.6.9.3.2.2,13.6.9.3.2.3,13.6.9.3.4

3 Project Budget And Financial Reporting

	PBS Item	Cost [k€]			Work Units [person-years]					
		Labor	Non-Labor	Total	02 P. Management	03 Design	04 Construction	05 Installation	06 Commissioning	Total Work
1	Beam Transport and Conditioning System	1 668.5	4 752.0	6 420.5	0.970	4.580	3.080	3.390	2.010	14.030
2	Sample Exposure System	218.6	372.4	591.0	0.110	0.640	0.390	0.290	0.340	1.780
3	Scattering Characterization System	183.4	521.0	704.4	0.200	0.460	0.400	0.360	0.220	1.650
5	Experimental Cave	287.4	665.0	952.4	0.190	0.800	0.180	1.200	0.090	2.450
6	Control Hutch	36.5	71.0	107.5	0.070	0.040	0.070	0.180	0.010	0.370
7	Sampe Preparation Area	15.1	11.2	26.3	0.020	0.030	0.000	0.110	0.000	0.160
8	Utilities Distribution	5.6	28.0	33.6	0.020	0.030	0.000	0.000	0.000	0.050
9	Support Infrastructure	65.5	180.0	245.5	0.030	0.190	0.000	0.290	0.130	0.640
10	Control Racks	421.6	146.3	567.9	0.220	1.160	0.090	1.940	0.610	4.020
	Travel	81.0	0.0	81.0						
	R&D Selene Guide	150.5	209.5	360.0						
	Phase 1	480.0	50.0	530.0						3.250
	Contingency			1 180.0						
	Sum	3 613.7	7 006.4	11 800.0	1.830	7.958	4.205	7.754	3.412	28.408

4 Project Risk Management

The most important project risks are presented in the table below. Technical risks for individual subsystems and components are described in the relevant design documents. The risk probabilities and consequences are listed before taking into account specific mitigation measures. The risk probability and consequence is quantified on a scale of 1−5 , where 1 denotes low probability and minor consequence.

Risk Level	Risk	Treatment Name	Treatment	Category	Treatment Plan
High 5x5	Delay in design-freeze process of key environment	Staged engineering	Migrate	schedule, budget and quality	Design of independent components as far as useful. *Estia* team. Responsible: NSS
High 4x3	Delay in monolith or bunker project	Insert and in-bunker installation	Observe	schedule and budget	Follow the progress of the design and project schedule. *Estia* team. Responsible: target
High 2x5	Conventional Facilities Delay	CF LEVEL ESS-0019533	Observe	schedule, budget, quality and function	Access to hall 1 is a milestone for *Estia* schedule. *Estia* team. Responsible: CF
		External areas like labs and workshops	Mitigate		External areas will give the opportunity to start pre-installations Responsible: CF
High 3x5	Significant changes to bunker	Shielding update plan	Mitigate	schedule, budget, quality and function	If ESS changes the bunker design significantly at a later stage this might have strong impact on *Estia* cost. An adjustment of funding should be through out. Responsible: *Estia* team and ESS group
High 3x4	Detector solution development late	Detector action plan and schedule with mitigation plan	Mitigate	schedule, budget, quality and function	Detector technical group is following an action plan and schedule plan for developments. Responsible: Detector Group
Med. 2x4	Increased ground sinking	Adjust heights	Mitigate	schedule and budget	If the ground sinking at vital point in the experimental hall exceeds expected values, it might be necessary to install new shims or different adjuster. The detailed design will try to minimize this risk by supplying large enough adjustment range, if feasible. *Estia* team
Med. 3x3	Late delivery of key components	*Estia* schedule	Mitigate	schedule and budget	Properly assess delivery time and transportation, order most important components at early stage. Responsible: *Estia* team
Med. 2x4	VS solution not suitable for rad. level	VS design change	Mitigate	budget	If the stage based solution of the preliminary design cannot sustain the radiation level in the bunker, a different one needs to be found, which likely will increase the cost. This is, however, expected to be much lower then the 10% contingency.
Med. 2x4	Limited SE for user operation	Reduce expectation	Observe	quality	If no upgrade to the *Estia* magnet system can be afforded before user operation some experiments will not be feasible or there might be interruption if other beamlines need the pool magnet. Responsible: ESS
Low 3x2	Mirror segment shape does not fulfill accuracy requirement	Imaging quality lost	Mitigate / Observe	quality	Regular communication with vendor and quality control of segments will be of large priority. If the degree of quality cannot be achieved some minor possibilities of *Estia* might show reduced performance.
Low 4x1	Not enough coffee during commissioning phase	Self Brewing	Mitigate	quality and function	Bring own coffee brewing equipment. Responsible *Estia*

ESS risk management procedures will be followed. The risk register will be maintained in specialised software (e.g. Exonaut Risk) and updated in regular workshops. The updated risk register will also be available to the Instrument Construction Sub-Project and the NSS Project for higher level risk monitoring. If a risk is realized it will be reported to the Instrument Construction Sub−Project even if it has no direct consequence at that level.