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System Requirement Specification for the ODIN instrument

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1 SCOPE

The scope of the system, namely ODIN, of which the requirements are presented in this document, is defined in accordance with the instrument system originally proposed, ref [1], endorsed by SAC and approved by STC (now Council). The scope of the system is limited to those items lying within the budgetary responsibility of the instrument project as defined in the Work Package Specifications [2], and excludes systems vital to the instruments purpose not lying within these boundaries like the ESS bunker, the Imaging related parts of the DMSC project, the ICS etc. These however represent essential functions for the functionality of the ODIN system and hence interfaces to the ODIN system exist with indispensible requirements of the ODIN system, which will be covered in this document as External Interface Requirements.

The scope of ODIN within these boundaries is defined for the system to enable to fulfil the high level scientific requirements as outlined in the ODIN Concept of Operations document (2. High Level Scientific Requirements) [3]. Consequently the system consists of and is limited to the subsystems outlined in the ODIN Concept of Operations document [3], in Chapter 3.4 (System Overview). These are reflected in the highest level PBS of ODIN as shown in Figure 1, the functional requirements will be structured accordingly.

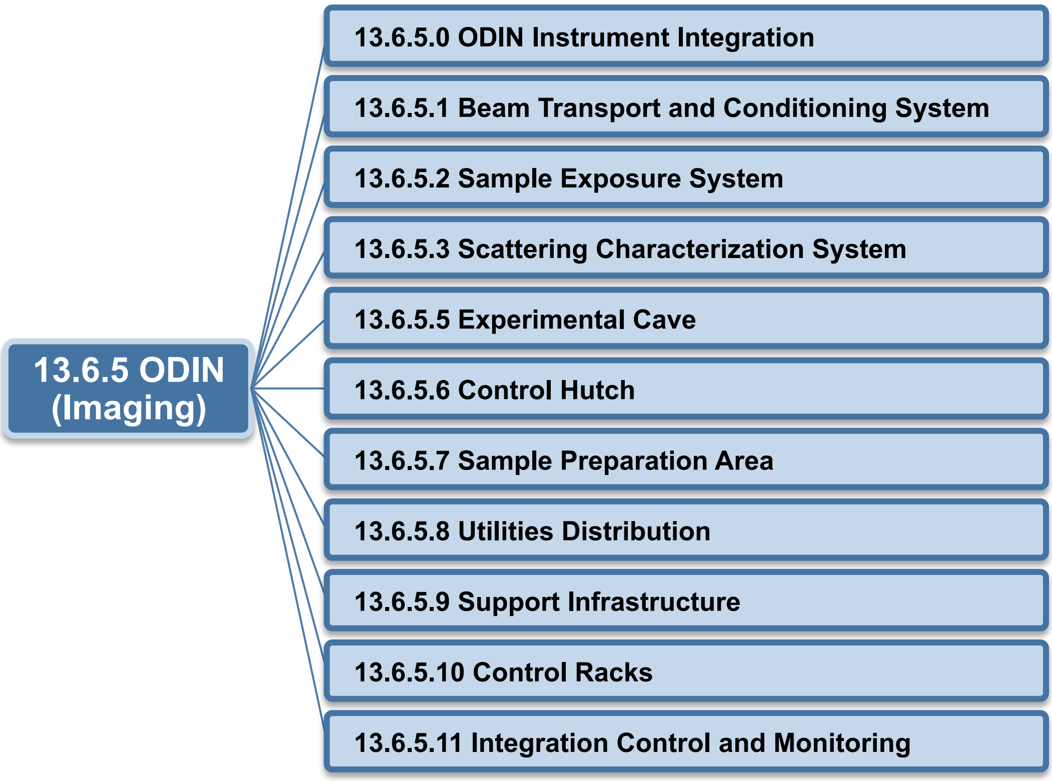

Figure 1. ODIN Product Breakdown Structure

2 REQUIREMENTS

2.1 Background and guidelines for generation of requirements

This entire section should be regarded as a brief background on how to read the system requirements.

2.1.1 Requirements Categories

ESS has organized system requirements in three categories. Ideally they can be separated as follows:

- Functional requirements – generally answering to the “what” is performed by the system
- Constraint requirements (or non-functional requirements) – generally answering to the “how” a function is performed by the system
- Performance requirements – generally answering to the “how well” a function has to perform or “to what extent” a constraint affects the system design

In reality it is often difficult to differentiate between what is a functional and what is a constraint requirement. Performance requirements are in principle either functional or constraint requirements with limiting statements quantifying the satisfaction level.

To clarify: In principle, constraint requirements do not impact on the functionality of the instrument. They will however have a lesser or greater impact on the design choices of the instrument in order to achieve the intended functionality. They could also have an impact on the performance of the instrument.

2.1.2 Requirements pre-requisites

When creating requirements the following principles should be respected:

- each requirement is necessary, unique and verifiable
- attempt to address each phase of the life cycle, as completely as possible, incl. decommissioning,

2.1.3 Requirement wording

Requirements are written in statements using shall or should, where the former implies a mandatory statement and the latter is a non-mandatory one. Should is used to set a goal which if fulfilled would increase the performance or functionality of the system. It can trigger discussions of prioritizing and how they can be achieved and at what impact (mainly to cost but also with respect to e.g. future upgrade possibilities etc.).

2.2 Functional Requirements

The following sections breakdown the high-level scientific requirements to requirements that the major subsystems need to fulfil.

2.2.1 Beam Transport and Conditioning System (BTCS)– PBS 13.6.5.1

Id	Text	Trace up to
1	Wavelength Transportation – Range The BTCS shall be optimised [1] to transport neutrons with wavelength from 1 Å to 20 Å from the thermal and cold moderator surfaces (a wavelength-averaged brilliance transfer higher than 40% as compared to the benchmark of an optics-less pinhole set-up with 6.5 m source to pinhole and L=10 m pinhole to detector)	ConOps 2.1.: I-II; 2.2.: 2,5-10, 12,13 3.2., 3.4.2
2	Field of View – Transported Divergence The BTCS shall be able to illuminate an area up to 20×20 cm^2 at L=14 m	ConOps 2.1.: I; 2.2.: 4,11 3.2. & 3.4.2
3	Beam Divergence – Profile The wavelength dependent divergence transported by the BTCS shall allow for homogeneous (75%) illumination of the FOV.[1]	ConOps 2.1.: I; 2.2.: 1,2,4,5, 11 3.2. & 3.4.2
4	Wavelength Resolution and Selection – Wavelength Range The BTCS shall be able to provide various selectable wavelength resolutions from smaller than 0.4% to bigger than 10%.	ConOps 2.1.: II; 2.2.: 6-13 3.2.
5	Wavelength Resolution and Selection – Natural Resolution A standard detector position shall be at 60m from the moderator to profit from a “natural resolution” [2] of 10% at 2 Å.	ConOps 2.1.: II; 2.2.: 7,8, 10-12 3.2.
6	Wavelength Resolution and Selection – Pulse Shaping For the detector position of 60m the BTCS shall allow pulse shaping to tune the wavelength resolution constantly for all wavelengths between 1 and 9 Å continuously from 1% to ≤ 0.4%	ConOps 2.1.: II; 2.2.: 6-13 3.2. & 3.4.7

[1] Verification: The homogeneity will be reviewed by an expert panel to assess acceptability as no strict definition applies. As a rough rule of thumb: no intensity variation >30% overall and no local intensity variation exceeding 10%/200µm.

[2] Natural resolution and natural bandwidth refer to values achievable without further pulse shaping, but provided by the source time structure at specific distances.

Id	Text	Trace up to
7	Collimation - Flight Path (L) The BTCS shall allow for a collimation path L from pinhole (D) to detector of up to at least 10m extendable up to 14m while avoiding air scattering.	ConOps 2.1.: I-II; 2.2.: 8-12 3.2. & 3.4.7.
8	Collimation – Pinhole Position The BTCS shall have a pinhole at 50 m.	ConOps 2.1.: II; 2.2.: 7,8, 10-12 3.4.2 & 3.4.7
9	Collimation – Pinhole Size, fixed The BTCS shall have at least 6 settings of the pinhole size covering 0-30 mm range.	ConOps 2.1. & 2.2. 3.2 & 3.4.7
10	Beam Collimation – L/D Ratio The BTCS shall allow for collimation ratios (L/D; L and D being pinhole to detector distance and pinhole diameter, respectively) to be chosen between 100 and 10000.	ConOps 2.1. & 2.2. 3.2. & 3.4.7 5.
11	Beam Size Selection – continuous variation BTCS shall be able to continuously reduce the maximum beamsize at any given distance of L.[3]	ConOps 2.1. & 2.2. 3.2. & 3.4.7
12	Bandwidth Selection The "natural" usable wavelength bandwidth at the 60 m detector position is about 4.5 Å. The BTCS shall be able to use an unlimited bandwidth allowing frame overlap as well as at least the double natural bandwidth without frame overlap.	ConOps 2.1. & 2.2. 3.2.
13	Operation Mode Changes – Remote Mode Switching Modes of operation concerning components upstream of the pinhole (and the pinhole system itself) shall be remotely configurable (during operation).	ConOps 2.2.: 15 3.2. & 3.4.5. 3.4.7. & 5.
14	Operation Mode changes – BTCS access requirements during switching The BTCS downstream of the pinhole shall be accessible for configuration during protons on target (target operation).	ConOps 3.2. & 3.4.6., 3.4.7. 3.4.11. & 5
15	White Beam Imaging – FoV The BTCS shall allow white beam imaging using the full range of sizes of the field of view.	ConOps 2.1.: I 2.2.: 4,10 3.2.1 & 3.4.7

[3] The required maximum beamsize that can be illuminated is given by requirement 2 above, for any defined distance L from the pinhole

Id	Text	Trace up to
16	White Beam Imaging – Spectrum range White beam imaging shall be possible utilising the full beam spectrum transported and any selected fraction of it.	ConOps 2.1.: I 2.2.: 4,10 3.2.1
17	White Beam Imaging – Spatial resolution White beam imaging shall be possible with spatial resolutions down to at least 10 μm on a limited field of view (approximately 5×5 cm^2 for best resolution).	ConOps 2.1.: I 2.2.: 4,10 3.2.1
18	Low ToF Resolution Imaging (LtoFR, natural wavelength resolution) – Maximum Field of View/resolution The BTCS shall allow LtoFR imaging using a maximum field of view of at least 5×5 cm^2 with high spatial resolution.	ConOps 2.1.: II 3.2. & 3.4.8
19	Low ToF Resolution Imaging (LtoFR, natural wavelength resolution) – FOV/resolution The BTCS shall allow LtoFR imaging using the full range of sizes of FOV with a spatial resolution relaxed to the mm range.	ConOps 2.1.: II 3.2. & 3.4.9
20	Low ToF Resolution Imaging (LtoFR, natural wavelength resolution) – Bandwidth The BTCS shall allow LtoFR Imaging to be possible using the natural bandwidth, double the natural bandwidth anywhere between wavelengths of 1 and 20 Å	ConOps 2.1.: II 2.2.: 7,8,12 3.2. 3.4.2 & 3.4.5
21	Low ToF Resolution Imaging (LtoFR, natural wavelength resolution) – Spatial Resolution The BTCS shall allow LtoFR Imaging with spatial resolution at least 100 μm on a limited field of view (approximately 5×5 cm^2).	ConOps 2.1.: II 2.2.: 7,8,12 3.2 & 3.4.9
22	Medium ToF Resolution Imaging (MtoFR, 1% wavelength resolution) – Maximum Field of View The BTCS shall allow MtoFR imaging using a maximum field of view of at least 5×5 cm^2 with high spatial resolution of at least 100 mm and using the full range of sizes of FOV with a spatial resolution relaxed to the mm range.	ConOps 2.1.: II 2.2.: 7-11,13 3.2. 3.4.9
23	Medium ToF Resolution Imaging (MtoFR, 1% wavelength resolution) – Bandwidth, shortest wavelength The BTCS shall allow MtoFR Imaging being possible using the natural bandwidth and double the natural bandwidth starting at 1 Å.	ConOps 2.1.: II 2.2.: 7-11,13 3.2. & 3.4.5
24	Medium ToF Resolution Imaging (MtoFR, 1% wavelength resolution) – Spatial Resolution The BTCS shall allow MtoFR Imaging with spatial resolution at least 100 μm on a limited field of view (approximately 5×5 cm^2).	ConOps 2.1.: II 2.2.: 7-11,13 3.2. & 3.4.9

Id	Text	Trace up to
25	High ToF Resolution Imaging (HtoFR, <1% wavelength resolution) – Maximum Field of View The BTCS shall allow HtoFR imaging using a maximum field of view of at least 5×5 cm^2 with high spatial resolution or using the full range of sizes of FOV with a spatial resolution relaxed to the mm range.	ConOps 2.1.: II 2.2.: 6,9 3.2. & 3.4.9
26	High ToF Resolution Imaging (HtoFR, <1% wavelength resolution) – Bandwidth, shortest wavelength The BTCS shall allow HtoFR Imaging shall be possible using the natural bandwidth starting between 1 Å and 3 Å.	ConOps 2.1.: II 2.2.: 6,9 3.2. & 3.4.5
27	High ToF Resolution Imaging (HtoFR, <1% wavelength resolution) – Spatial Resolution The BTCS shall allow HtoFR Imaging with spatial resolution at least 100µm on a limited field of view (approximately 5×5 cm^2).	ConOps 2.1.: II 2.2.: 6,9 3.2. & 3.4.9
28	Beam Monitoring The BTCS shall allow for monitoring the beam flux with a wavelength resolution of <0.3% at 9, 33 and 50 m downstream the moderator under any operation condition.	ConOps 2.1.: I, II 2.2.: 2,3,5,8, 10,11 3.2.
29	Background The fast neutron and gamma background shall not exceed signal to background values in the white beam mode and shall not exceed a 1% level in any time channel for the best HtoFR with an MCP detector from UC Berkeley. The latter can be relaxed if reliable background correction is possible. Background level refers to measured background assuming current state of the art detectors.	ConOps 2.1.: I, II 2.2.: 2,3,5,6, 8-10 3.4.3. 5.3.3

BTCS requirements below refer to imaging modalities foreseen for staging. In order to ensure an instrument that can host these imaging techniques in a straightforward fashion, corresponding requirements are listed.

Id	Text	Trace up to
30	White Beam Imaging – Depolarisation imaging The White beam Imaging shall allow for depolarisation imaging and polarisation and analyser efficiencies with a wavelength average of 70% between 1 and 20 Å.[4]	ConOps 2.1.: I 2.2.: 13 3.2.1 & 3.4.8
31	Low ToF Resolution Imaging (LtoFR, natural wavelength resolution) – FOV for grating interferometry The LtoFR Imaging shall allow for grating interferometry with a FOV of at least 5×5 and 7.5×7.5 cm^2 for different spatial resolutions respectively.[4]	ConOps 2.1.: II 2.2.: 12 3.2. 3.4.8 & 3.4.9
32	Low ToF Resolution Imaging (LtoFR, natural wavelength resolution) – FOV for SEMSANS imaging The LtoFR Imaging shall allow for SEMSANS Imaging with a FOV of at least 5×5 cm^2.[4]	ConOps 2.1.: II 2.2.: 12 3.2. 3.4.8 & 3.4.9
33	Medium ToF Resolution Imaging (MtoFR, 1% wavelength resolution) – FOV for polarized and polarimetric imaging The MtoFR Imaging shall allow for polarized and polarimetric imaging with a FOV at least of 5×5 and 7.5×7.5 cm^2 for different spatial resolutions respectively and polarisation with a wavelength average of 70% between 1 and 10 Å.	ConOps 2.1.: II 2.2.: 13 3.2. & 3.4.9
34	Medium ToF Resolution Imaging (MtoFR, 1% wavelength resolution) – Detector coverage in diffraction geometry The MtoFR Imaging shall allow for additional detector coverage in diffraction geometry (a planned future upgrade).	ConOps 2.1.: II 2.2.: 9 3.2. & 3.4.9
35	High ToF Resolution Imaging (HtoFR, <1% wavelength resolution) – Detector coverage in diffraction geometry The HtoFR Imaging shall allow for additional detector coverage in diffraction geometry.	ConOps 2.1.: II 2.2.: 6,9,10 3.2. & 3.4.9

[4] The specific requirements for this system will be detailed at a later time since their implementation is planned at a later point (staging).

2.2.2 Sample Exposure System, SES – PBS 13.6.5.2

Id	Text	Trace up to
36	SES – Alignment The SES shall have the capability to align small and large samples including their sample environment for measurements with the respective required size and resolution of a study (i.e. down to 1 μm).	ConOps 2.1. 3.2. 3.4.7. 5.
37	SES Positioning The SES shall offer the capability to perform positioning across the beam remotely for scans with a precision of up to 1 μm.	ConOps 2.1. & 3.2. 3.4.7. & 5.
38	SES Tomography The SES shall offer the capability for remotely controlled tomographic scans, i.e. rotations around the z axis (360°) with the accuracy of the image resolution requirements: 0.005°	ConOps 2.1. 3.2. 3.4.7. & 5.
39	SES Tomography axis alignment The SES shall offer the capability to align the rotation axis within the image resolution requirements, ideally about 1 μm.	ConOps 2.1. & 3.2. 3.4.7. & 5.
40	SES longitudinal positioning The SES shall offer the possibility to perform corresponding measurements along the positions foreseen for sample exposure, i.e. from about 1 m to up to 14 m from the pinhole position, with mm accuracy.	ConOps 2.1. 3.2. 3.4.7. & 5.
41	SES maximum weight capacity The SES shall be able to handle samples up to 1000kg.	ConOps 2.1. & 3.2. 3.4.7. & 5.
42	SES control All remotely controlled alignment of the SES shall be possible from the control hutch but also from within the cave, i.e. in close vicinity (visual control) of the SES.	ConOps 2.1. & 3.2. 3.4.7. & 5.

2.2.3 Scattering Characterization System, SCS – PBS 13.6.5.3

Id	Text	Trace up to
43	The SCS system shall enable the fulfilment of the High-level scientific requirements for the instrument. It shall detect the beam according to the beam transport and condition requirements defined for the BTCS in terms of size, spatial resolution, time resolution, instrument configurations and modes etc. As no one detection system can fulfil all requirements the instrument shall include a number of detectors that best fulfil all the above requirements. The detector suite shall satisfy the minimum requirements as defined below.	ConOps 2.1. 3.2. 3.4.9. 5.
44	Detector Area The SCS shall provide detector areas of up to at least 20×20 cm^2.	ConOps 2.1.& 2.2: 4,11 3.2.
45	Spatial resolution The SCS shall provide effective resolutions of down to at least 10 µm but should reach values of the order of 1 µm.	ConOps 2.1. 2.2: 1,10,11 3.2.
46	Time resolution – ToF Imaging The SCS shall provide detector time resolutions down to the ns range (sub-µs range) for ToF imaging measurements.	ConOps 2.1.: II 2.2: 3,6-13 3.2. & 3.4.9.
47	Time resolution – Kinetic Imaging The SCS shall provide detector time resolutions down to ~70 ms for kinetic imaging applications.	ConOps 2.1. & 2.2: 2 3.2.
48	Time resolution – Stroboscopic measurements The SCS shall provide detector time resolutions of at least 10ns to allow stroboscopic measurements with time resolutions around 1 µs.	ConOps 2.1. & 2.2: 2 3.2.
49	Efficiency – Lower acceptable limit Detection efficiency of the SCS shall not fall below 30% at 4 Å for any specific detector system.	ConOps 2.1. 3.2. & 3.4.9.
50	Efficiency – Optimal minimum Detection efficiency of the SCS shall in optimum case reach at least 90% at 4 Å.	ConOps 2.1. 3.2. & 3.4.9.
51	Efficiency – Ambition The detection efficiency of the SCS shall be optimum according to the state of the art available in 2019/20.	ConOps 2.1. 3.2. & 3.4.9.

52	Count rate – Limitation and Decay The detectors should have no count rate limitation and corresponding efficiency decay.	ConOps 2.1. 3.2. & 3.4.9.
53	Count rate – Local minimum Detectors shall reach values of $10^8 cm^{-2}s^{-1}$, for local count rates and corresponding integrated count rates over their respective detection area. That should even apply for systems used for ToF	ConOps 2.1. 3.2. & 3.4.9.
54	Count rate – Local optimum Detectors should in optimum case allow for local count rates and corresponding integrated count rates over their respective detection area of higher than $10^{10} cm^{-2}s^{-1}$.	ConOps 2.1. 3.2. & 3.4.9.
55	Gamma Sensitivity The gamma sensitivity of SCS systems shall be at least as low as the state of the art of specific currently used systems for corresponding applications. (A minimum requirement should potentially be defined for each specific system based on the current choice and the corresponding state of the art.)	ConOps 2.1. 3.2. 3.4.9.
56	Background Noise The background noise (read out noise) of specific SCS detection systems shall be at least as good as the state of the art of specific currently used systems for corresponding applications.	ConOps 2.1. 3.2. & 3.4.9.
57	Space requirement The active detection area of every SCS detection systems shall be possible to be placed not more than 10 mm from the closest surface of a sample or any sample environment respectively at very foreseen position of the SES.	ConOps 2.1. 3.2. 3.4.9.
58	Alignment – Hot Alignment Live view mode of imaging detectors shall allow quick alignment (hot alignment).	ConOps 2.1. & 3.2. 3.4.9. & 5.
59	Beam Stop – Attenuation The beamstop of the SCS shall be able to attenuate a direct beam to a level below 3 μSv/hr outside the Experimental Cave	ESS-0001786 “Supervised area” versus 3^{rd} safety area

2.2.4 Experimental Cave, EC – PBS 13.6.5.5

Id	Text	Trace up to
60	The Experimental Cave – access to pinhole components The Experimental Cave shall provide access to all components downstream the pinhole – part of BTCS, SES and SCS (including the pinhole)	ConOps 3.& 5.
61	The Experimental Cave – Flexible support structure Shall house the flexible support structure for all components downstream the pinhole.	ConOps 3.& 5.
62	The Experimental Cave – Utilities access The Experimental Cave shall have access to a variety of utilities including various power outlets (10A, 15A, 20A 32A), chilled water, compressed Instrument air and gas supplies.	ConOps 3.& 5.
63	The Experimental Cave – Utilities removal The Experimental Cave should allow for removal of exhaust gases and cooling water etc.	ConOps 3.& 5.
64	Biological shielding, Experimental Cave – Access to SES while proton beam on Target The Experimental Cave shall allow the user to access the SES while the proton beam is on target but only while systems are in place to ensure the dose level in the Experimental cave is acceptable.	ConOps 3.& 5.
65	Biological shielding, Experimental Cave – Access SES while proton be on Target, acceptable dose level The dose level in the Experimental Cave when accessing SES in it, with shutters closed, shall be 3 µSv/h in accordance with ESS-0001786 & ESS-0051603.	ConOps 3.& 5. ESS-0001786 ESS-0051603
66	Biological shielding, Experimental Cave – Access to SES during irradiation Experimental Cave shall prevent access to the SES while a sample irradiation is occurring.	ConOps 3.& 5.
67	Biological Shielding, Experimental Cave – dose attenuation The Experimental Cave shall attenuate the dose rate emanating from the SES and SCS during a sample irradiation , i.e shutter open, to 3 µSv/h, in accordance with ESS-0001786 & ESS-0051603,	ConOps 3.& 5. ESS-0001786 ESS-0051603
68	Experimental Cave – manual alignment of objects Laser equipment shall allow aligning detectors and samples to the beam manually.	ConOps 3.& 5.
69	Experimental Cave – Laser equipment remote removability Laser should be removable from beam remotely.	ConOps 3.& 5.

70	Experimental Cave – Visual monitoring of cave Live CCTV shall allow for visual control of movements in cave.	ConOps 3.& 5.
71	Experimental Cave – Floor Space The Experimental Cave shall provide a floor space > 70 m^2	ConOps 3.& 5.
72	Experimental Cave – Beam access height The Experimental Cave shall have a floor to beam axis height of 1.25±0.1 m (at least along beam for manual manipulations).	ConOps 3.& 5.
73	Experimental Cave – Object accommodation Entry to the Experimental cave shall allow for the movement of apparatus up to 1m wide × 1m thick × 2m tall.	ConOps 3.& 5.
74	Experimental Cave – SES accessibility It should be possible to access the SES and the cave through the entire area of the roof. The SES shall be accessible with	ConOps 3.& 5.
75	Experimental Cave – Accessibility It should be possible to access the cave directly from the loading dock to allow easy installation of heavy, sensitive equipment e.g. environment chambers.	ConOps 3.& 5.

2.2.5 Control Hutch, CH – PBS 13.6.5.6

Id	Text	Trace up to
76	Control Hutch – Instrument control terminal(s) The control hutch shall allow the user to remotely control the technical components from dedicated computer terminals	ConOps 3.& 5.
77	Control Hutch – Detector terminals The control hutch shall allow the user to remotely control detector systems from dedicated computer terminals and view live streams of detectors and CCTV.	ConOps 3.& 5.
78	Control Hutch – Data reduction terminal The control hutch shall allow the user to process the neutron data	ConOps 3.& 5.
79	Control Hutch – Comfort The control hutch should be a comfortable working environment for up to 6 users. ISO 11064-6 provides good guidelines for defining comfort and should be followed where possible.	ConOps 3.& 5.

2.2.6 Integration Control and monitoring, IC&M – PBS 13.6.5.12

Id	Text	Trace up to
79	IC&M – Instrument Control and Automation All motorized axes and electronic driven systems shall be remotely controllable with the instruments computer system	ConOps 3.& 5.
80	IC&M – Monitoring All viable systems shall be monitored electronically and feed back into the control system	ConOps 3.& 5.
81	IC&M – Source pulse synchronizing A signal, (ideally NIM) synchronized with the source pulse, shall be available to the system	ConOps 3.& 5.
82	IC&M – ODIN Standalone mode All electronic systems shall be configured such that the instrument can be controlled and utilized in a standalone mode independent of the ICS.	ConOps 3.& 5.
83	IC&M – Personal Safety System (PSS) The PSS shall be fully integrated into the Instrument control such that the Instrument can be operated safely.	ConOps 3.& 5.

2.3 Constraint Requirements

2.3.1 Operational constraint requirements

Id	Text	Trace up to
84	Operation Mode Changes – Mode Redundancy Maintenance or failure issues of one mode shall have a minimum impact on other modes (That choppers are removable or can be set to an open position is more important than repair and maintenance times that still should be kept to a minimum).	ConOps 5.3.3 6.1.2
85	Operation mode changes – BTSC access, configuration time No configuration mode change requiring access in the area downstream the pinhole shall take longer than 8 hours (including alignment).	ConOps 3.& 5.
86	BTCS Ergonomics The beam and BTCS components downstream of the pinhole shall be accessible at a comfortable height. (125±10 cm)	ConOps 3.& 5.
87	Detector exchange – As the SCS shall include a number of detectors, any change of detector configuration and system shall be a smooth standard operation carried out within 15 min (not including hot alignment, i.e. requiring beam).	ConOps 3.& 5.

2.3.2 Reliability, Availability, Maintainability & Inspectability (RAMI) requirements

Id	Text	Trace up to
88	Operation Schedule The system shall be operational according to the schedule of the ESS source and the set availability goals of NSS RAMI Handbook	ConOps: 5.1 ESS-0003640 NSS RAMI Handbook ;
89	Maintainability The system shall be maintainable in a way fulfilling the Operation Schedule requirement (above).	ConOps: 5.3 NSS RAMI Handbook ;
90	Access Instrument components shall be accessible for all maintenance and repair activities needed to fulfil the Operation Schedule and Maintenance requirements (above).	ConOps: 5.3, NSS RAMI Handbook ; ESS-0039408 NOSG Handbook
91	Reliability – MTBF (Mean Time Between Failure) Instrument components and sub-systems shall meet MTBF requirements (as specified elsewhere in detail) that enable to meet the Operation Schedule requirement (above).	ConOps: 5.3 NSS RAMI Handbook ;
92	Availability – MTTR (Mean Time To Repair) Instrument components and sub-systems shall meet MTTR requirements (as specified elsewhere in detail for critical sub-systems) that enable to meet the Operation Schedule requirement.	ConOps: 5.3 NSS RAMI Handbook ;
93	Internal Interfaces (physical connection) Instrument sub-systems shall be connected and integrated such to enable to meet the functional and other RAMI requirements.	ConOps 3.4
94	Design Robustness The overall system design shall enable to meet the Operation Schedule requirements through robustness against single sub-system failure.	ConOps 5.3.3 & 6.1.2
95	Spares The system shall include spares critical to meet OS requirement, where reasonably possible.	ConOps 5.3.3

2.3.3 Environmental Requirements

Id	Text	Trace up to
96	Shielding The radiological shielding of the system shall satisfy all applicable legal regulations incorporated in ESS procedures, guidelines, handbooks etc. to guarantee safe operation concerning radiation hazards.	ESS-0019931 ESS Procedure for designing shielding for safety , ESS-0052625 NOSG Phase 2 guidelines for designing instrument shielding, NOSG Handbook
97	Activation The Activation of system components shall comply with ALARA criteria, corresponding ESS procedures, guidelines, handbook, etc. incorporating applicable legal regulations, in particular also with respect to disposal.	ESS-0020168 NSS radioactive inventory - Part 2 (Exp. Hall and instruments), ESS-0052491 NSS radioactive inventory -Part 3 (Bunker)
98	Sample handling The system shall allow for sample handling procedures complying with ESS environmental policies and legal regulations incorporated in ESS procedures, guidelines, handbooks etc., in order not to pose an environmental risk.	ESS-0024112 Sample Handling Procedure
99	Materials The materials used in the system shall avoid environmental hazards and comply with all applicable legal regulations incorporated in ESS procedures, guidelines, handbooks etc.	ESS-0011452 ESS Procedure for sustainable selection of materials, ESS-0011458 ESS Guideline for sustainable selection of materials

2.3.4 Conventional Safety Requirements

Id	Text	Trace up to
100	Safety The system and all required operational procedures shall comply with ESS safety procedures, guidelines, handbooks etc. and legal regulations, incorporated in the former.	ESS-0043151 ESS-0039408 NOSG Handbook (Annex N)?

2.3.5 Radiation Safety Requirements

Id	Text	Trace up to
101	Activation The Activation of system components shall comply with ALARA criteria, corresponding ESS procedures, guidelines, handbook, etc. incorporating applicable legal regulations, in particular also with respect to disposal.	ESS-0020168 ESS-0052491
102	Sample handling The system shall allow for sample handling procedures complying with ESS environmental policies and legal regulations incorporated in ESS procedures, guidelines, handbooks etc., in order not to pose an environmental risk.	ESS-0024112 Sample Handling Procedure
103	Materials The materials used in the system shall avoid environmental hazards and comply with all applicable legal regulations incorporated in ESS procedures, guidelines, handbooks etc.	ESS-0039408 NOSG Handbook, ESS-0042895 ESS-0001786
104	PSS The system shall feature a PSS complying with ESS regulations and policies that enables radiological safety for the access to sub-systems.	ESS-0004620

2.3.6 External Interface Requirements

Id	Text	Trace up to
105	CF environment The system shall fit within and profit from the boundary conditions set through CF.	ConOps 3.& 5. NSS-Site Infrastructure IRS; ref [5].
106	Neighbouring Systems The system shall comply with the physical requirements of neighbouring systems and its design shall take into account needs of potential future neighbours. (E.g. modular FOC 5 pit to allow integration with potential shielding for a future S1 instrument)	ConOps 3.& 5.
107	ICS The system shall connect to the ICS to allow for monitoring and control with respect to all viable functions through ICS.	ConOps 3.& 5.
108	Data Streaming The system together with ICS shall enable to stream all recorded data through ICS to central data storage and back to instrument control/data computers.	ConOps 3.& 5.
109	Remote Control Software The system shall interface with control software to satisfy all remote control requirements for operation, testing, maintenance and meta-data production for users and operators. A specification of which components and operations require remote control is provided elsewhere in the instrument documentation [9].	ConOps 3.& 5.
110	Data Reduction Software The entirety of ODIN operational modes shall be the basis for the specification of all required data reduction and visualisation through a GUI and through command line interface, suitable for use by users with only minor training requirements. Detailed requirements for the reduction software constitute the major part of the interface with DMSC/Data Reduction and are in a process of development.	ConOps 3.& 5.
111	Data Analyses Software The entirety of ODIN operational modes shall be the basis for the specification of all required data analyses and corresponding visualisation through a GUI and through command line interface, suitable for use by users with only minor training requirements. Detailed requirements for the analyses software constitute the mayor part of the interface with DMSC/Data Analyses and are in a process of development available.	ConOps 3.& 5.

112	Sample Environment The system shall enable the use of pooled sample environment, as well as it should support custom designed SE from users or other groups.	ConOps 3.& 5.
113	The system shall comply with the bunker design.	ConOps 3.& 5.
114	Vacuum The system shall connect with vacuum services where required.	ConOps 3.& 5.
115	Monitoring The system shall enable monitoring with regards to radiological data, safety functions, operational conditions of sub-systems, vacuum, smoke, heat, specific gases etc. as required for safe operations by other sub-systems, systems and policies and regulations.	ConOps 3.& 5.
116	Required Services The system shall enable connection to all support systems and services provided centrally and required for operation not limited to but including these specified in these requirements.	ConOps 3.& 5.

GLOSSARY

Term	Definition
CCTV	Closed Circuit Television (surveillance)
ConOps	Concept of Operation for the ODIN Instrument

REFERENCES

[1] ESS Instrument Construction Proposal; ODIN – Optical and Diffraction Imaging with Neutrons
[2] Work Package Specifications – ODIN: ESS-00100655
[3] Concepts Of Operations for the ODIN Instrument: ESS-0053465
[4] NSS RAMI Handbook, ESS-TBD
[5] NSS-Site Infrastructure Interface Requirement Specification (IRS), ESS-TBD
[6] NSS-Target Station (Beam Extraction System) Interface Requirement Description, ESS-TBD
[7] "Supervised area" versus 3rd safety area, ESS-0001786
[8] NSS zoning document - part 1, ESS-0051603
[9] Preliminary System Design for the ODIN instrument: ESS-00100656

DOCUMENT REVISION HISTORY

Revision	Reason for and description of change	Author	Date
1	First issue	Markus Strobl/Peter Sångberg	2016-05-10
2	Revision of TG2 panel implemented	Michael Lerche	2017-02-17