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BEER - Work Package Specification

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SUMMARY

The BEER Work Package will deliver an engineering materials neutron diffractometer ready for hot commissioning with spallation neutrons by the end of 2021. The scope of the work is described along with the budget, schedule and project processes used. The total budget agreed on at the Scope Setting meeting is about 14.987 k€ including 10% of contingency. The BEER instrument is a collaborative project of two in-kind partners: Nuclear Physics Institute CAS (NPI) and Helmholtz-Zentrum Geesthacht (HZG), sharing approximately 50% each of the total budget.

1. PROJECT ORGANIZATION

1.1 Project Goal

The goal of the project is to deliver an upgradeable, world class, materials engineering Diffractometer BEER ready for hot commissioning with spallation neutrons from the ESS target station end of 2021. The instrument shall deliver from day one a performance comparable to existing time-of-flight engineering diffractometers or exceed them in some aspects. Therefore, BEER will provide the best possible scientific performance that will allow users of the instrument to solve more challenging scientific and industrial problems than is currently possible, e.g. in-situ studies of materials properties and its evolution in close-to-real conditions and enable state-of-the-art strain scanning technique using pulse modulation method.

1.2 General Project Strategies

The BEER instrument is a complex instrument consisting of different subsystems (optical system, detector system, etc.) that in turn consist of their own subsystems. All of these subsystems together must fulfil the functional requirements for the scientific performance as well as non-functional requirements for maintainability as well as safety requirements.

The general strategy to achieve this is that the Core Instrument Team (Instrument Scientist, Instrument Engineer and Technicians) from the in-kind partners HZG and NPI set the requirements for various subsystems and provide technical solutions that fulfil these requirements in agreement with the standards provided by the ESS technical groups in the corresponding technical area. HZG and NPI design, procure or fabricate, install and test the technical components of the BEER 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 team together with the relevant technical groups (if not provided by the ESS Conventional facility group or else) and procurement and installation will be coordinated within the instrument construction sub-projects.

1.3 Governance structure

The governance structure is described in the NSS project specification and the instrument construction sub-project specification [1], references therein and the Memorandum of Understanding (MoU) for the BEER Instrument Consortium. The project organisation includes the Instrument Consortium Executive Board (ICEB) which oversees the project. Members of the Instrument consortium are on the date of delivery of this document NPI, HZG and ESS. Contribution from NPI and HZG includes leading scientist, leading engineer and further personnel.

1.4 Instrument Consortium Partners

The contributions to the project will be coordinated within the ICEB and specific contributions will be defined in technical annexes. Where necessary the ICEB may also formulate plans for future contributions.

1.5 Connections to other Projects or Assignments

Detector technology fulfilling the instrument requirements is currently under development by HZG and industry as a contribution to the ESS detector group. This development will provide detectors with requested parameters for BEER.

BEER is a long instrument but most of the chopper systems are within the region that is surrounded by the common shielding bunker. This is an important interface, and during design, it will be important to maintain close interconnection between the design of the chopper systems and the bunker, e.g. movability of choppers within or out of the bunker.

The data management and software centre (DMSC) will provide or support the data acquisition, storage, management, reduction and analysis for the BEER instrument. There will be close coordination between the instrument team and the DMSC.

The vacuum group will provide the support necessary for the vacuum system at BEER. There will be close coordination between the BEER team and the vacuum group.

The footprint of BEER and the neighbouring instruments NMX and C-SPEC can have an influence on positions of different components. Therefore, close coordination between the instrument teams is envisaged.

We will also seek external funding for the dedicated sample environment especially the Gleeble®. The cave and surrounding infrastructures are designed to accommodate the Gleeble® system in the future.

2. PROJECT SCOPE

2.1 Instrument Overview

The BEER instrument consists of three main technical subsystems: the beam transport and conditioning system (BTS), the sample exposure system (SES) and the scattering characterization system (SCS). In addition, the instrument includes the structures that house and support these subsystems and the software to control the instrument and process the data. A detailed breakdown of the instrument subsystems can be found in the product breakdown structure (PBS; delivered as an appendix of the document) and a description of the subsystems is summarised in the preliminary system design document [2].

Beam transport and conditioning system (BTCS) (13.6.6.1)

The beam transport system transports a beam of neutrons from the moderator surface to the sample position. The size, divergence and wavelength spectrum of the beam are tailored to the needs of the experiment. The surroundings of the beam transport system are shielded against ionising radiation.

Sample exposure system (SES) (13.6.6.2)

The sample exposure system positions the sample in a beam of neutrons and controls the physical and chemical environment of the sample using various sample environments. The choice of sample environment is driven by requirements of the experiment.

Scattering characterization system (SCS) (13.6.6.3)

This system detects neutrons scattered from the sample as individual events which can be converted to the meaningful experimental data.

Experimental cave (13.6.6.5)

The experimental cave houses the beam defining elements of the BTCS, SES, and SCS. It shields the surrounding hall from the radiation generated by these systems as well as shielding the detector system from the external radiation.

Control hutch (13.6.6.6)

The control hutch houses the experiment control and data processing terminals. During an experiment, the user team spends most of their time in the control hutch.

Sample preparation area (13.6.6.7)

The sample preparation area contains all the necessary equipment for sample handling, mounting, treatment and storage between experiments.

Utilities distribution (Infrastructure) (13.6.6.8)

The utility distribution supports all components in hall 2, 3 (D03, E01) and the neutron guide hall (E02).

Support infrastructure (13.6.6.9)

The support infrastructure supports the mounting of components in hall 2, 3 and the neutron guide hall.

Control racks (13.6.6.10)

The control racks support all moving devices in hall 2, 3 (D03, E01) and the neutron guide hall (E02). It includes the control racks for motion control and chopper control as well as DAQ, DMSC, vacuum control and PSS unit components.

Integrated control and monitoring system (13.6.6.11)

The integrated control and monitoring system allow the user to control the experimental parameters and process the neutron data. It also contains the control and monitoring systems needed for the safe operation of the instrument.

The BEER – Preliminary System Design Description [2] and the documents referred therein describe in detail the design baseline. These documents also show how the presented design meets the functional and constraint requirements documented in BEER – System Requirements document [3].

3. WORK BREAKDOWN

3.1 Instrument Work Units

The Work Units are composed of all the deliverables with which a responsible group contributes to the instrument construction WP. The work units are summarised following the work breakdown structure used in the Scope Setting meeting:

01 Shielding	NPI
02 Neutron Optics	NPI – transport and focusing, HZG – bunker
03 Choppers	HZG
04 Sample Environment	ESS, NPI, HZG

05 Detectors and Beam Monitors	HZG
06 Data Acquisition and Analysis	ESS
07 Motion Control and Automation	HZG
08 Instrument Specific Technical Equipment	NPI, HZG
09 Instrument Infrastructure	NPI, HZG
10 Vacuum	ESS
11 Personal Safety System	NPI, HZG

Each of these work units comprises the corresponding subsystems described in the PBS and will be shown in the following text. Each work unit has a coordinating partner marked in brackets behind the work unit name. If deliverables within the whole work unit do not belong to the one coordinating partner, the responsible partner is marked behind the individual PBS element.

3.1.1 Shielding Work Unit (NPI)

The Shielding Work unit delivers the shielding necessary for the transport neutron guide outside the bunker wall. Furthermore, the work unit is responsible for shielding functionalities, e.g. shutters, cave walls and roof. The deliverables include the design, delivery and installation of shielding systems. The relevant PBS items are:

13.6.6.1.10.2	Beamline Shielding
13.6.6.1.8.3.1	Shutter 1
13.6.6.1.8.6	Beam Stop
13.6.6.5.4.1	Cave Shielding (Nuclear)

3.1.2 Neutron Optics Work Unit (NPI)

The Neutron Optics Work unit delivers the neutron transport functionality from the moderators inside the target monolith up to the sample position. This includes the interfaces to the halls floor, vacuum jackets and alignment system. It includes further the design, delivery and installation.

13.6.6.1.1	Beam Extraction System (HZG)
13.6.6.1.2.1.1	Chopper Section (HZG)
13.6.6.1.2.1.2	Expansion part (HZG)
13.6.6.1.2.1.3	Narrow bent guide (HZG)
13.6.6.1.2.1.4	Transport guide
13.6.6.1.2.1.5	Focusing guide
13.6.6.1.2.2	Guide Housing (Vacuum) (HZG+NPI)
13.6.6.1.2.3	Guide Support System (HZG+NPI)
13.6.6.1.4.5.1	Slit 1
13.6.6.1.4.5.2	Slit 2
13.6.6.1.4.5.3	Slit 3

13.6.6.1.4.8 Beam Geometry Conditioning Support and alignment

13.6.6.1.4.9.1 Motion Mechanics

13.6.6.1.4.9.2 Vertical focusing guide

13.6.6.1.4.9.3 Absorbing walls

13.6.6.1.4.10.1 Radial collimators +90° detector (HZG)

13.6.6.1.4.10.2 Radial collimators -90° detector (HZG)

3.1.3 Choppers Work Unit (HZG)

The Choppers Work unit will deliver the pulse shaping, modulation and framing chopper systems to the instrument including the integration into the ICS.

13.6.6.1.3.1 Assembly 1

13.6.6.1.3.2 Assembly 2

13.6.6.1.3.3 Assembly 3

13.6.6.1.3.4 Assembly 4

13.6.6.1.3.5 Assembly 5

13.6.6.1.3.6 Assembly 6

13.6.6.1.3.7 Assembly 7

3.1.4 Sample Environment Work Unit (NPI)

The Sample Environment Work Unit will deliver the sample environment for BEER. Within the BEER project no budget is foreseen for sample environment. There will be, however, sample environment provided by the SAD group dedicated for BEER, e.g. a dilatometer and a stir welding machine. Deformation rig is foreseen for the Day-one configuration, but funding schema is not resolved. It was removed from the instrument budget after the scope setting meeting because the other funding opportunity for it appeared. Based on the results of approval of such funding, the decision about the re-examination of the instrument budget will be made, or other solutions need to be found.

13.6.6.2.3.1 Uniaxial Load Frame

13.6.6.2.3.3 Dilatometer

13.6.6.2.3.4 Stir Welding Machine

3.1.5 Detector and Beam Monitors Work Unit (HZG)

The Detector and Beam Monitors Work Unit will provide the instrument with its detector system and diagnostic beam monitors. This will include all the necessary electronics and interfaces to the data management and software centre (DMSC) and the instrument control system (ICS).

13.6.6.3.2.1.1 Horizontal Detector +90°

13.6.6.3.2.1.2 Horizontal Detector -90°

13.6.6.3.2.2 Neutron Detector Positioning System

13.6.6.1.6.1 Beam Monitors

13.6.6.1.6.2 Flux Measurements Assembly

3.1.6 Motion Control and Automation Work Unit (HZG)

The Motion Control and Automation WU will deliver the electronic hardware and software necessary to integrate instrument motion axis into the Integrated Control System (ICS). The WU will also provide control racks for all the instrument electronics.

13.6.6.10.2.3	Motion Control Rack
13.6.6.10.2.4	Chopper Control Rack
13.6.6.10.3.3	Motion Control Rack
13.6.6.10.3.4	Chopper Control Rack
13.6.6.10.4.3	Motion Control Rack
13.6.6.11.1.1	Generic Motion Control Integration (HZG+NPI)
13.6.6.11.1.2	Special Purpose Motion Control Integration
13.6.6.11.1.6	EPICS Integration (HZG+NPI)

3.1.7 Instrument Specific Technical Equipment Work Unit (HZG)

The Instrument Specific Technical Equipment work unit will deliver positioning systems for the BEER instrument, e.g. robots.

13.6.6.2.1.1	Hexapod
13.6.6.2.1.2	Robot
13.6.6.2.1.3	Rotary stage (NPI)

3.1.8 Instrument Infrastructure Work Unit (NPI)

The instrument Infrastructure Work unit delivers the structural function of the experimental cave, control hutch and the interfaces to the halls floor, the distribution of media such as electricity, fluids and gases and local craning.

13.6.6.5.5	Cave Structure
13.6.6.5.3	Support Infrastructure
13.6.6.5.2	Utilities Distribution (NPI+HZG)
13.6.6.6.1	Support Infrastructure
13.6.6.6.2	Hutch Building (Structure)
13.6.6.6.3	Control Terminal
13.6.6.8.2	Hall 2 (NPI+HZG)
13.6.6.8.3	Neutron Guide Hall (NPI+HZG)
13.6.6.8.4	Hall 3 (NPI+HZG)
13.6.6.9.2	Hall 2 (NPI+HZG)
13.6.6.9.3	Neutron Guide Hall (NPI+HZG)
13.6.6.9.4	Hall 3 (NPI+HZG)

3.1.9 Personnel safety system (PSS) Work Unit (ESS+HZG+NPI)

The Personnel safety system will deliver the personnel safety system for the full instrument and its integration at ESS level.

13.6.6.5.1 Personnel Safety System (PSS) (ESS+HZG+NPI)

13.6.6.11.2 Personnel Safety System Integration (ESS+HZG+NPI)

13.6.6.10.4.6 Personnel Safety System Rack (ESS+HZG+NPI)

3.2 Excluded

All deliverables not explicitly mentioned in the work unit descriptions are excluded from the WP. Some exclusions are nonetheless essential for the functionality and operation of the instrument and are described below. These will be delivered by other parts of the ESS program where also the budget for these items is allocated.

3.2.1 Vacuum system Work Unit

The vacuum system will deliver the integration of hardware and software to operate the instrument components under vacuum and to control the vacuum components through the integrated control system.

13.6.6.1.9 Vacuum System

13.6.6.11.1.3 Vacuum Control Integration

13.6.6.10.2.5 Vacuum Control Rack

13.6.6.10.3.5 Vacuum Control Rack

13.6.6.10.4.5 Vacuum Control Rack

3.2.2 Data Acquisition and Analysis Work Unit

The Data acquisition and analysis is excluded from the formal scope and hence budget of the WP. It will deliver the software necessary to process the data, as well as the hardware and the software to collect, store and analyse the data from the detector and beam monitor system.

13.6.6.10.4.1 DAQ Rack

13.6.6.10.4.2 DMSC Rack

3.2.3 Supporting laboratories and sample environment

Any sample environment equipment that is part of the ESS sample environment pool (magnets, cryostats, etc.) is excluded from the WP. The sample environment integration deliverable will provide a standard panel and mechanical interface that allows sample environment equipment from the ESS sample environment pool to be used for the instrument. There is a Laboratory dedicated to engineering science, the equipment in the laboratory and the infrastructure of the lab is excluded from the instrument WP.

13.6.6.7.4 Laboratory Equipment and Sample Storage

3.2.4 Conventional facilities

All civil construction activities not explicitly mentioned in the work units descriptions will be part of the CF WP. This includes the supply of cooling water, sprinkler water electricity and gases up to the distribution points in the installation galleries.

3.3 Deliverables

The work unit description above lists the relevant deliverables for each Work Unit. A more detailed overview is given by the PBS (delivered as an appendix of the document), the different Work units are, herein, indicated by colour coding.

4. PROJECT SCHEDULE

4.1 Time Schedule

The schedule of the WP is organised in four phases as outlined in [4]: Preliminary Design (Phase 1), Detailed Design (Phase 2), Manufacturing and Procurement (Phase 3), Installation and Integration (Phase 4). While the activities in various phases may overlap in time, the overall schedule is structured by the Tollgate (TG) reviews that mark the nominal end of each phase.

The schedule presented here will be refined and adapted as the project progresses, but the major milestones (section 4.2) serve as a basis for reporting.

4.2 Milestone Plan

The major milestones in the WP are divided into external milestones – that are outside the control of the instrument team but yet have a major impact – and progress milestones that are used to track progress and report to the Instrument Construction Sub-Project.

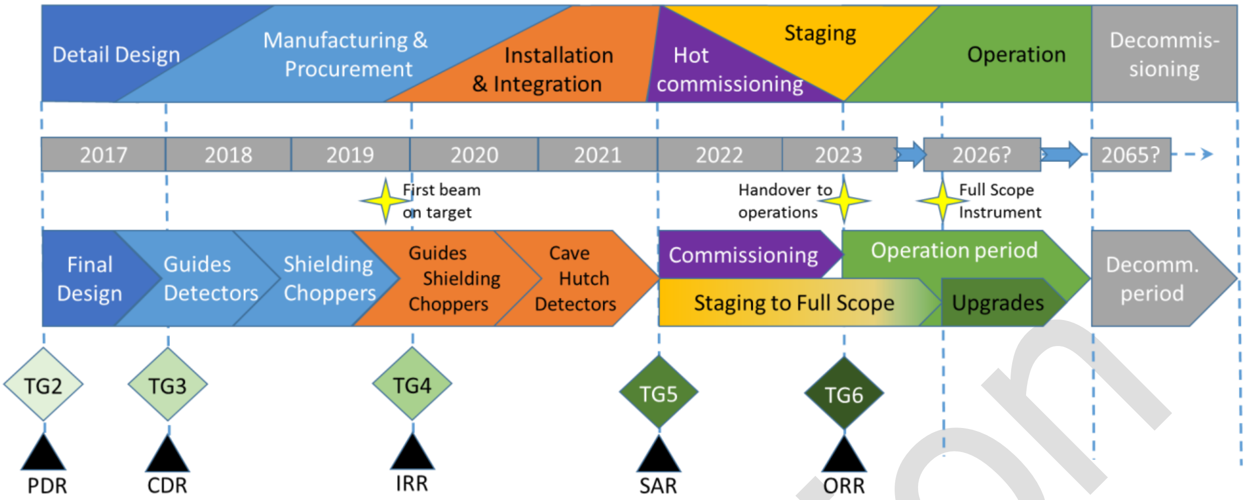
Milestone	Projected date
Crane & Access to D03 Main Hall	01/11/2019
Crane & Access to D03 Bunker	01/11/2019
End of Access to D03 Bunker	01/05/20
Crane Access to Neutron Guide Hall E02-1 (close to E01)	27/04/2019
Crane Access to Neutron Guide Hall E02-2	15/10/2019
Crane & Access to E01	27/04/2019
First Proton on Target, 570MeV (ACCS)	01/10/2020

Progress milestones	
Milestone	Projected date
MS BEER Start of Detailed Design (Phase 2)	**MAR - 2017**
Readiness for beam extraction system Procurement	SEP - 2017
Readiness for Optics Procurement	MAR - 2018
Readiness for Chopper Procurement	NOV- 2017

Readiness for Shielding Procurement	MAR - 2018
Readiness for Detector Procurement	AUG- 2018
Readiness for Experimental Cave Procurement	AUG- 2018
Readiness for Control Hutch Procurement	JUL - 2018
Readiness for Special purpose MCA Procurement	MAY - 2018
TG3 (Phase 3) Manufacturing & Procurement	**FEB - 2018**
Beam extraction system ready to install	MAY - 2018
Neutron Optics inside the bunker ready to install	OCT - 2019
Neutron Optics outside bunker ready to install (Neutron guide hall)	OCT - 2019
Focusing Optics ready to install	AUG - 2020
Chopper inside the bunker ready to install	DEC - 2019
Chopper outside the bunker ready to install	JUL - 2020
Secondary Shutter 1 ready to install	JAN - 2020
Detector ready to install	JAN - 2021
Guide Shielding ready to install	NOV - 2019
Experimental Cave ready to install	DEC - 2020
Control hutch ready to install	JAN - 2021
Special Purpose MCA ready for install	DEC - 2019
TG4 Phase 4 Installation & Integration	**JAN - 2020**
Experimental Cave ready to accept components	DEC - 2021
Control hutch ready to accept components	JUL – 2021
Beam extraction system installed	MAR - 2019
Neutron Optics inside the bunker installed	MAY - 2020
Neutron Optics outside the bunker installed (Neutron Guide hall)	AUG - 2020
Focusing Optics installed	MAR - 2021
Chopper inside the bunker installed	MAY - 2020
Chopper outside the bunker installed	JAN - 2021
Secondary Shutter 1 installed	JUL - 2020
Guide shielding installed	MAY - 2021
Detector installed	SEP - 2021
Cave Equipment and Support installed	DEC - 2021
Components integrated into EPICS	SEP - 2021
BEER ready for cold commissioning	SEP - 2021
TG5 Hot Commissioning	**JAN - 2022**

4.3 Detailed Plan

The detailed plan (Gantt chart) is provided as an appendix to the document. Below is a high-level summary chart showing the phases of the project with the tollgate reviews.


Detail Design
Manufacturing & Procurement
Installation & Integration
Hot commissioning
Staging
Operation
Decommis-sioning
2017
2018
2019
2020
2021
2022
2023
2026?
2065?
First beam on target
Handover to operations
Full Scope Instrument
Final Design
Guides Detectors
Shielding Choppers
Guides Shielding Choppers
Cave Hutch Detectors
Commissioning
Operation period
Staging to Full Scope
Upgrades
Decomm. period
TG2
TG3
TG4
TG5
TG6
PDR
CDR
IRR
SAR
ORR

5. PROJECT BUDGET AND FINANCIAL REPORTING

5.1 Project Budget

The cost presented here is for the agreed scope during the Scope Setting meeting. It presents the high-level Budget and time.

	01 Phase 1	02 Project Management & Integration	03 Design	04 Procurement & Fabrication	05 Installation	06 Cold Commissioning	SUM
01 Shielding	0	0	0	2.543.726	476.672	0	3.020.398
02 Neutron Optics	0	0	0	2.741.000	0	0	2.741.000
03 Choppers	0	29.920	0	1.155.000	35.640	19.140	1.239.700
04 Sample Environment	0	0	0	30.000	0	0	30.000
05 Detector and Beam Monitors	0	0	0	2.762.900	0	0	2.762.900
06 Data Acquisition and Analysis	0	0	0	0	0	0	0
07 Motion Control and Automation	0	0	0	94.100	45.660	0	139.760
08 Instrument Specific Technical Equipment	471.850	690.000	648.000	552.000	442.800	302.400	3.107.050
09 Instrument Infrastructure	0	0	0	500.000	0	0	500.000
10 Vacuum	0	0	0	0	0	0	0
11 PSS	0	0	0	127.000	0	0	127.000
12 Contingency	0	71.992	64.800	1.050.393	100.077	32.154	1.319.596
Total	471.850	791.912	712.800	11.556.299	1.100.849	353.694	14.987.404
Person year	3.12	5.43	6.00	2.00	5.43	3.27	25.25

6. PROJECT RISK MANAGEMENT

The risks are divided into technical, cost and schedule risks and their probability and consequence on a scale of 1-5 (where 1 denotes low probability and minor consequence) according to ESS risk management practice. The risk level then was calculated by multiplying probability by estimated consequences. As a result, the high, medium and low-risk levels were identified.

Low (1-4)
Medium (5-6)
High (7-15)

6.1 Risk List

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.

Technical				
Risk	**Probability**	**Consequence**	**Risk level**	**Mitigation**
^{3}He-free detectors will not fulfil requirements	2	4	8	Backup detector solution
Bunker Design interferes with Chopper positions	1	4	4	Adapt Chopper positions
Bi-spectral extraction system does not perform as expected	2	4	8	Accept lower performance
Shielding does not meet requirements	2	4	8	Add additional shielding
Optics performance does not meet requirements	1	3	3	Accept lower performance
High background in cave	1	3	3	Add shielding to cave and detectors
Experimental hall floor stability is not sufficient	1	3	3	Implement active damping, accept lower precision
Cost				
Risk	**Probability**	**Consequence**	**Risk level**	**Mitigation**
Detector cost estimates are exceeded	2	2	4	Use of contingency, de-scoping
Underestimated price and design of shielding	2	3	6	Use of contingency
Experimental Cave and Control hutch cost increase	2	2	4	Use of contingency
Increased cost exceeds available contingency	2	2	4	Negotiate Scope and Budget with ESS
Optics cost increases	1	2	2	Use of contingency,
Schedule				
Risk	**Probability**	**Consequence**	**Risk level**	**Mitigation**
Delay in signing contracts	2	4	8	Early start of negotiations
Delay in installation of in-bunker components	2	5	10	Careful installation planning with neighbour instruments
Delay in access to instrument halls	2	4	8	Early delivery of components, careful installation planning
Key personnel left the project	2	4	8	Find new personnel
Delay of integration of special purpose motion into EPICS	2	3	6	Early start of integration
Delay in detector delivery	2	2	4	Timely decision on technology, timely procurement
Delay in optics delivery	3	2	6	Early procurement
Delay in Chopper delivery	2	2	4	Early Procurement
Delays in procurement	2	2	4	Early procurement

6.2 Risk Monitoring and Control

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 realised it will be reported to the Instrument Construction Sub-Project even if it has no direct consequence at that level.

7. GLOSSARY

Abbreviation	Explanation of abbreviation
BEER	Beamline for European materials Engineering Research
BTCS	Beam transport and conditioning system
CF	Conventional facilities
ESS	European Spallation Source
HZG	Helmholtz-Zentrum Geesthacht
ICEB	Instrument Consortium Executive Board
MoU	Memorandum of Understanding
NPI	Nuclear Physics Institute
NSS	Neutron scattering systems
P&ID	Process and instrumentation diagram
PBS	Product breakdown structure
PSS	Personnel safety system
SCS	Scattering characterization system
SES	Sample exposure system
TG	Tollgate
WP	Work package
WU	Work unit

8. REFERENCES

[1] Instrument Construction Sub-Project Specification
[2] BEER – Preliminary System Design Description
[3] BEER – System Requirements Document
[4] Process for Neutron Instrument Design and Construction (ESS-0051706)

DOCUMENT REVISION HISTORY

Version	Reason for revision	Date
0.1	New Document	2016-12-07
0.2	TG2 version	2017-01-06