EUROPEAN SPALLATION SOURCE

Remote Handling

Strategy and implementation

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Overview

- Why do we need RH at ESS
- How are we going to implement RH
- Implementation examples on instruments
- Future

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Remote Handling

Justification

ESS unique source, with unique boundary conditions.

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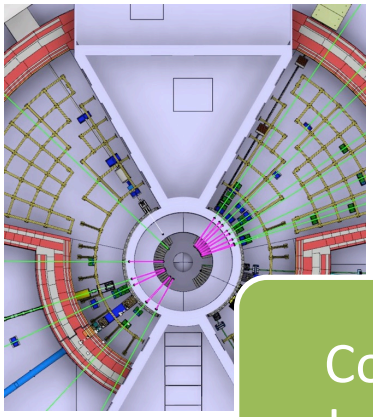


Complex Installed systems

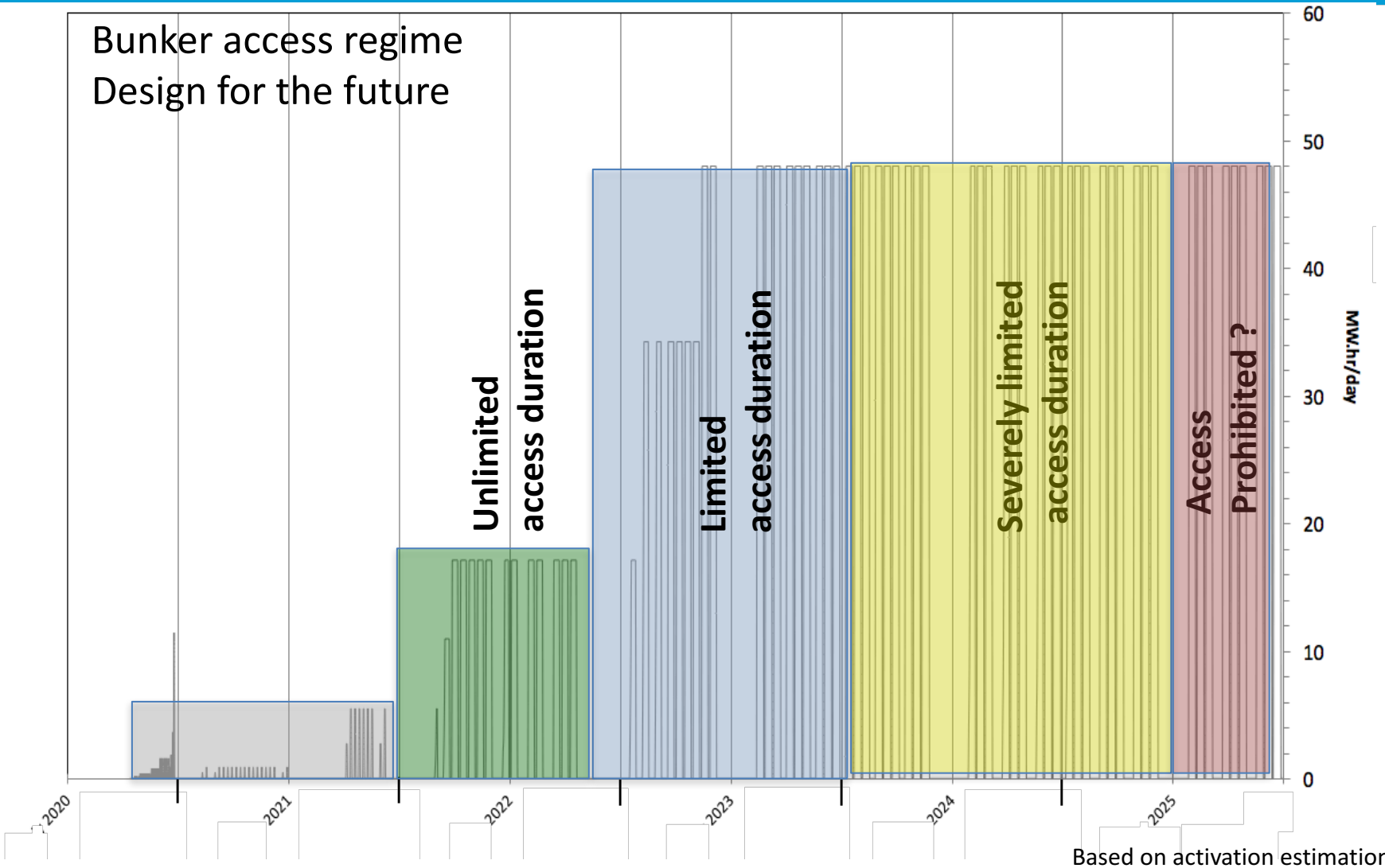
Radiation environment

Internal and External rules and legislation

A challenging environment to operate equipment

Limited access opportunities

Component activation a long term issue …



Based on activation estimations

Exact access regime will be dependent on operational experience

Activity during shutdown - rear of bunker

Whole body dose @ about 30 cm [µSv/h]							
Delay following beam shutdown	Material	1h	1 day	3 days	7 days	1 year
Guide upstream of the 1st chopper	Aluminium (5083)	200	<3	<0.5	<0.5	<0.5
Guide downstream	Aluminium ?	<25	<3	<0.5	<0.5	<0.5
Collimator (streaming)	Copper	<50	<25	<3	<3	<3
Chopper (no steel)	Aluminium housing / Alu rotor	300	<50	<3	<0.5	<0.5
Heavy shutter	Tungsten / no housing	1000	100	<50	<25	<25
T_0 chopper (Tungsten hammer)	Tungsten / steel housing	1000	100	<50	<25	<25
Inside rear bunker wall (with lead)	Lead /PolyConcrete/ Steel	<3	<3	<3	<3	<0.5

Note all calculations assume **idealized configura**
Exposition prior to shutdown is assumed to be **1**

Dose >3 <25 microSv/h
UNRESTRICTED CONTROLLED WORK AREA
(BLUE ZONE)

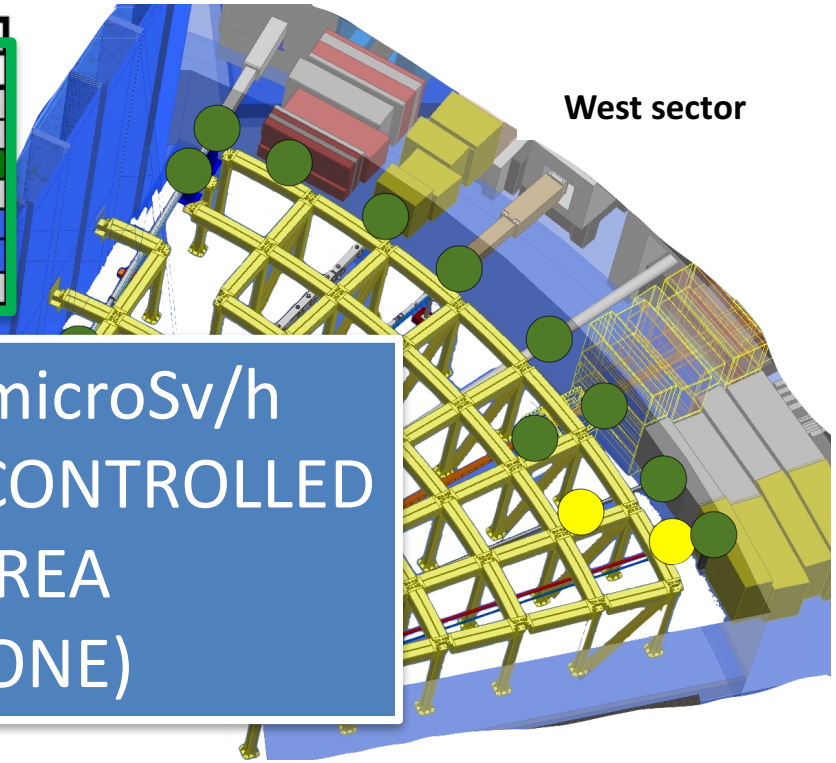
Number of sources (>0.5)

Source 'density

Exposure dominated by 'ambient

Access prerequisites Gamma shutters

Remove or shield hotspots



Gamma source distribution 72hrs after shutdown (@30cm)

Activity during shutdown - front of bunker

Delay following beam shutdown	Material	Contact dose [µSv/h] 1h	1 day	3 days	7 days	1 year
Guide upstream of the 1st chopper	Aluminium (5083)	1000	50	<3	<3	<3
Guide downstream	Aluminium ?	40	<3	<3	<0.5	<0.5
Collimator (streaming)	Copper	1000	200	<25	<25	<25
Chopper (no steel)	Aluminium housing / Alu rotor	15000	200	<25	<3	<3
Heavy shutter	Tungsten / no housing	20000	1000	500	<100	<100
T_0 chopper (Tungsten hammer)	Tungsten / steel housing	20000	1000	500	<100	<100
Inside rear bunker wall (with lead)	Lead /PolyConcrete/ Steel	<3	<3	<3	<3	<0.5

Note all calculations assume **idealized configu**
Exposition prior to shutdown is assumed to b

Dose >25microSv/h
RESTRICTED CONTROLLED WORK AREA
(YELLOW ZONE)

Number of sources (>0.

Source ‘density’ >5 per m2

‘contact’ dose dominates

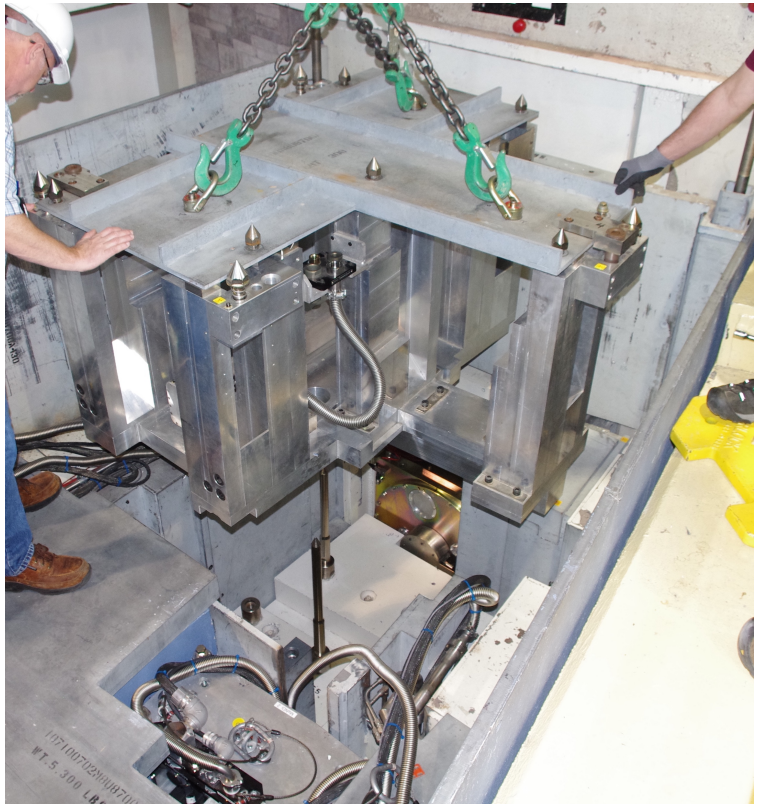
Access prerequisites Gamma shutters

Earliest access

Gamma source distribution three days after shutdown (@contact)

Other facilities

- SNS (1-1.4MW)
  - Critical systems prepared for remote handling
  - Activation levels increasing (10 years of operation)
- J-PARC (~0,5MW)
  - Critical systems designed for remote handling
  - Maintenance equipment handled remotely
- ISIS (~200KW)
  - No RH compatibility on instrument component
  - Still manageable after 30 years
- JET (Joint European Torus)
  - Forced to retrofit RH components
  - 3-5 times longer handling time on upgraded equipment compared to original RH designs



Large (dual beamline) RH module at SNS

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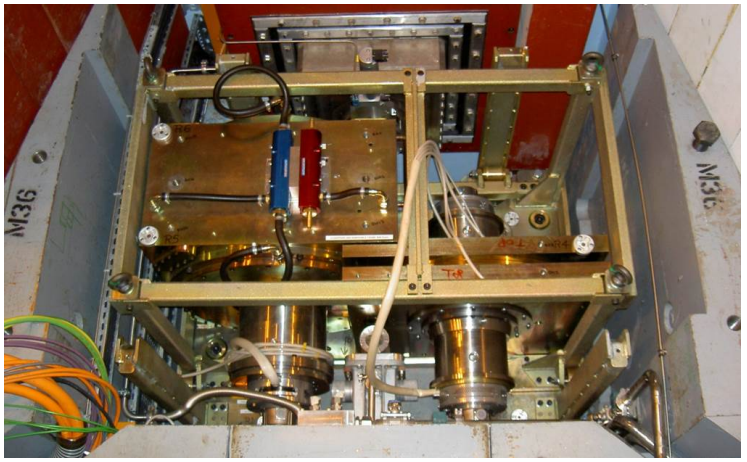
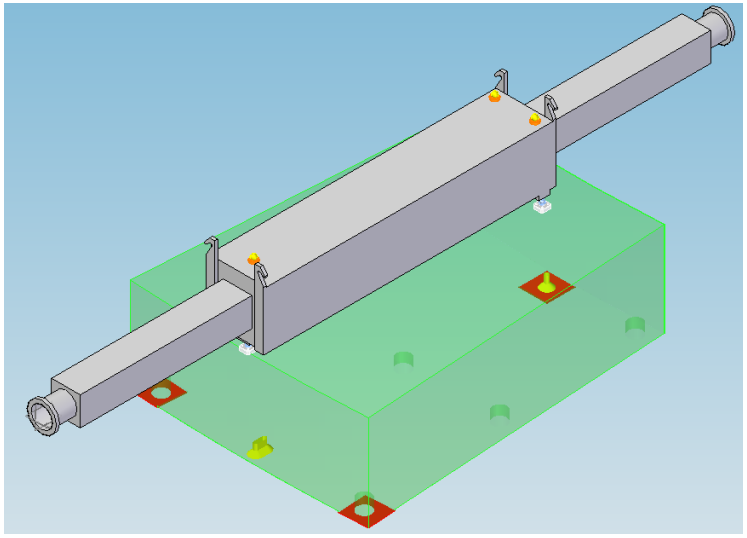
Remote Handling

Strategy – ESS-0042943

Use of modules

- Design instruments in modules.
  - Aim to reduce the number of modules along the beamline.
- Module is defined as
  - Common maintenance unit and/or
  - Common extraction unit.
- All modules shall be classified during detailed design





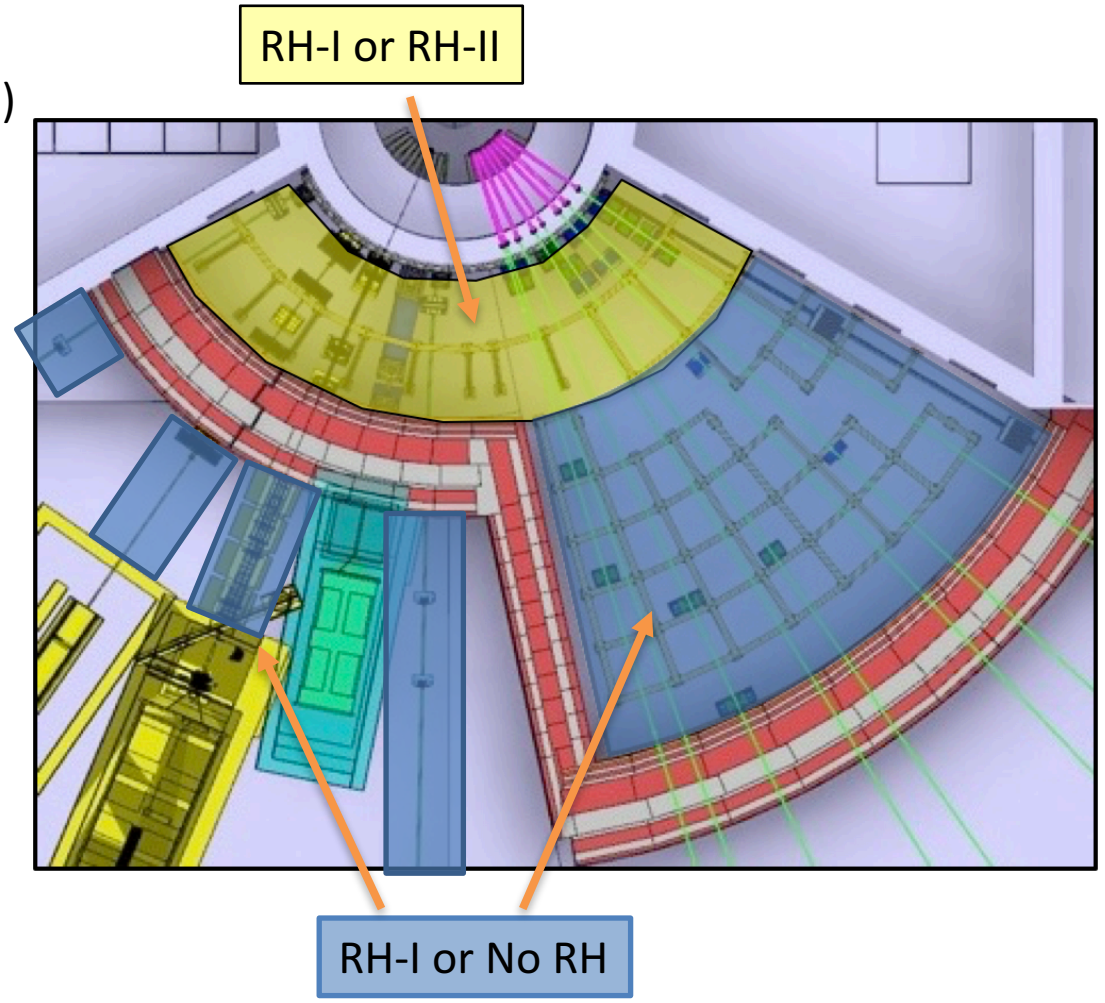
Classification

Classification dependent on

- Location (Yellow* or blue* zone)
- Levels of activation after 72 hours (expected time to access)
- Expected service interval
- Reliability

Three levels of classification

- Full remote handling compatibility (RH-I)
- Limited remote handling compatibility (RH-II)
- No remote handling compatibility.



*Exact demarcation TBD.

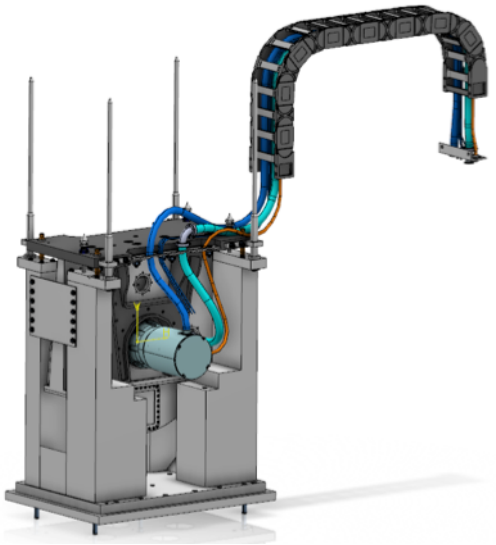
Handling strategy

- Activities restricted to
  - **Extraction (RH-I and RH-II)**
  - **Reinstallation (RH-I)**
  - Inspection and/or realignment of component/module (if required)
- Complex RH activities shall be avoided.
  - Straight vertical lifts only.
- No in-situ RH maintenance is foreseen.

Remote handling classification
RH-I

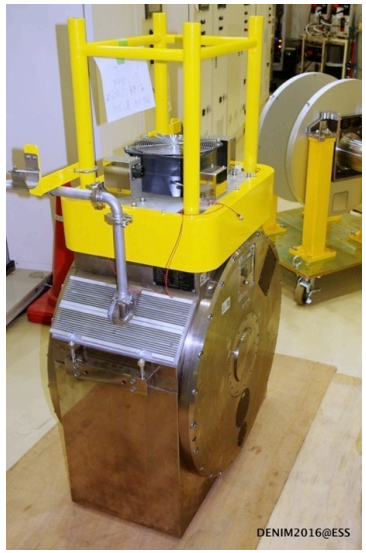
Module classified as RH-I if **any** of the following three criteria apply

1. Module is installed within Yellow zone* and has maintenance or reliability constraints**
2. Module is installed in Blue Zone and has maintenance, reliability or activation constraints***.
3. Module has to be removed to access another RH-1 module.



Typical modules classified in RH-I:

- Chopper assemblies
- Collimator assemblies
- Shutters
- T0-Choppers



*Exact demarcation TBD.

**Less then 5 years service interval or MTBF of less than 10 years

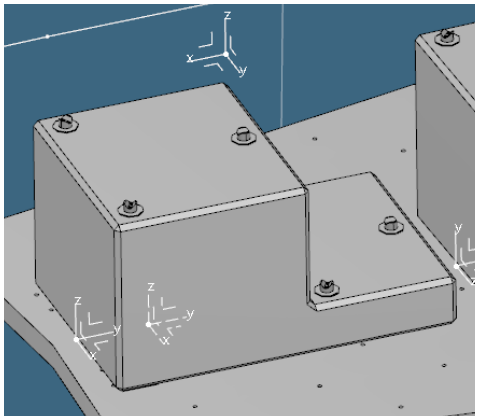
*** Less than 5 years service interval, MRBF of less than 10 years or contact dose of >25µSv/h after 72h.

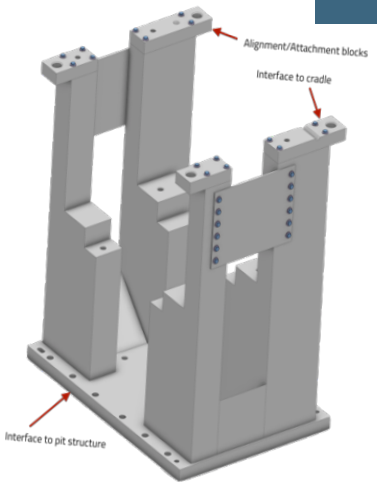
Remote handling classification
RH-II

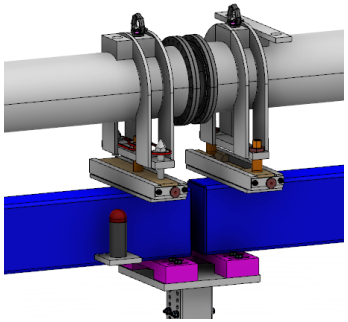
Modules shall be classified as RH-II if it is installed within Yellow Zone and is not classified as RH-I

Typical modules classified in RH-II:

- Base plates
- Supports and alignment mounts
- Most neutron guides
- Service infrastructure





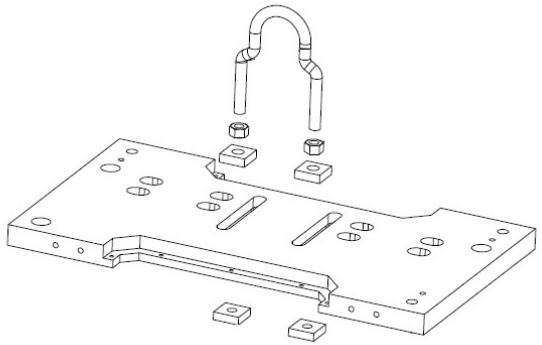


Best practices

- Handling
- Alignment
- Module interfaces
- Activation and contamination
- Viewing, visibility and identification
- Failure considerations
- Standardisation

Best practices – Handling

- Vertical lift of modules, using the overhead crane and supported by self aligning features.
- Use available lifting interfaces.
  - Simple and safe engagement and disengagement.
  - Special tools, jigs, and fixtures should be avoided
  - Single point lifting in combination with guide rails/pins.
- No loose items during handling.
  - Unbolted fasteners for extraction is required to be captive.
- Avoid multiple simultaneous handling.
- Avoid damage during handling.
- Any exceptions to this shall be discussed and approved.

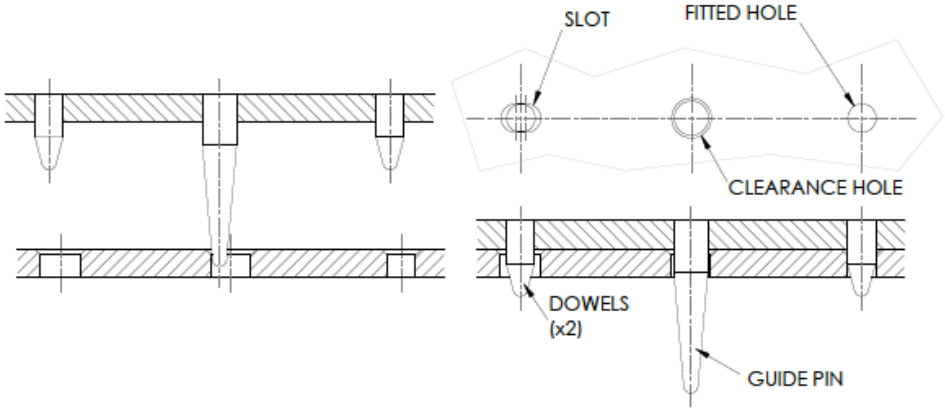


Single point lifting

Maintenance support

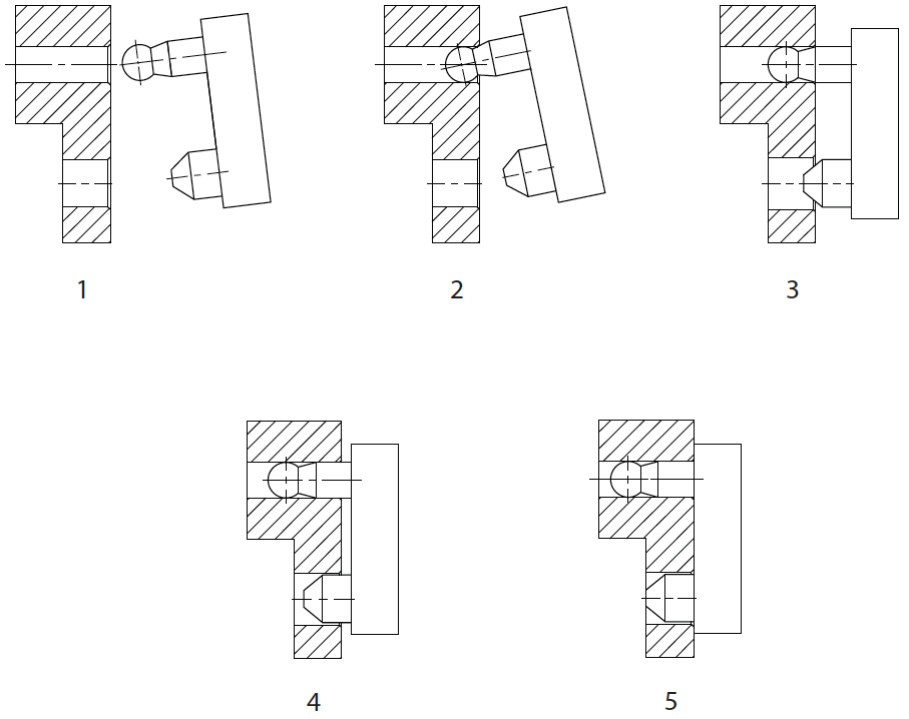
Best practices – Safe alignment of module

- Self engaging and self aligning
  - Gradual alignment using guide pins or rollers
  - Generous tolerances and realistic capture range.
  - Guide pins should be of different lengths.
  - Dowels should generally be used in pairs.
  - Dowels shall be as short as possible.
- Consider what RH equipment is available and required
- Incorrect mating shall be impossible.



Best practices – Safe alignment of module

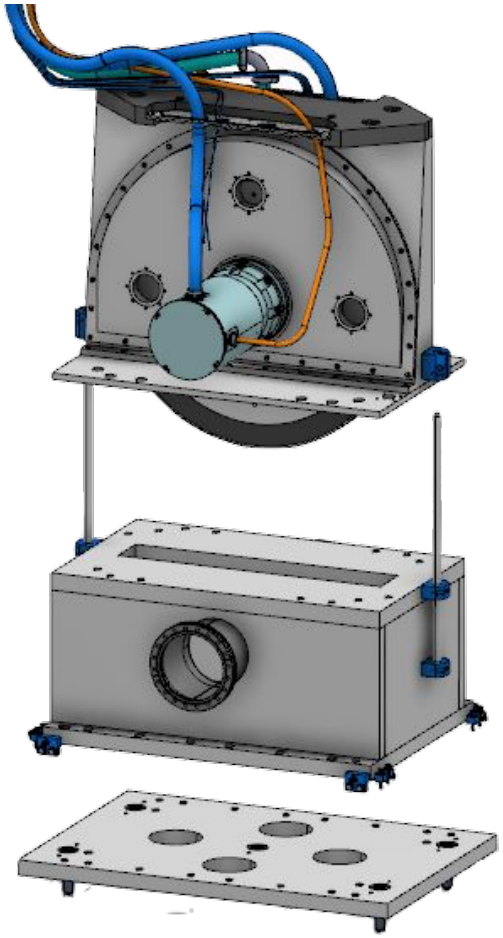
Step	DoF's	Type
1. Module held in free space	6	3 Translation 3 Rotation
2. Module located on dowel ball-end	4	1 Translation 3 Rotation
3. Module located on single long ball-ended dowel pin	2	1 Translation 1 Rotation
4. Module item located on second short dowel pin	1	1 Translation 0 Rotation
5. Module fully in contact with mating face	0	0 Translation 0 Rotation

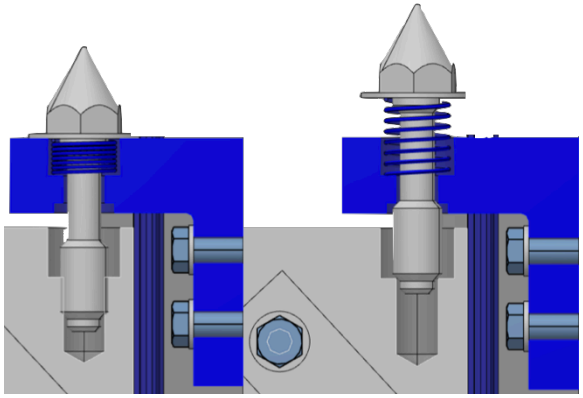


Example of gradual kinematic constraint

Best practices - Interfaces

- Modules should be independent of other modules.
- Bolted interfaces
  - Minimise number of bolts
  - Use few bolt sizes
  - Design according to standard or use standard components.
  - Captive pop-up design
- No welding interfaces between modules.
- Work on remote handling interface between vacuum sections is ongoing (together with the ESS vacuum group).



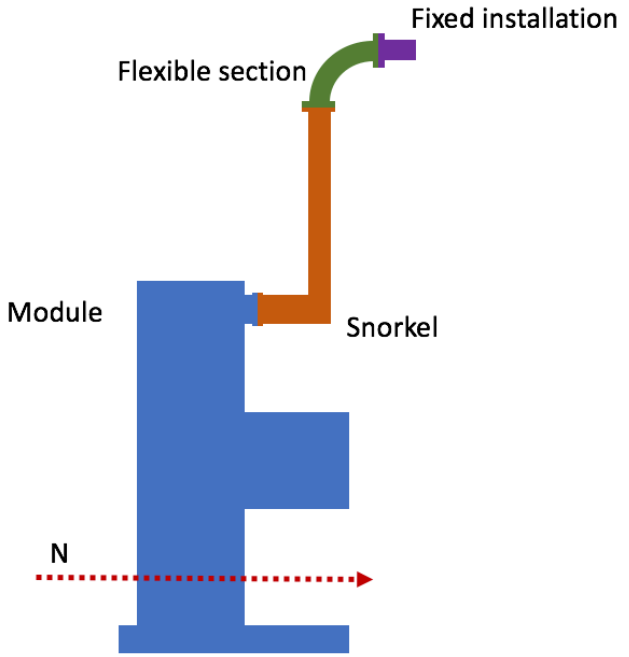


Example of captive bolts

Best practices – Interfaces

Electrical and fluid interfaces

- Utilities routed in three sections
  - Self supporting snorkel
  - Flexible section
  - Fixed section
- Bundling of connectors
- Push-pull type connectors

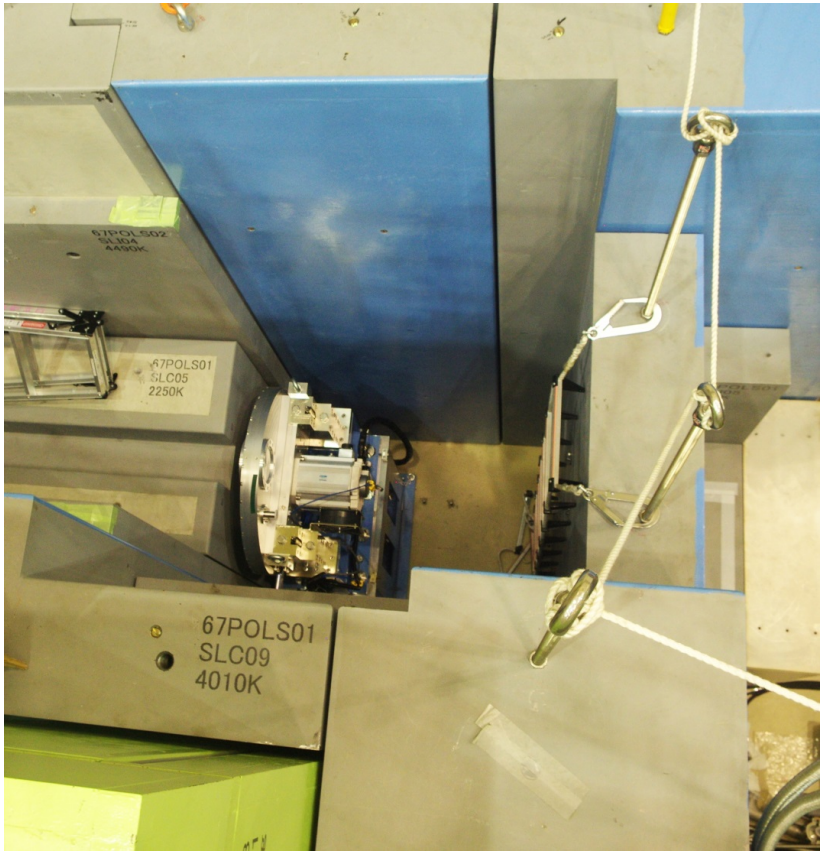


Best practices – Activation and contamination

- Minimising the activation lowers the cooldown period
  - Beneficial for bunker access – Errors can cause access to bunker to be impossible.
  - Beneficial for hands on maintenance.
  - Lowers waste cost.
- Must comply to the instruction and materials list to be released
  - Exceptions shall be approved by ESS.
  - Choose construction materials that minimise the need for decontamination.

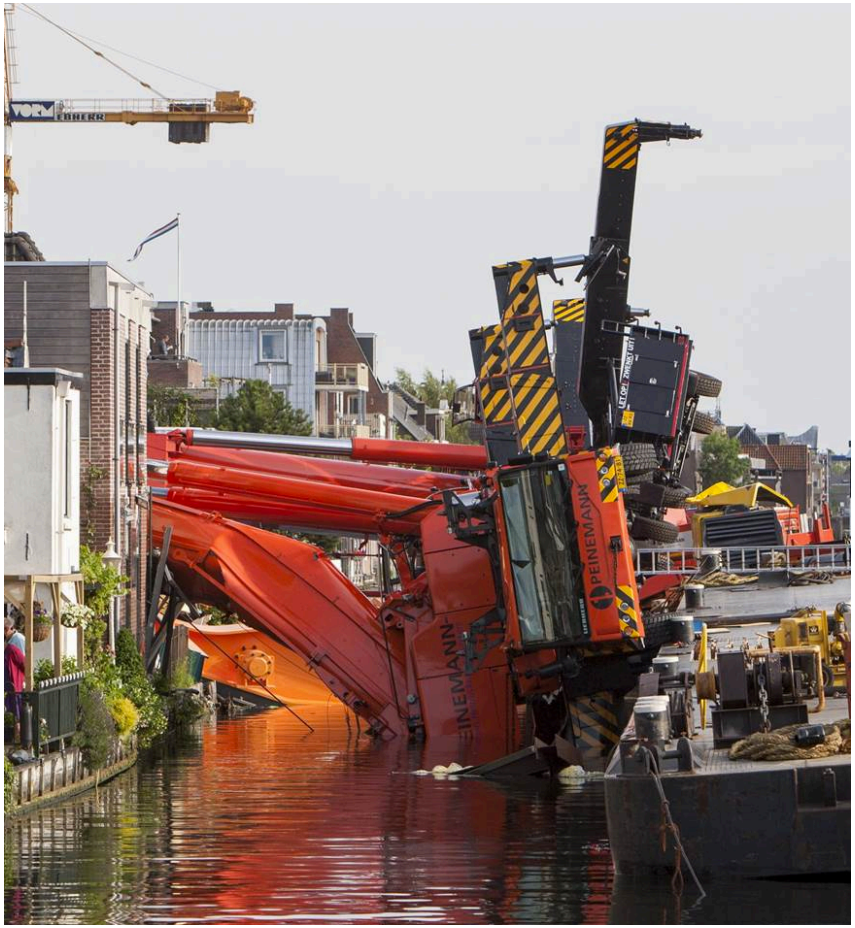
Best practices – Viewing, Visibility and Identification

- High contrast or colour difference between mating modules and avoid highly reflective surfaces.
- Physical features that clearly align when correctly assembled.
- All module items, must be clearly marked and identified.
- Have means to perform inspection in service, if required.
- Incorporate suitable survey and alignment attachment points.



Best practices – Failure consideration

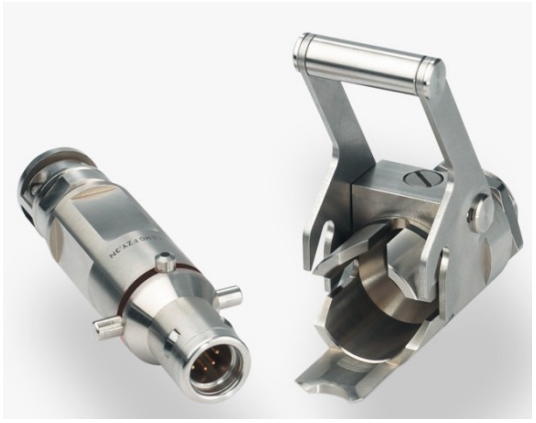
- All modules shall be assessed for the probability and modes of failure.
- Failure analysis
- RH features shall not be damaged in any failure scenario.



Best practices – Standardisation

- Large benefits of standardisation, over the lifetime of ESS.
- General standardization best practices:
  - Use standard design solutions, instead of new design solutions.
  - Commercial components are preferred over own designs.
  - Limit the number of different types of commercial components.
- List of standardisation areas:
  - Location and alignment devices (ESS-0111248) [Guide pins, rods wheels etc.]
  - Fasteners and mechanical load transferring components (ESS-0111249) [Screws, bolts etc.]
  - Lifting and handling features (ESS-0111250) [Lifting eyes etc.]
  - Electrical connectors (ESS-0111251)
  - Fluid couplings (ESS-0111255) [Including vacuum components for optics]
  - Construction materials use at ESS instruments
  - Seals and gaskets (ESS-0059912)
- We need your help and input!

Elasticity after irradiation



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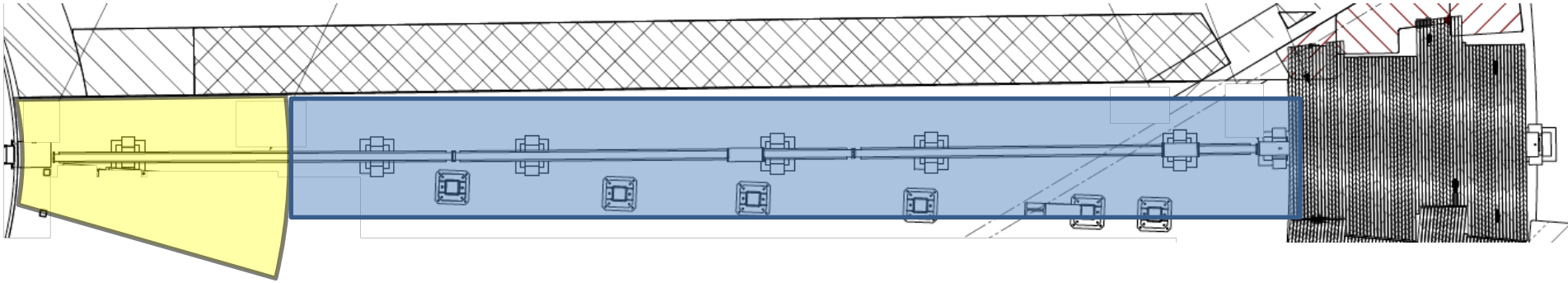
Remote Handling

Example implementations

Design example – ***inspired*** by NMX

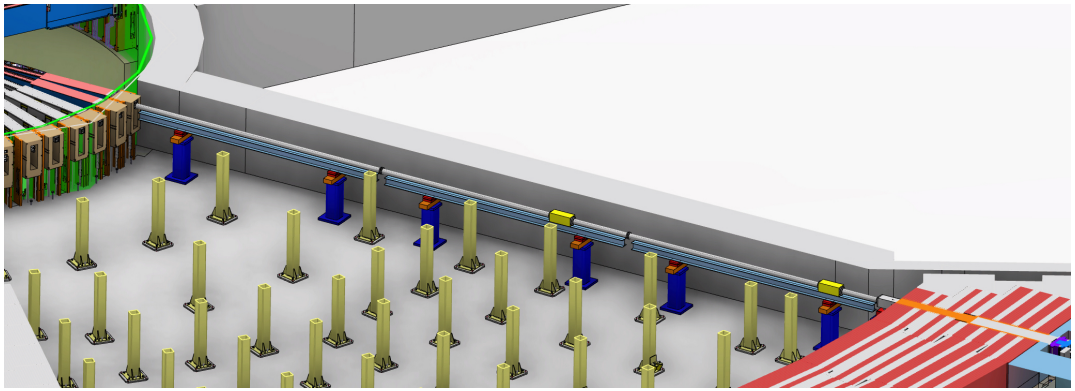


Yellow Zone
Guide sections

- One or two guide modules
- Support modules
- RH-II Classed
- Designed for RH-extraction
  - Lifting interface
  - RH-disconnection
  - Separated by windows or RH-Bellows
- Failure analysis
- Low activation materials

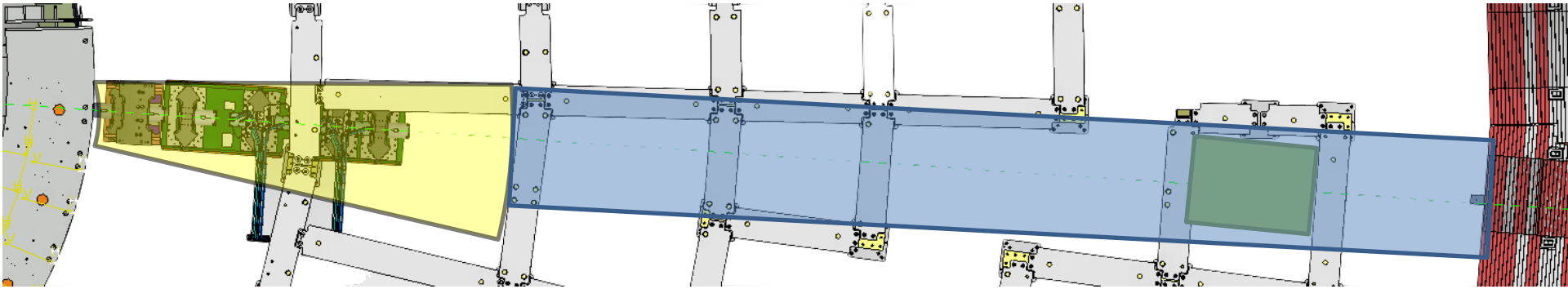
Blue Zone
Guide and collimator sections

- No remote handling classed modules
- No RH impact on design
- Low activation materials



Images courtesy of NMX team

Design example – ***inspired*** by BEER



Yellow Zone

Chopper modules

- Five to six chopper modules
- Translating chopper support module
- RH-I Classed
- Designed for RH extraction and reinstallation
  - Lifting interface
  - RH-disconnection
  - Guide system
  - Alignment system
- Failure analysis
- Low activation materials

Guide/Support modules

- Lower enclosure modules
- Guide modules
- Support modules
- RH-II Classed
- Designed for RH-extraction
  - Lifting interface
  - RH-disconnection
  - Separated by windows or RH-Bellows
- Failure analysis
- Low activation materials

Blue Zone

Heavy shutter module

- RH-I Classed
- Designed for RH extraction and reinstallation
  - Lifting interface
  - RH-disconnection
  - Guide system
  - Alignment system
- Failure analysis

Guide/Support modules

- No remote handling classed modules
- No RH impact on design
- Low activation materials

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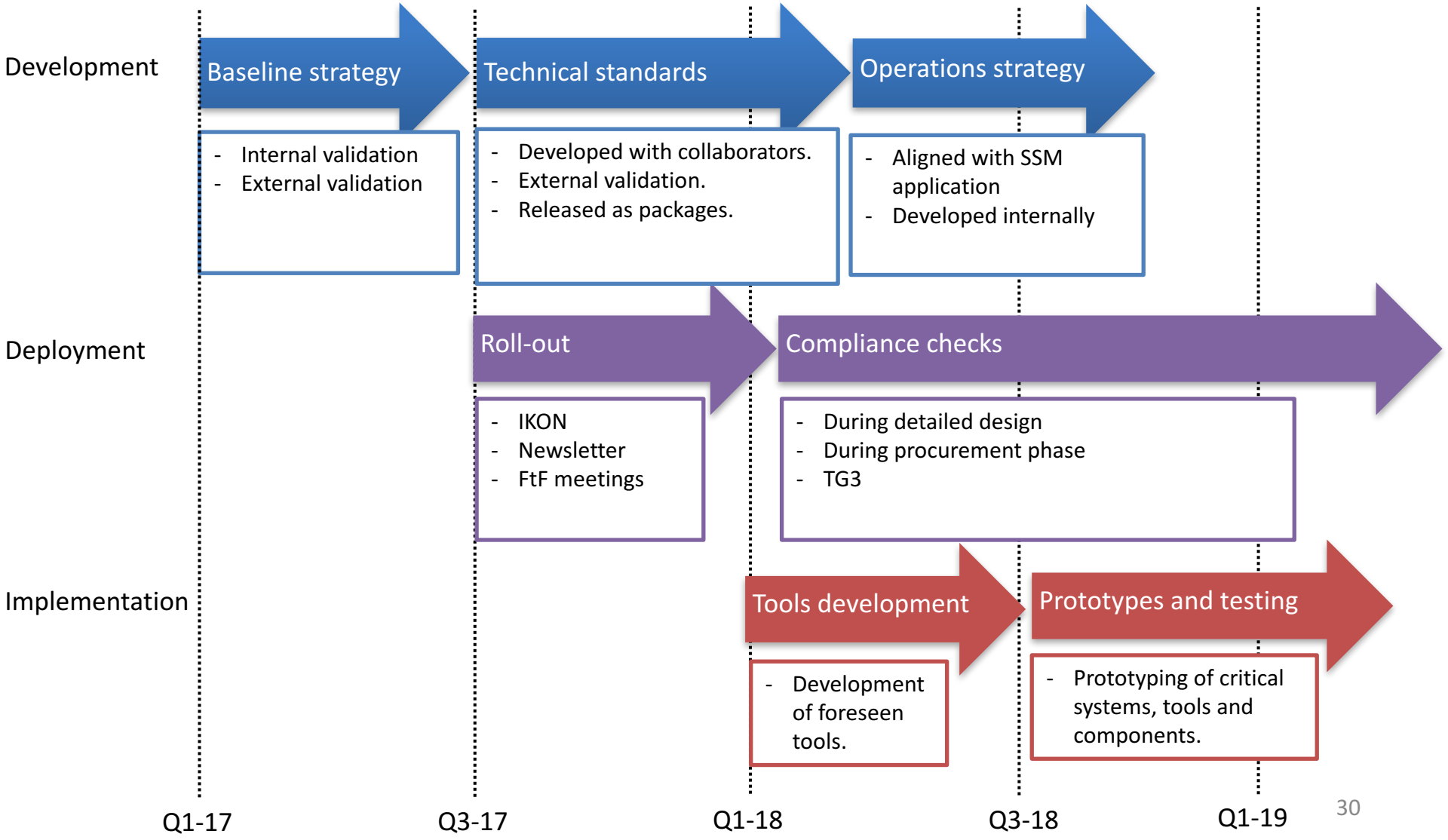
Remote Handling

Future

RH Compatibility for instruments

- The instrument are required to present the following in the TG3 documentation:
  - Module definition and classification.
  - RH consideration for handling, alignment and fastening.
  - Failure analysis of modules.
  - Case and reason when ESS best practices are not followed (if any).
  - Case and reason when ESS standard RH equipment is not used (if any).
  - Requirements on specialised tooling outside of ESS standards.
- The instruments projects shall communicate changes to TG3 scope as early as possible to allow for tools and equipment adaptation.

RH Deployment



Thank you for your attention

Questions?