PURESAFE
Preventing hUman intervention for IncREased SAfety inFrastructures Emitting ionizing radiation

RP 7

Remote Handling Concept Study for the Super-FRS Plug System

A Systematic Approach to Define, Analyse and Develop Remote Handling Tasks in Radiation Areas

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GSI Helmholtzzentrum

Project: 02/12 – 01/15

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Outline

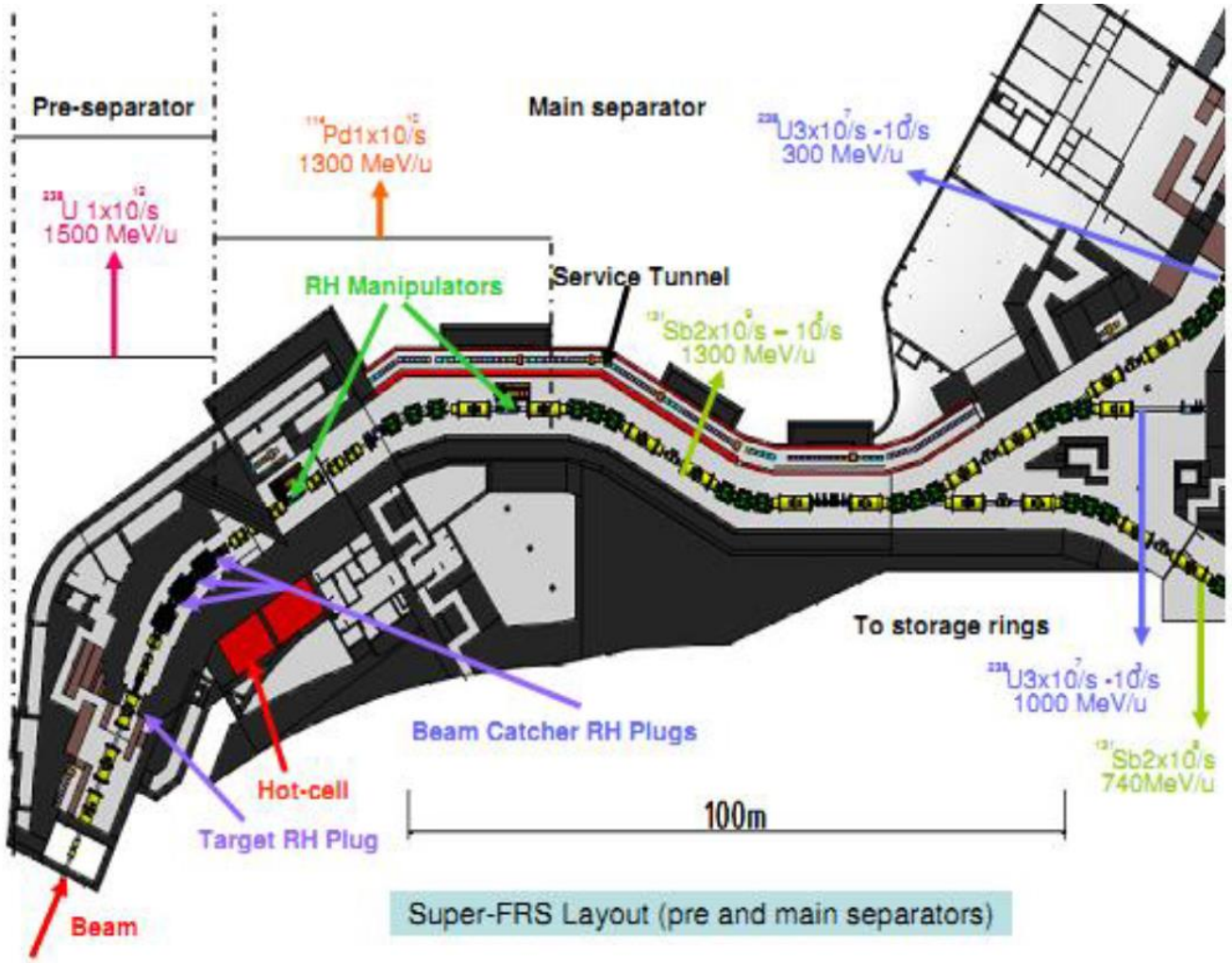
- Background information
- Super-FRS target area remote handling
- Remote handling
- My research
- Summary

Background Information

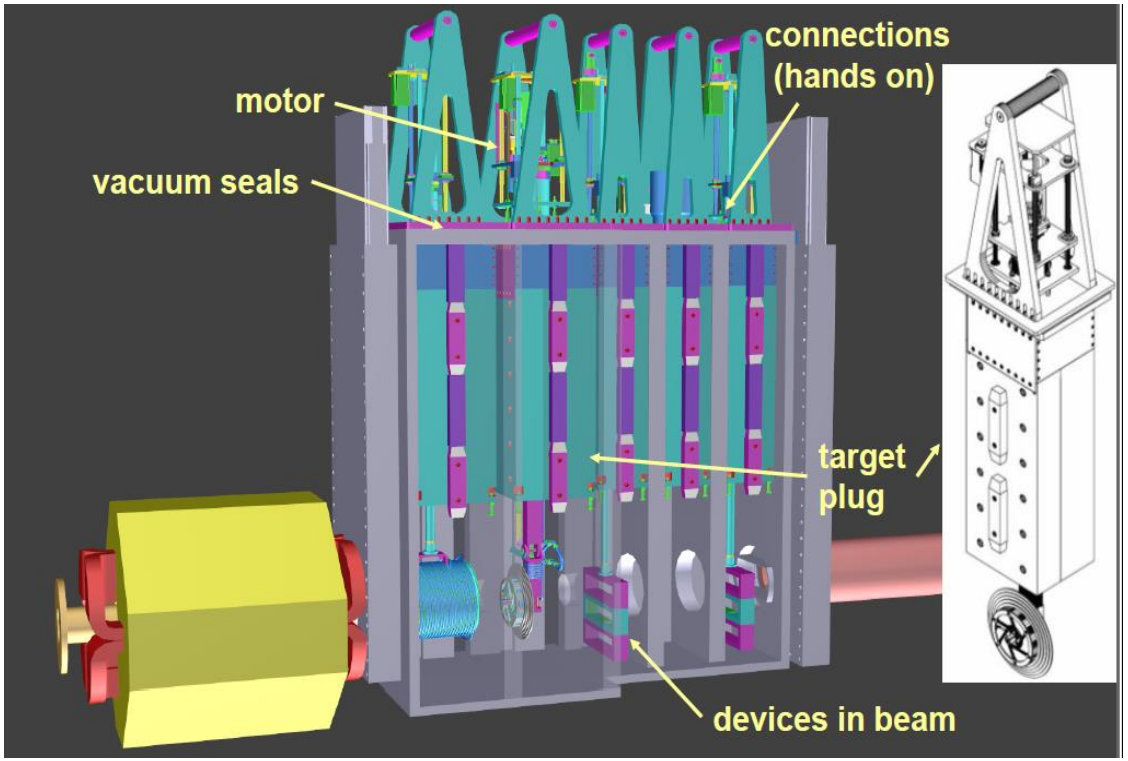
- Luis M. Orona D.
- Dr. Helmut Weick
- GSI Helmholtzzentrum - Germany

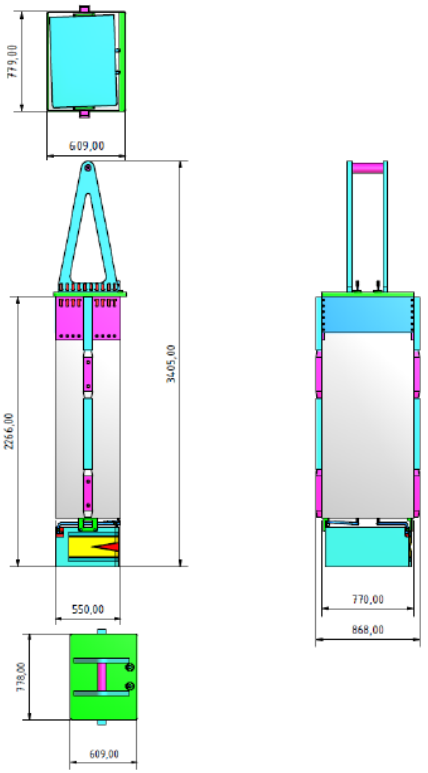
- Tampere Univeristy of Technology (TUT) - Finland
- Prof. Jouni Mattila

Super-FRS

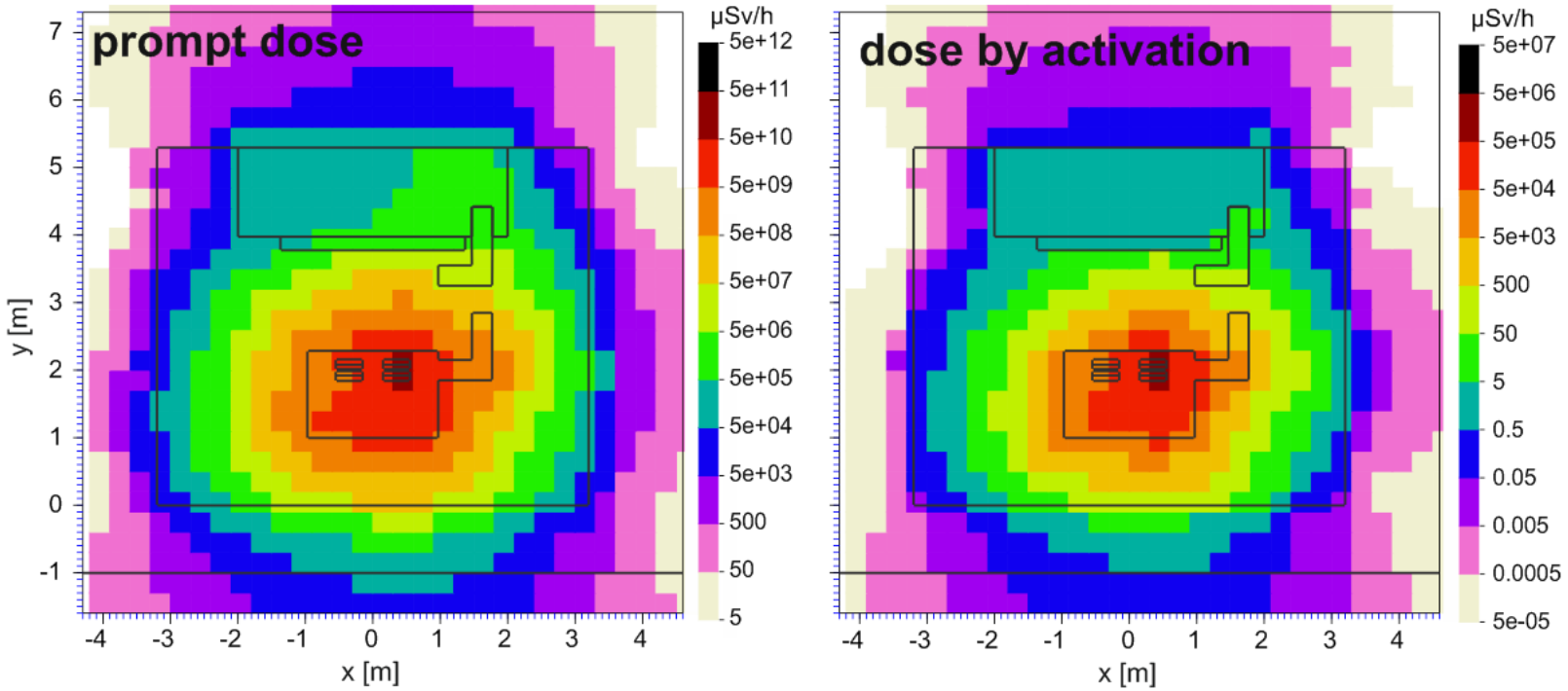

Pre-separator
Main separator
^{238}U 1x10^{12}/s
1500 MeV/u
^{114}Pd1x10^{12}/s
1300 MeV/u
^{238}U3x10^{7}/s -1^{0}/s
300 MeV/u
RH Manipulators
Service Tunnel
^{131}Sb2x10^{9}/s – 1^{0}/s
1300 MeV/u
To storage rings
^{238}U3x10^{7}/s -1^{0}/s
1000 MeV/u
^{131}Sb2x10^{8}/s
740MeV/u
Beam Catcher RH Plugs
Hot-cell
Target RH Plug
100m
Beam
Super-FRS Layout (pre and main separators)

Plug System


connections
(hands on)
motor
vacuum seals
target
plug
devices in beam


779,00
609,00
2266,00
3405,00
550,00
778,00
609,00
770,00
868,00

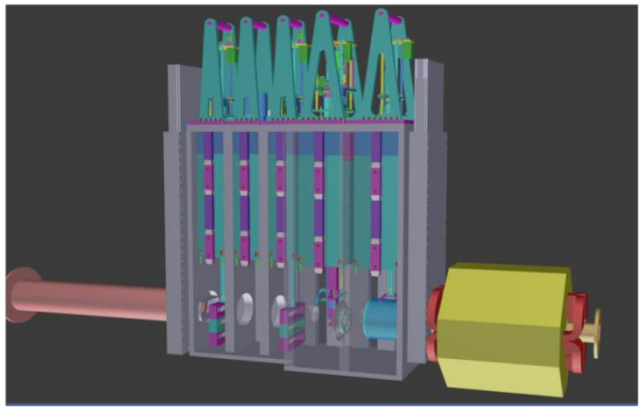
Target Area prompt dose and activation dose



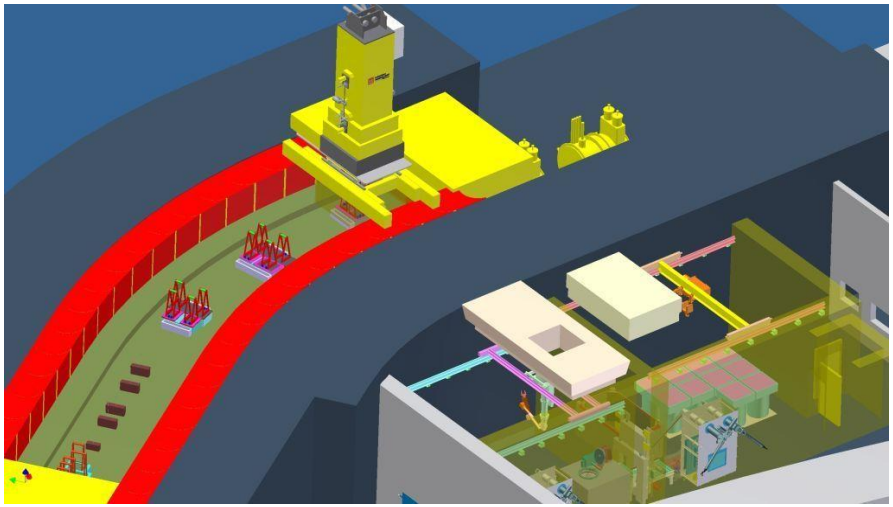
L. M. Orona, et al. "Super-FRS Target Area Remote Handling: Scenario and Development." *INTERNATIONAL JOURNAL OF ADVANCED ROBOTIC SYSTEMS* 10 (2013).

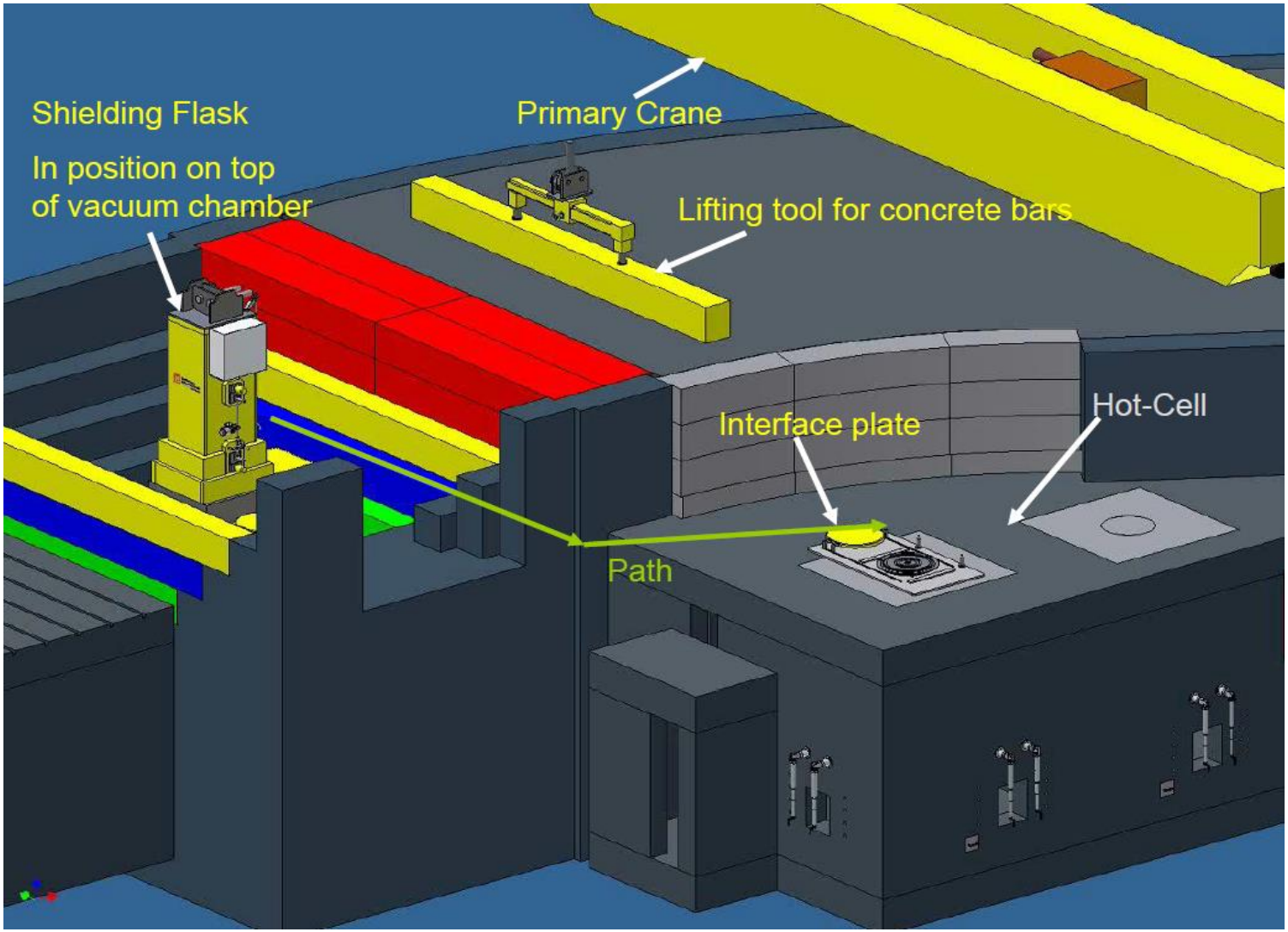
Remote Handling concept for the *Super-FRS plug system*

Super-FRS plug system:

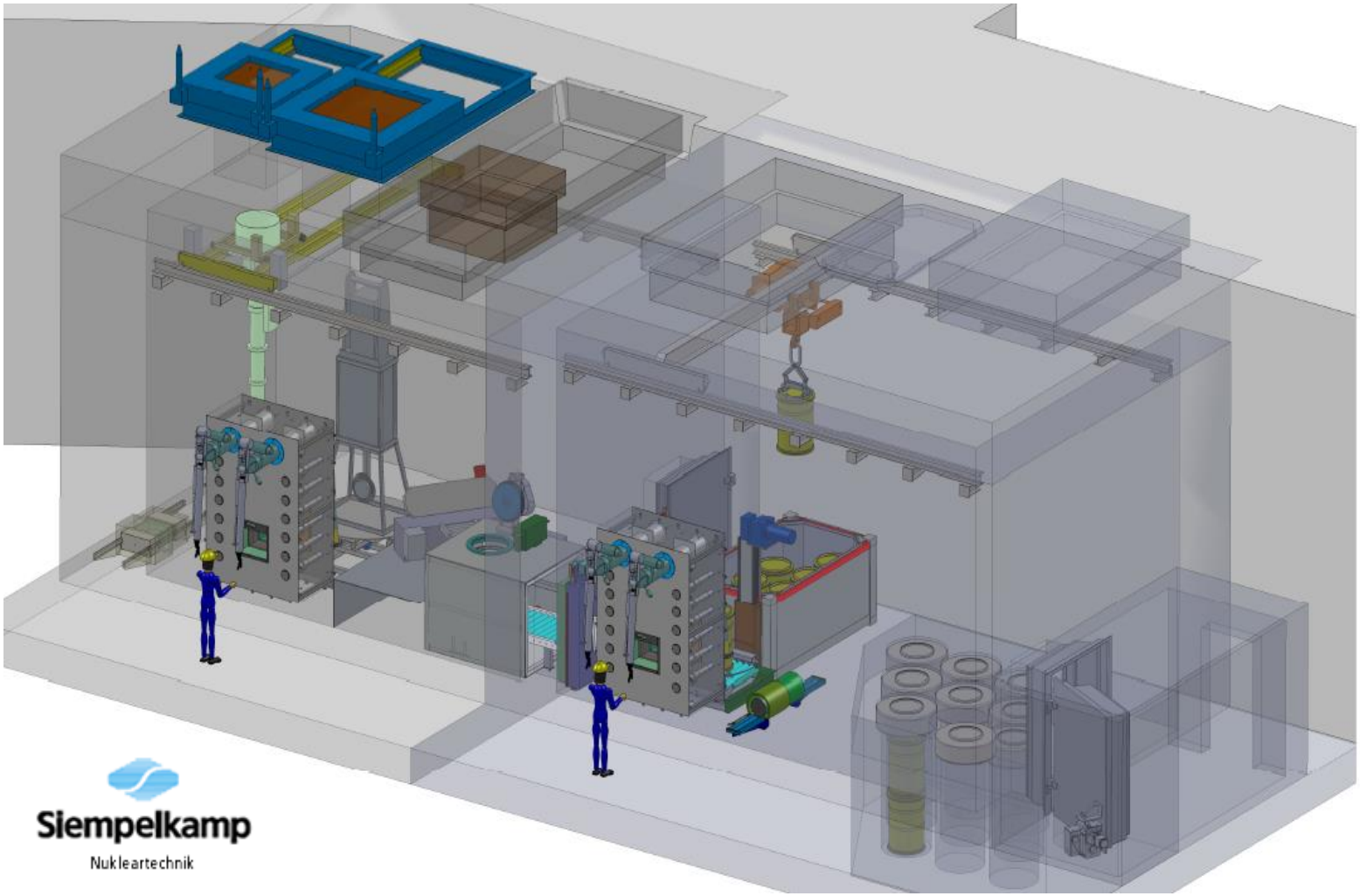


Remote handling concept:




Shielding Flask
In position on top of vacuum chamber
Primary Crane
Lifting tool for concrete bars
Interface plate
Hot-Cell
Path

Hot cell and storage cell conceptual design



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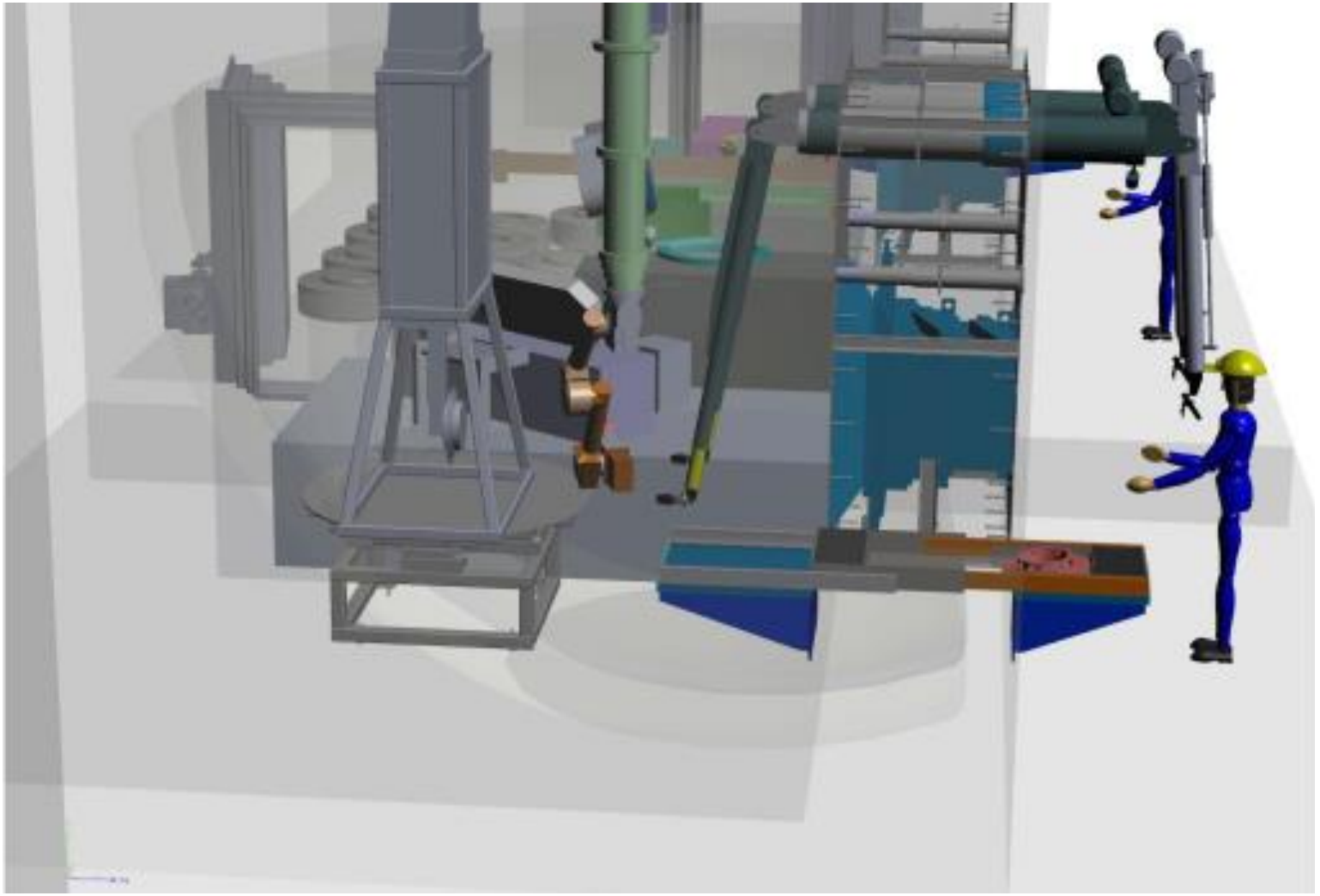
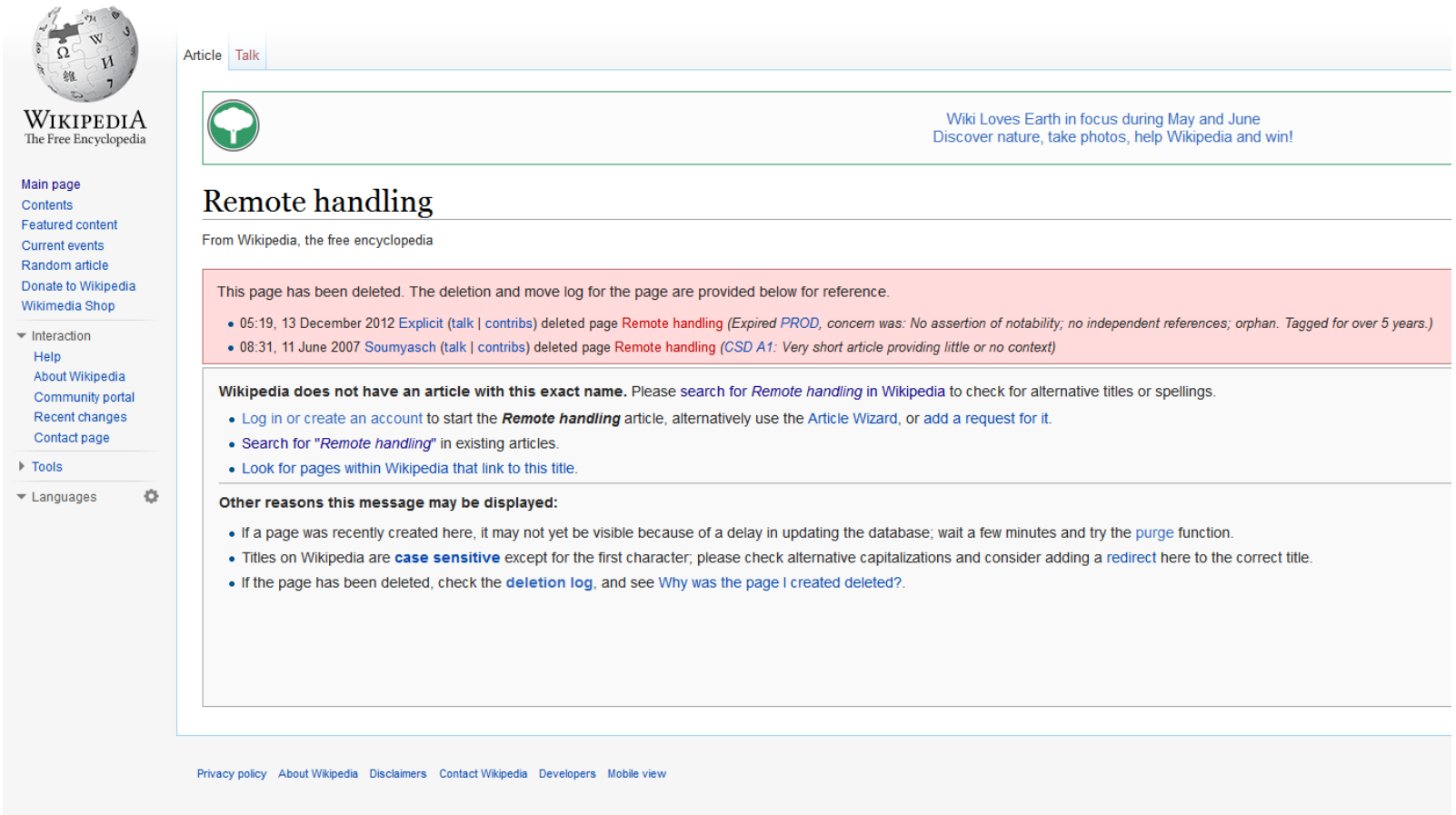
Inside the Hot cell



About Remote Handling (RH)



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Tools

Languages

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Discover nature, take photos, help Wikipedia and win!

Remote handling

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- 05:19, 13 December 2012 Explicit (talk | contribs) deleted page Remote handling *(Expired PROD, concern was: No assertion of notability; no independent references; orphan. Tagged for over 5 years.)*
- 08:31, 11 June 2007 Soumyasch (talk | contribs) deleted page Remote handling *(CSD A1: Very short article providing little or no context)*

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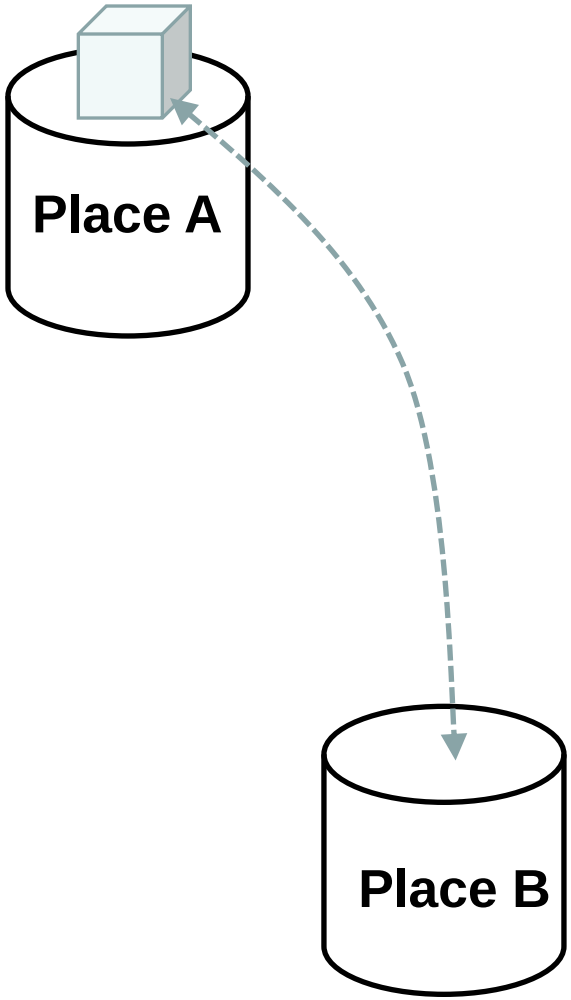
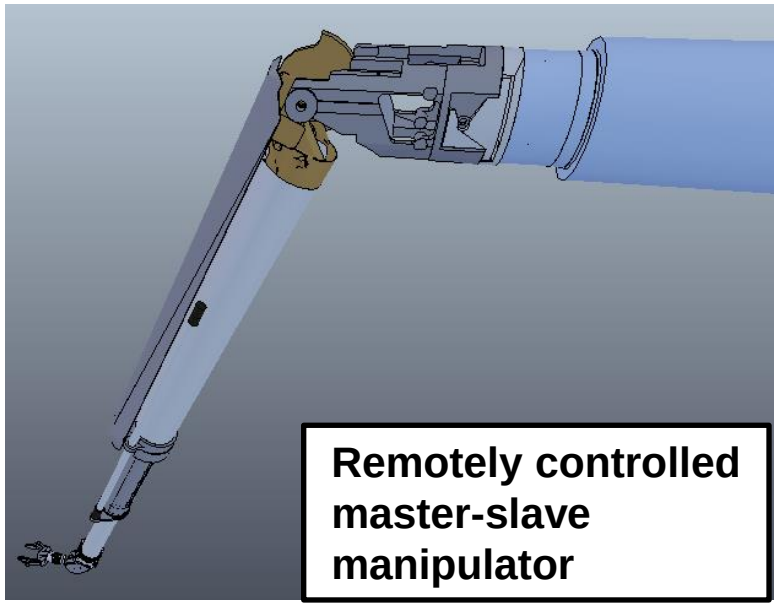
Remote Handling (RH)





Remote handling is about handle (move) objects from one place to another and perform different activities on either places like: fixing, cutting, welding, actuating among others, by means of remotely controlled handling devices (e.g. manipulator arms).

My research work

How to conduct a remote handling study?

How to conduct the remote handling concept study?

- Given that the Super-FRS plug system comprises many different components and several RH tasks can be identified and therefore must be analyzed.

- The proposed approach is to define a framework to systematically define, analyze and develop RH tasks.

Research Goals and Results

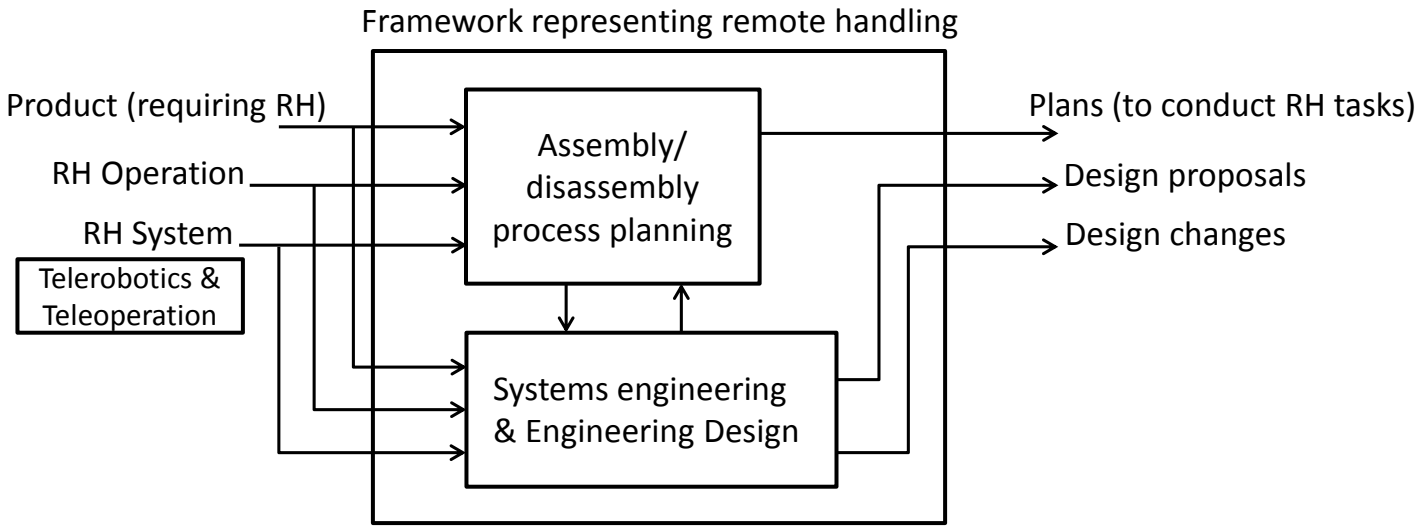
Research Goals:

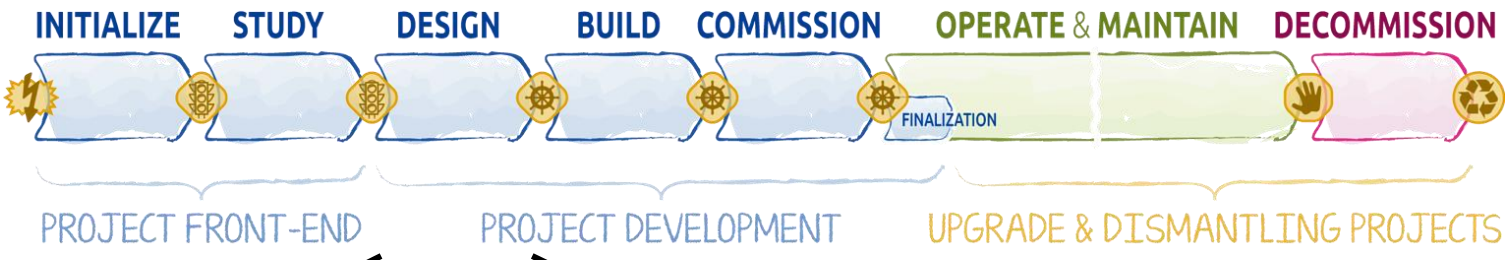
- To develop a framework to systematically define, analyze and develop remote handling maintenance tasks.
- To provide groundwork to formalize remote handling beyond good practices and design guidelines into a more analytical approach.
- To increase the understanding about remote handling due to ionizing radiation environments.
- To generate in deep knowledge for the design and development of the Super-FRS target area plug system with respect to remote handling.

Research Goals and Results

Research Methodology:

- Under the hypothesis that by combining the fields of process planning for assembly and disassembly, systems engineering and engineering design a framework can be formulated that both; represents remote handling as an input/output model and can be used to systematically define, analyze and develop remote handling maintenance tasks.





openSE Lifecycle

System(s) requiring remote handling

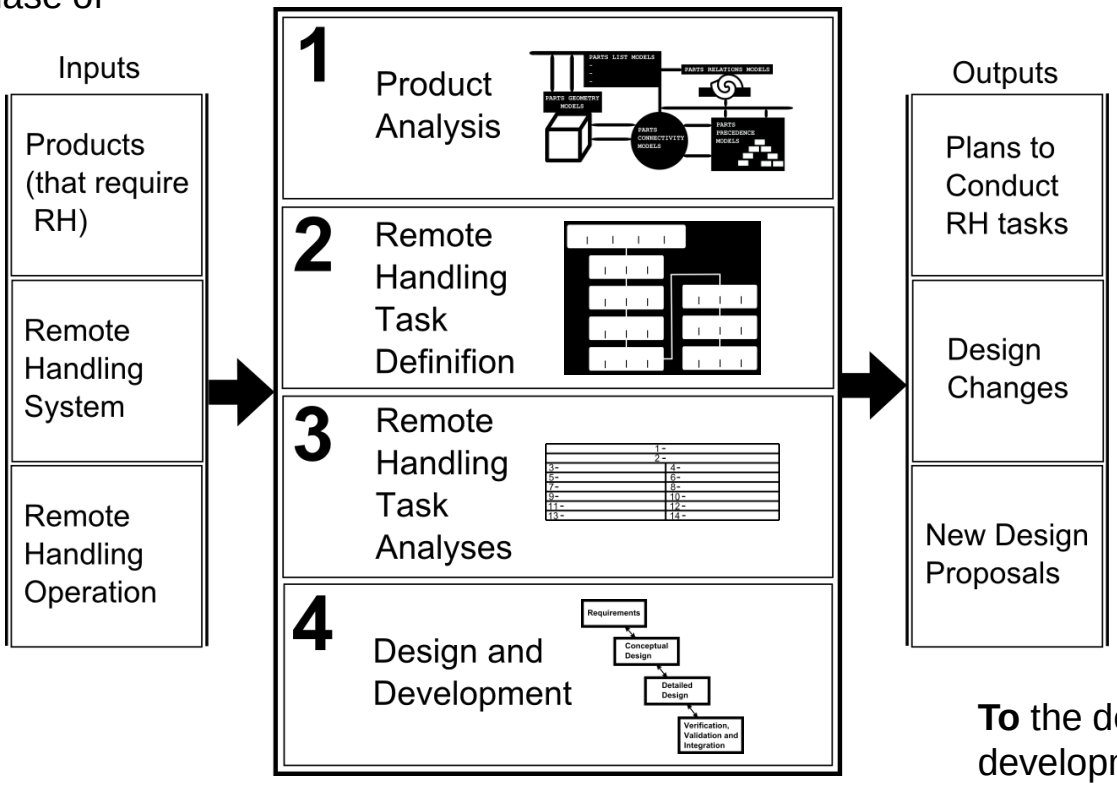
Remote handling analyses

Remote handling system

-
-
-

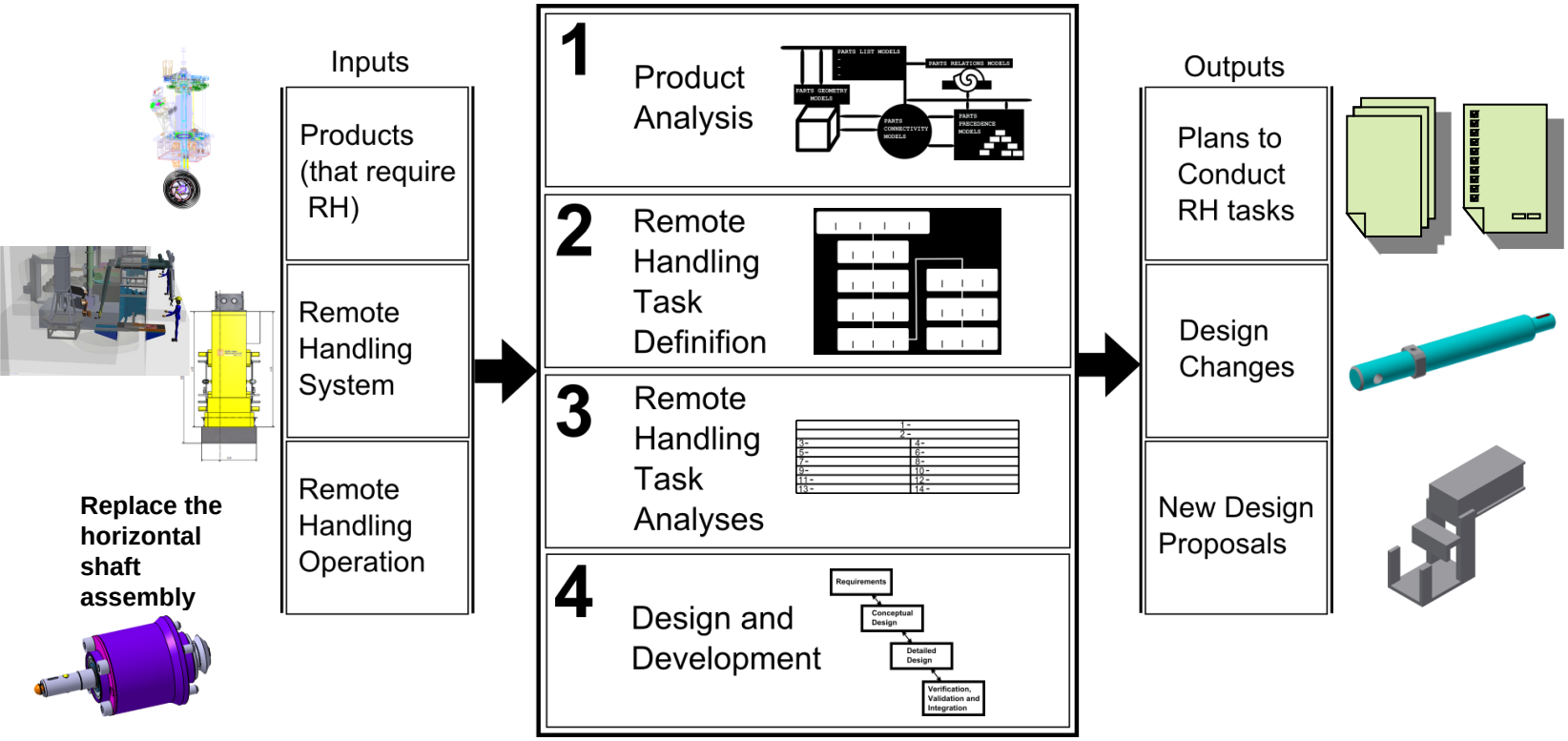
Results: the proposed framework

From the design and development phase of the facility

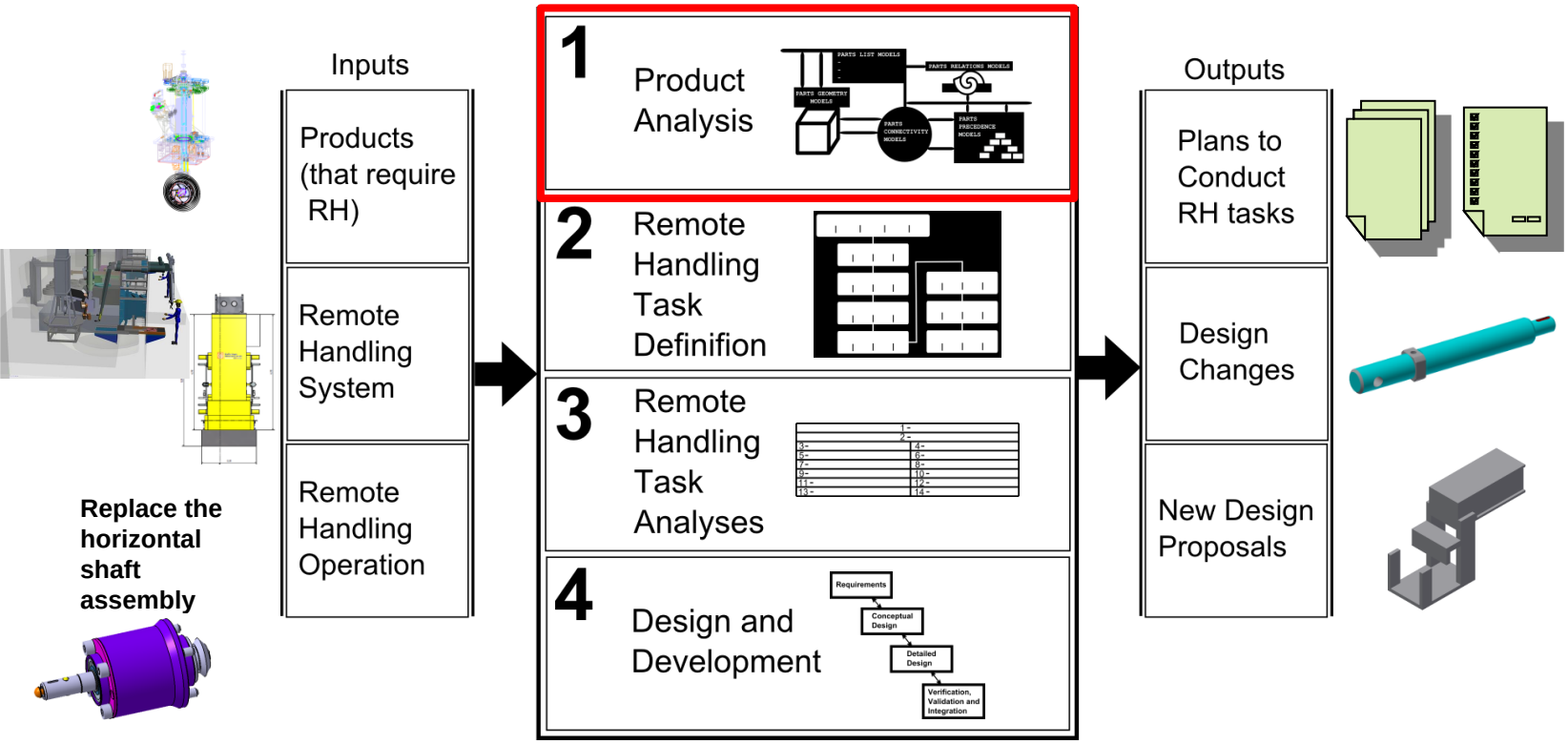


To the design and development phase of the facility

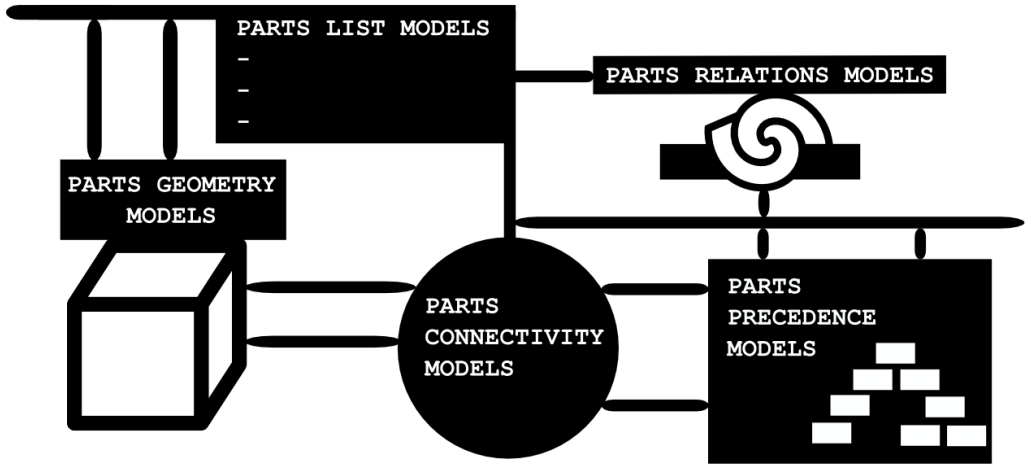
The proposed framework



The proposed framework

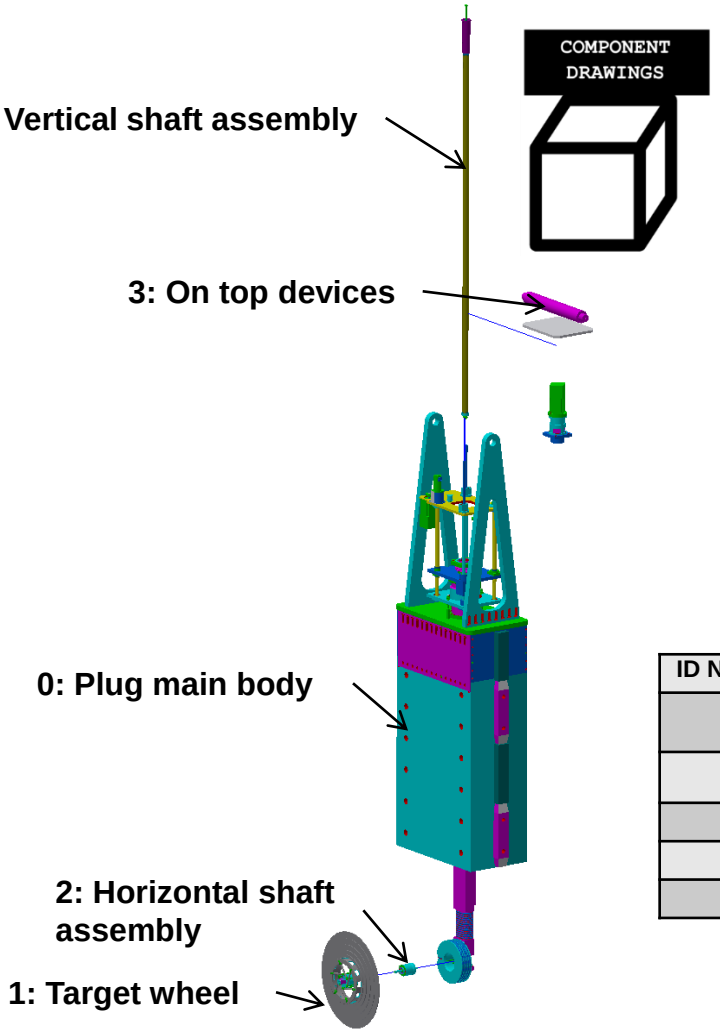


1 Product Analysis



Consist of developing five assembly models to define and describe the product

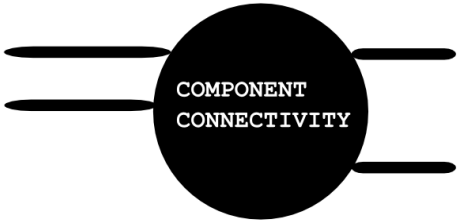
Product Analysis
Product definition:

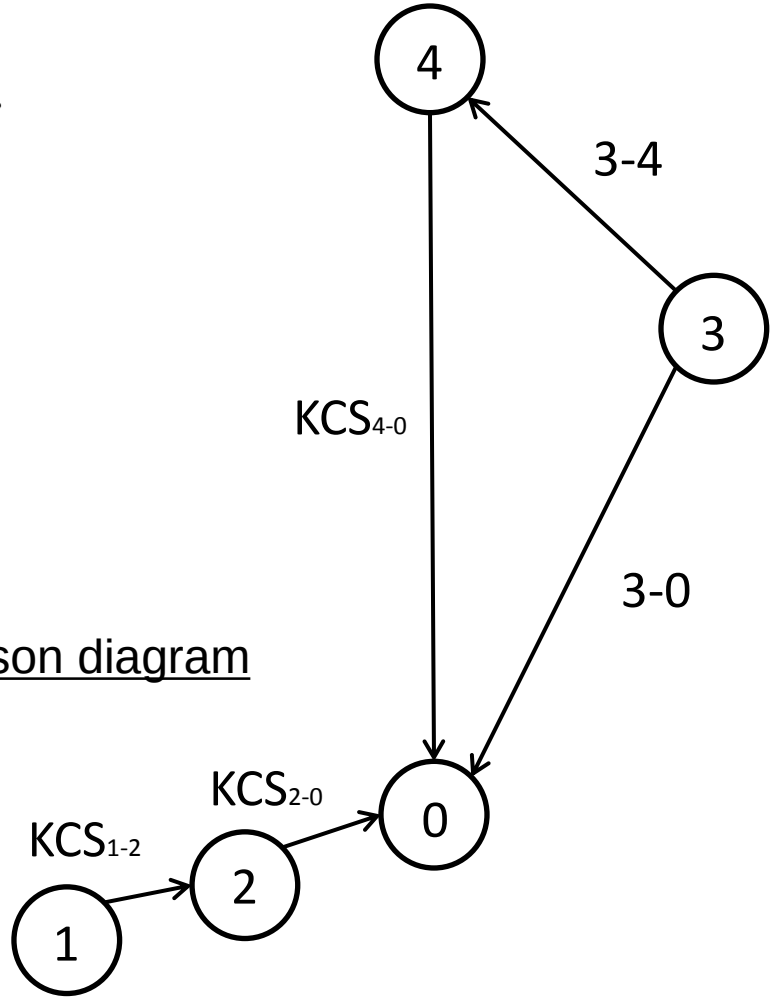


COMPONENTS OF INTEREST
-
-

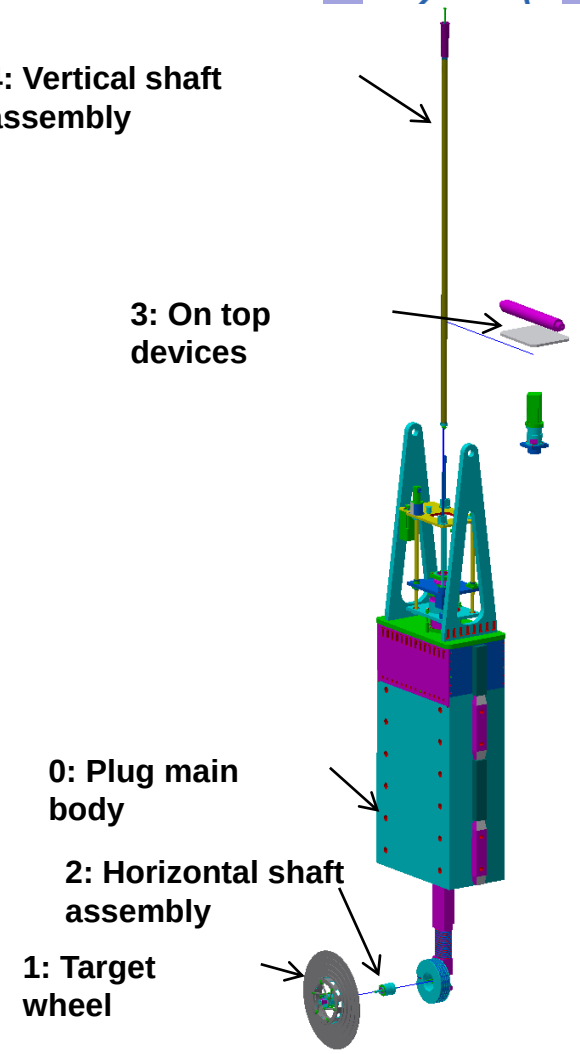
ID Number	Name	Ref. Name	Type
0	Target Plug	TaPl	Main subassembly
1	Target wheel	TaWh	Subassembly
2	Horizontal shaft	HoSh	Subassembly
3	On top devices	ToDe	Collection of components
4	Vertical shaft	VeSh	Subassembly

Product Analysis
Product description:

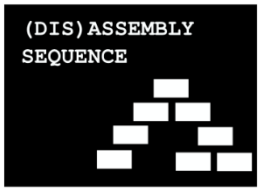


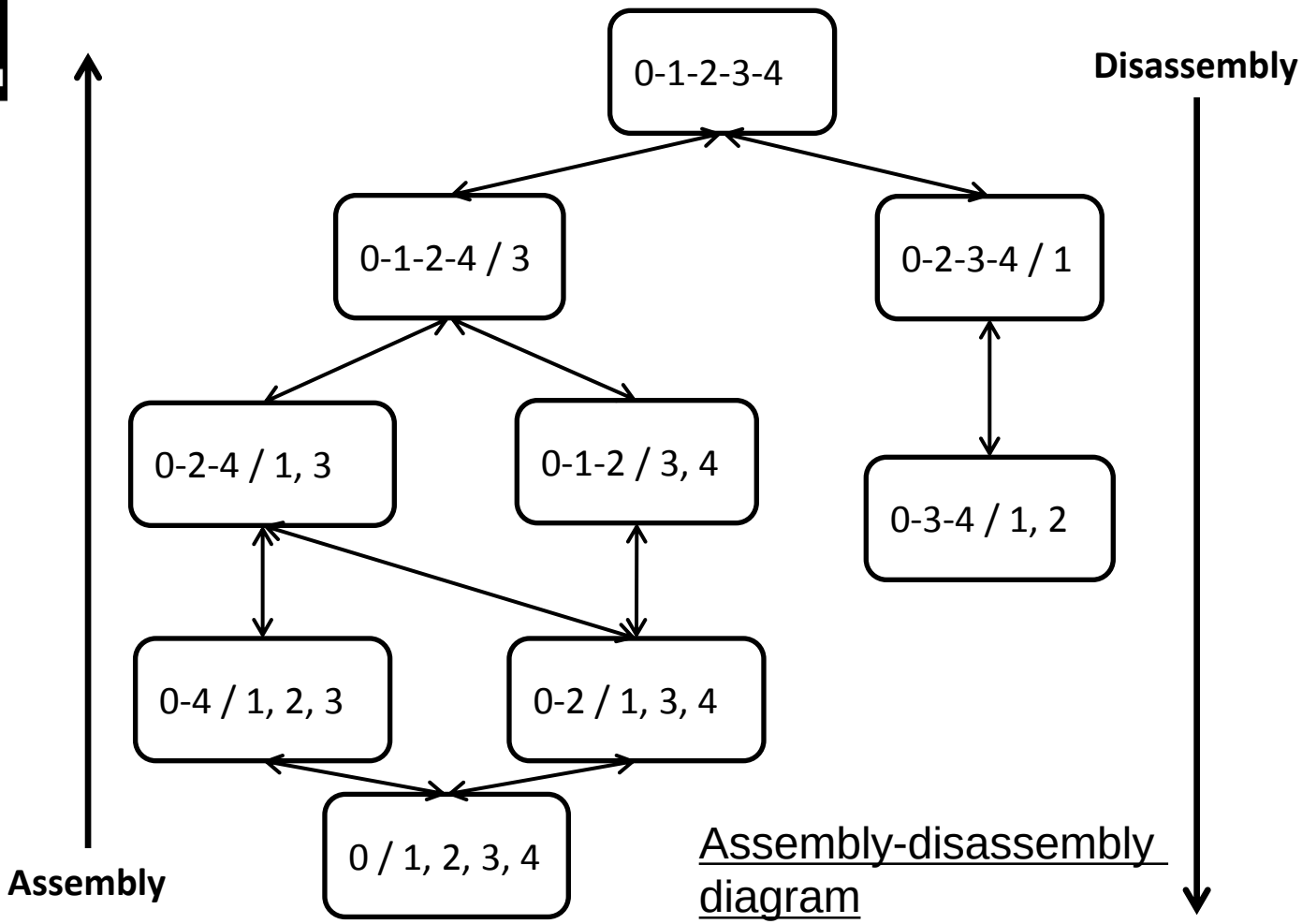


Liaison diagram



Product Analysis
Product description:

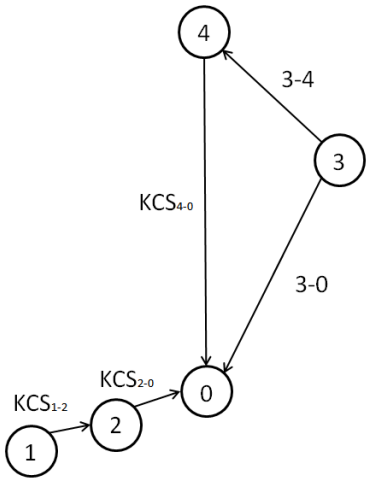




Product Analysis
Product description:

COMPONENT CONNECTIONS

The connection between components is defined as a kinematic constraint sequence (KCS) comprising 4 stages: locate, guide, fit and lock.



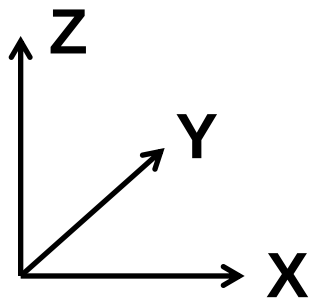
	Locate	Guide	Fit	Lock
KCS1-2	Kind of cylindrical	Cylindrical	Cylindrical	Ball mechanism
KCS2-0	Two kind of cylindrical	Two cylindrical	Cylindrical and Surface	4 bolts
KCS4-0	Kind of cylindrical	Cylindrical	Cylindrical	Plate with bolts (manual)
3-0 **3-4**	Hands on	Hands on	Hands on	Hands on

Product Analysis
Product description:

COMPONENT CONNECTIONS

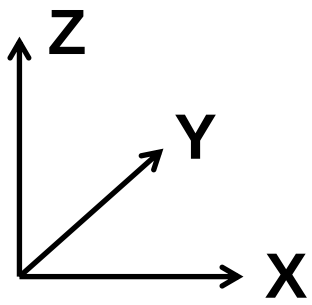
Each stage of the KCS has one or more kinematic constraints which are modeled with a constraint matrix (Schluss-Matrix) [Roth]

$$S = \begin{pmatrix} Tx & -Tx & Rx & -Rx \\ Ty & -Ty & Ry & -Ry \\ Tz & -Tz & Rz & -Rz \end{pmatrix}$$



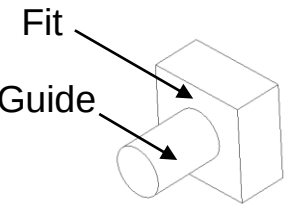
Product Analysis
Product description:

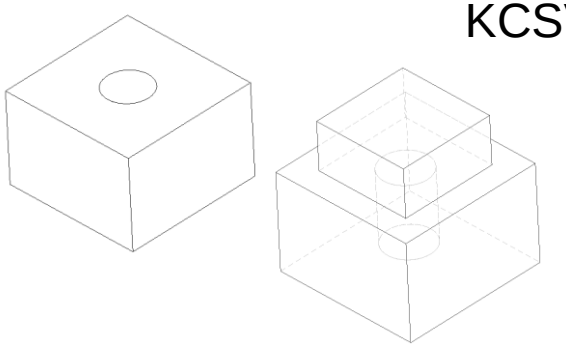
$$S = \begin{pmatrix} Tx & -Tx & Rx & -Rx \\ Ty & -Ty & Ry & -Ry \\ Tz & -Tz & Rz & -Rz \end{pmatrix}$$



0 - no constrained
1 - constrained
>1 - over constrained

- Example:





Guide (cylindrical)

Fit (Plane)

$$KCSV = \begin{pmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix} + \begin{pmatrix} 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 0 \end{pmatrix} = \begin{pmatrix} 1 & 1 & 2 & 2 \\ 1 & 1 & 2 & 2 \\ 0 & 1 & 0 & 0 \end{pmatrix}$$

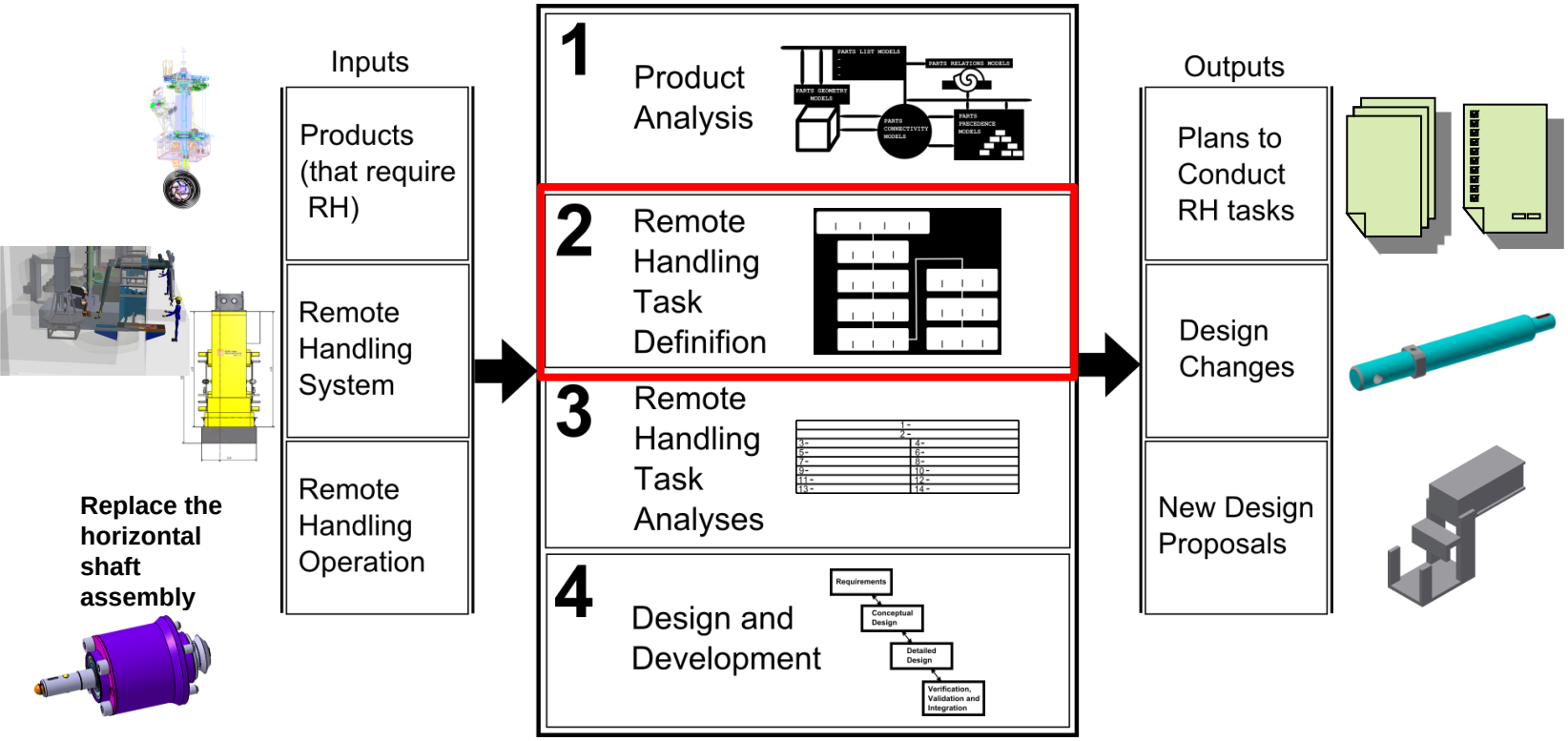
Kinematic Constraint Sequence (KCS)

$$KCSV_{1-2} = \sum_{i=1}^{a} S_{1-2(LOCATE)_i} \cdot \alpha_i + \sum_{j=1}^{b} S_{1-2(GUIDE)_j} \cdot \beta_j + \sum_{k=1}^{c} S_{1-2(FIT)_k} \cdot \gamma_k + \sum_{l=1}^{d} S_{1-2(LOCK)_l} \cdot \delta_l$$

$KCSV_{1-2}$	Kinematic constraint sequence value for the assembly of component 1 into 2
$S_{1-2(LOCATE)_i}$	Constraint matrix for the i[th] kinematic constraint in the locate stage for the assembly of component 1 into 2. The same nomenclature applies for the rest of constraint matrices in the equation.
$\alpha_i, \beta_j, \gamma_k, \delta_l = \begin{cases} 1: \\ 0: \end{cases}$	If $S_{1-2(LOCATE)_i}, S_{1-2(GUIDE)_j}, S_{1-2(FIT)_k}, S_{1-2(LOCK)_l}$ respectively are active at the end of the KCS Otherwise
a, b, c, d	Amount of KCs in the locate, guide, fit and lock stages respectively

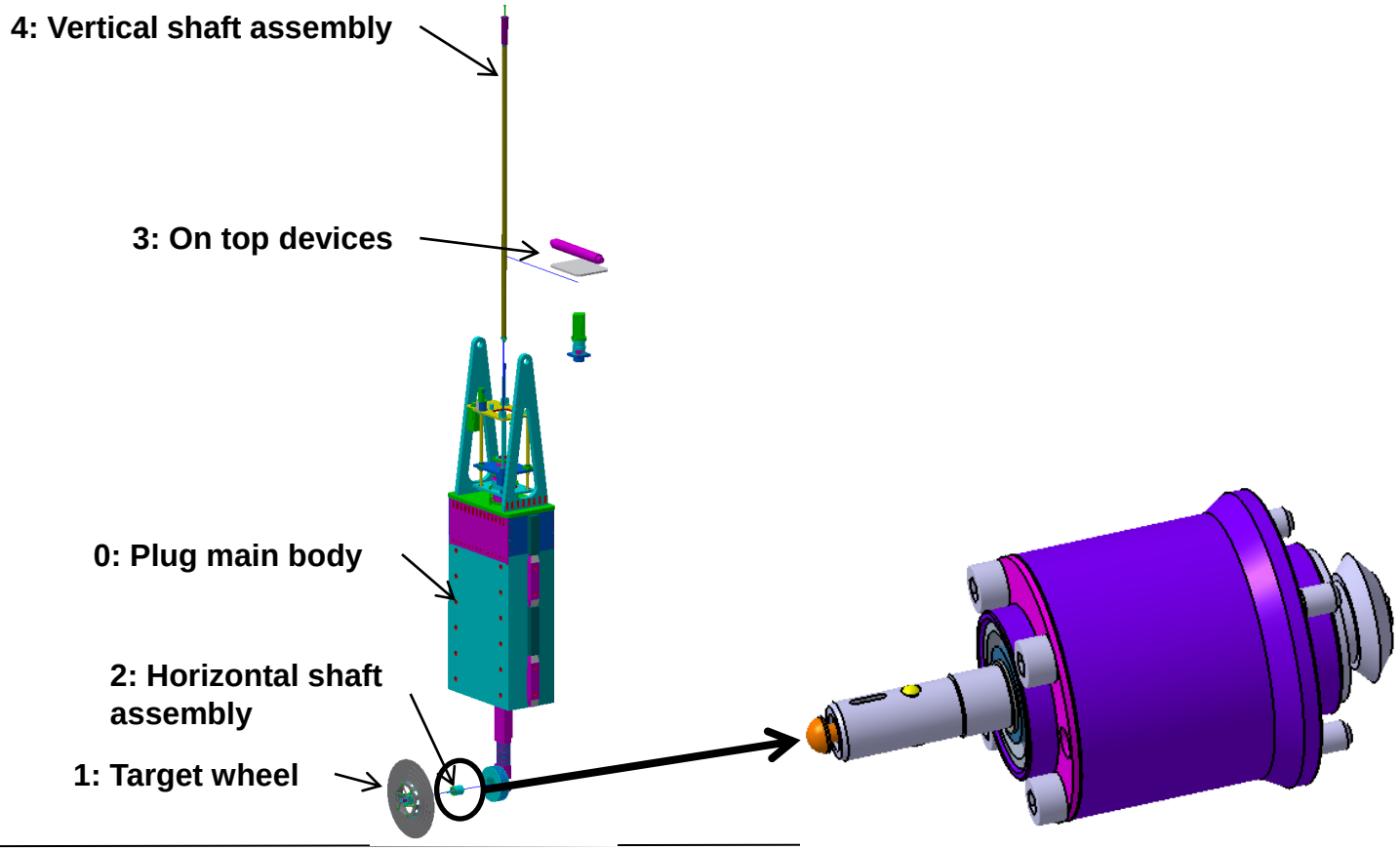
L. M. Orona, et al. “A Systematic Approach for Modeling and Analyzing Mechanical Assemblies That Require Remote Handling." The 2nd Annual International Conference on Mechanical Manufacturing, Modeling and Material. Jan 2015 Shanghai, China.

The proposed framework



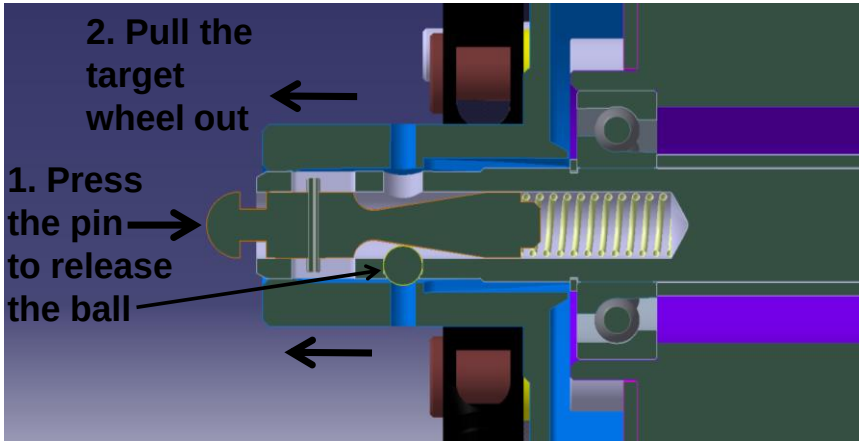
Remote Handling Task Definition Example:

Exchange of horizontal shaft assembly



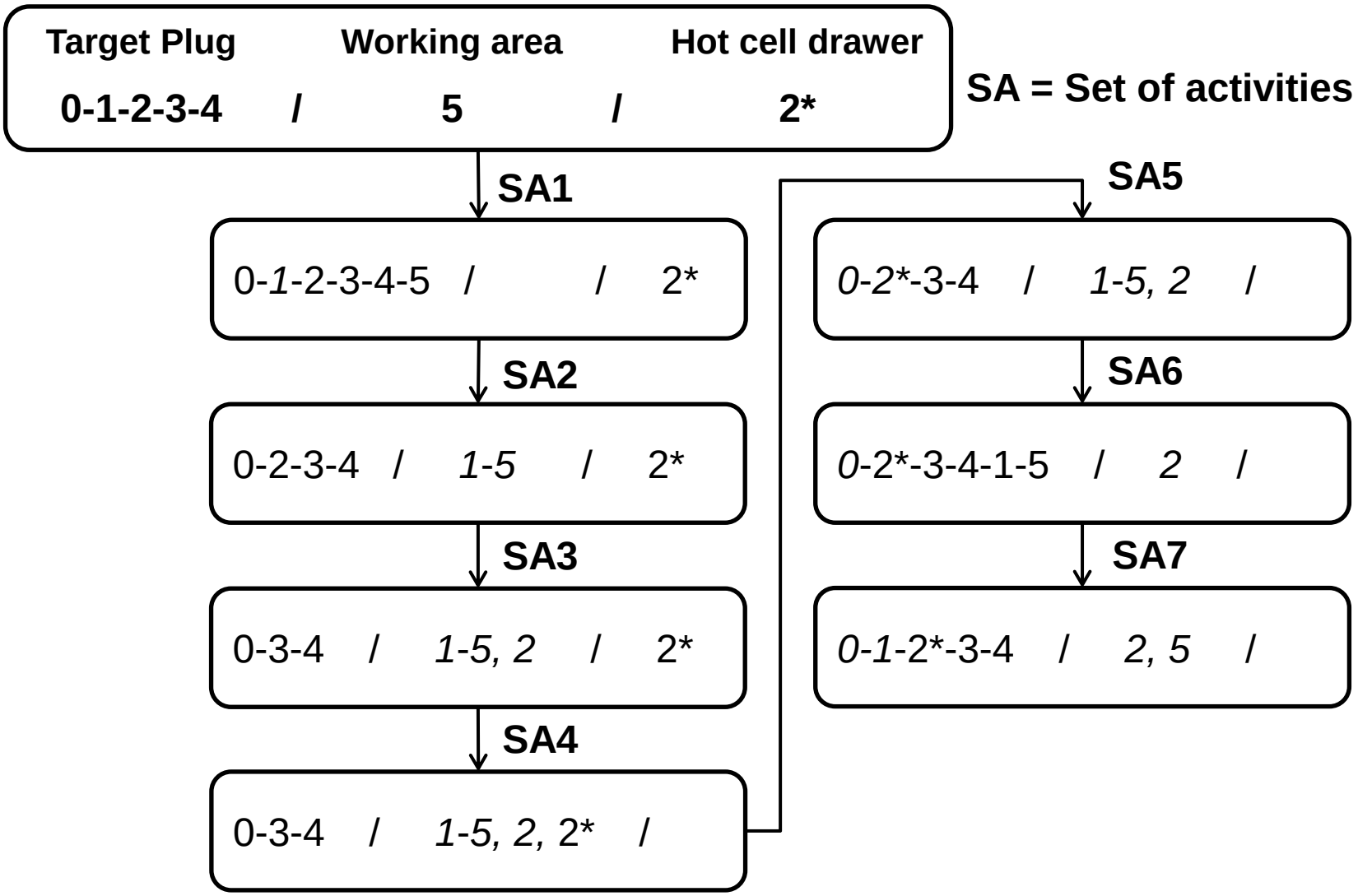
Remote Handling Task Definition Example:

To disassembly the target wheel, a tool is necessary to deactivating the locking mechanism

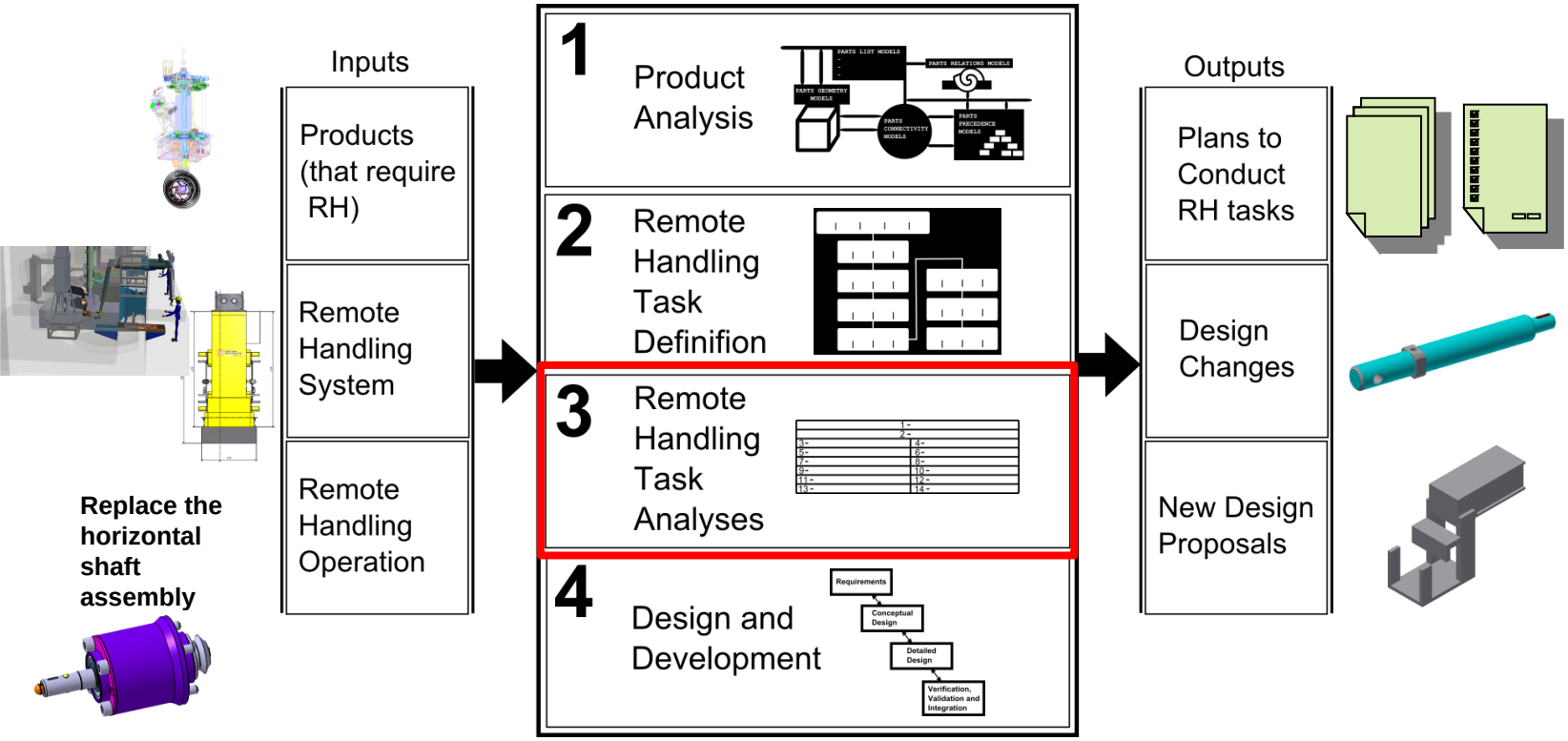


ID Number	Name	Ref. Name	Type
5	Tool for target	TL_1	Tool

Remote Handling Task Definition (RHTD) diagram



The proposed framework



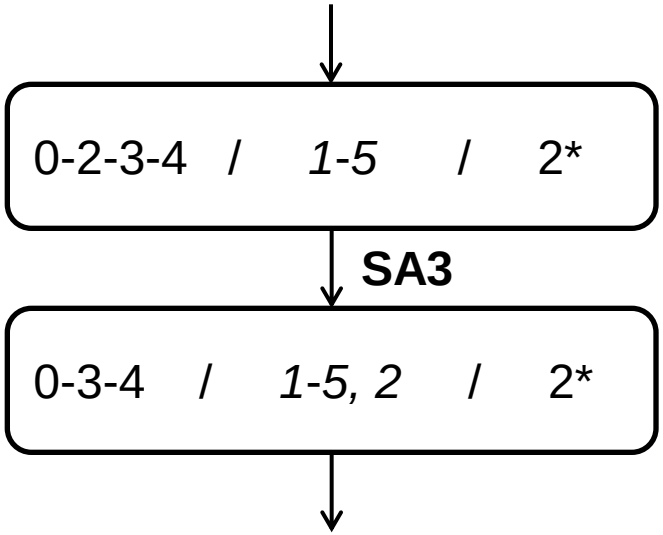
Remote Handling Task Analyses

14 states/actions to be analyzed for each set of activities defined in the RHTD diagram:

1. Gripping, clamping or hooking the object	
2. Moving the object	
3. Removing the lock in place 1	4. Applying the lock in place 2
5. Removing the fit in place 1	6. Applying the fit in place 2
7. Object placed in place 1	8. Object placed in place 2
9. Reaching place 1	10. Reaching place 2
11. Gripping the object in place 1	12. Releasing the object in place 2
13. Removing the object from place 1	14. Placing the object in place 2

In assembly:
Place 1: Fixture, the floor, hot cell drawer, etc.
Place 2: The product (the machine)
In disassembly:
Place 1: The product (the machine)
Place 2: Fixture, the floor, hot cell drawer, etc.

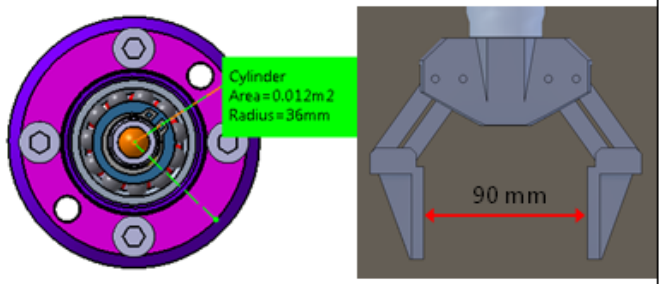
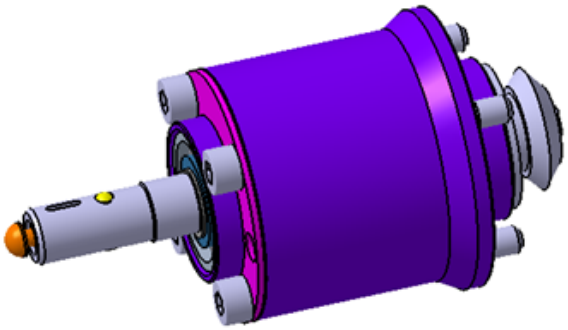
Remote Handling Task Analyses Example:



Disassembling the horizontal shaft

Remote Handling Task Analyses Example:

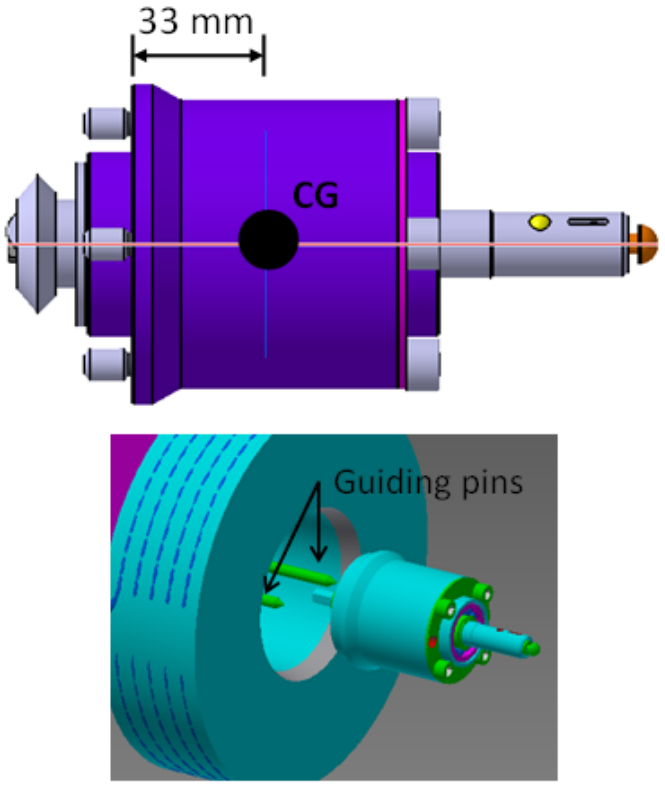
Analyses for set of activity 3 (SA3)

Object: Horizontal shaft Place 1: Target plug Place 2: The floor		
Activity	Evaluations:	Supporting figures:
1. Gripping the object	The horizontal shaft assembly has a main diameter of 72 mm and the gripper of the manipulator can open up to 90 mm, in this case the horizontal shaft can be grip directly by the MT200 gripper.	
2. Moving the object	The weight of the horizontal shaft is 2.2 kg and the payload of the MT200 is 5 kg (when considering 6 DOF).	

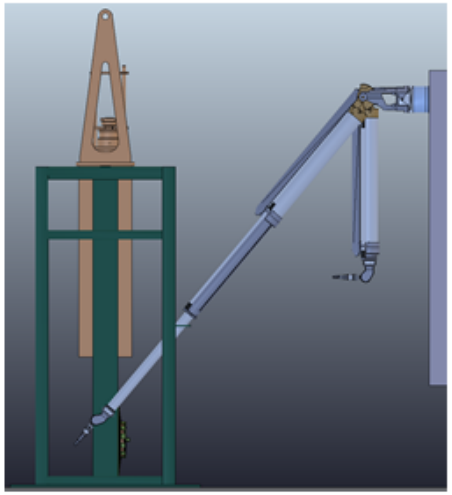
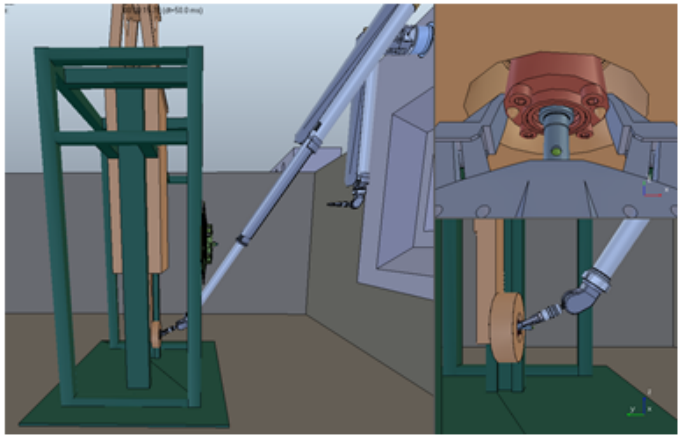
Remote Handling Task Analyses Example:

3. Removing the lock in place 1	The locking mechanism comprises basically 4 bolts of Allen type number 6. They can be unscrewed with the MT200 but most likely the bolts cannot be loose only with the MT200. This analysis will be further developed.	
5. Removing the fit in place 1	The fit between the horizontal shaft and the target plug is of the peg-hole type. Based on engineering drawings: Hole: 46 H7 Peg: 46 g6 Based on a test performed in the hot cell mock up, it was notice that sometimes the fit feels very tight and is somewhat difficult to be removed by the MT200 manipulator; however even in those cases the fit was successfully removed.	FIT Parameter / Value / Unit Designation / 46 H7/g6 / --- Fit Type / Clearance fit / --- Maximum Clearance / 50 / µm(0.001mm) Minimum Clearance / 9 / µm(0.001mm) www.amesweb.info

Remote Handling Task Analyses Example:

7. Object placed in place 1	The center of gravity of the horizontal shaft is located 33 mm from the flat surface from which the guiding pins are getting into the horizontal shaft. Once the guiding pins are about 33 mm into the horizontal shaft, it is possible to release the horizontal shaft and leave it on the guiding pings only. However, it was observed from the prototype that once the chamfer from the guiding pins is inside the holes of the horizontal shaft, the assembly becomes stable.	

Remote Handling Task Analyses Example:

9. Reaching the place 1	Based on simulations of the hot cell environment, it is concluded that the position of the horizontal shaft can be within the working area of the MT200 manipulators. Of course if the holding structure with the target plug is far from the manipulators, then it could be the case that the horizontal shaft would be outside the working space.	
11. Gripping the object in place 1	Based on simulations, it is concluded that the MT200 manipulators can grip the horizontal shaft when it is located on the target plug.	

Remote Handling Task Analyses Example:

13. Moving the object away from place 1	Based on a small test with the target plug prototype in the hot cell mock-up it was found as feasible to move the horizontal shaft away from the target plug by means of the MT200 manipulator.	
4. Applying the lock in place 2	Not apply	
6. Applying the fit in place 2	Not apply	
8. Object placed in place 2	The horizontal shaft can be placed on the floor without problems.	
10. Reaching the place 2	There is a certain area on the floor of the hot cell where the MT200 can reach easily. If for some reason the horizontal shaft has to be placed outside this area, other RH devices than the MT200 must be used.	
12. Releasing the object in place 2	This is feasible and at the moment there are no special requirements.	
14. Placing the object into place 2	This is feasible and at the moment there are no special requirements.	

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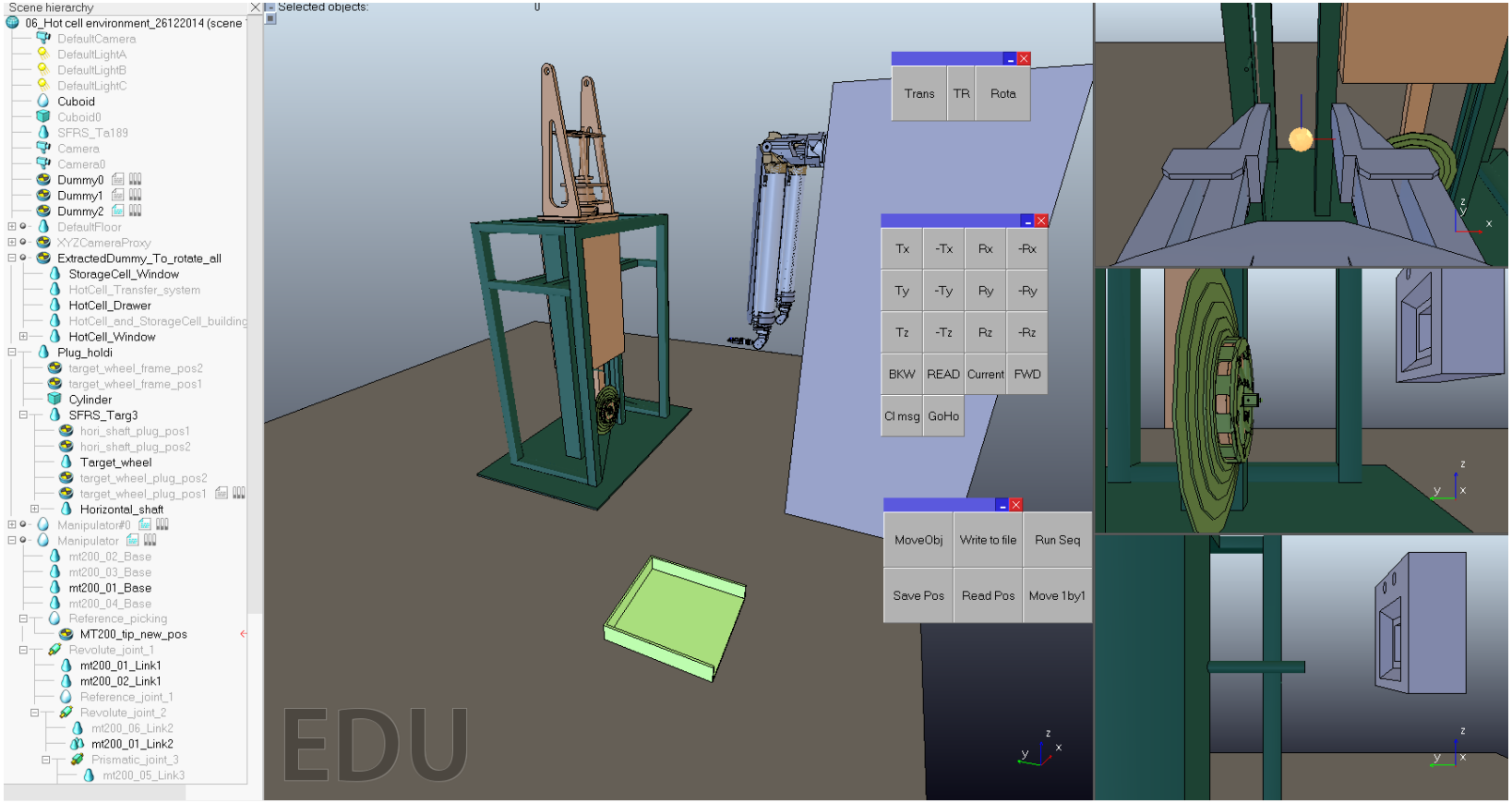
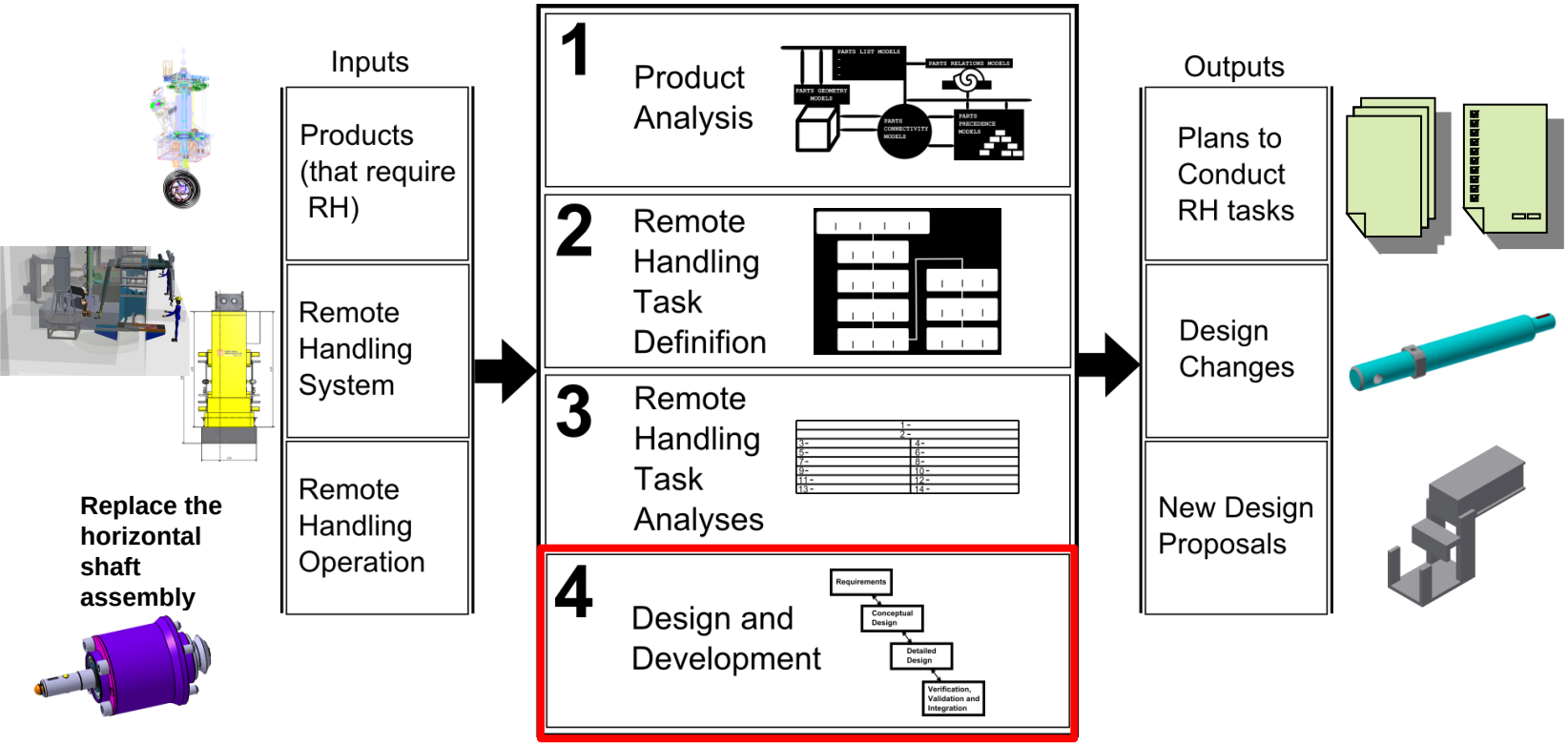
Remote Handling Task Analyses: Simulations with V-REP

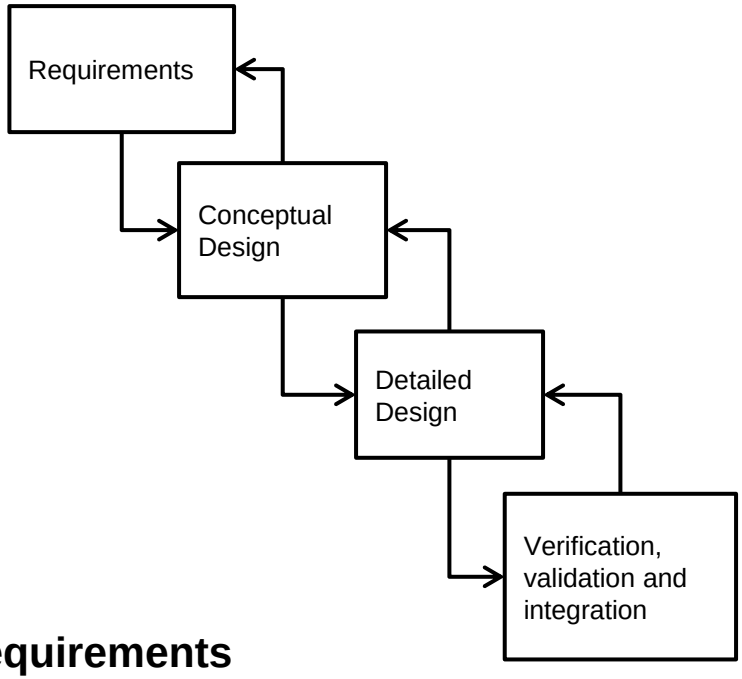


The proposed framework

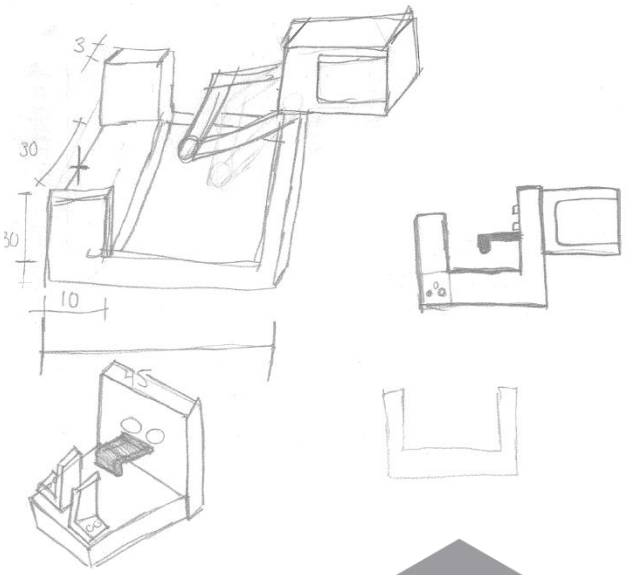


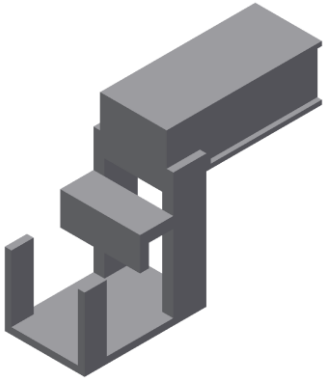
Design and Development Example:

Design and development waterfall approach



Tool concepts

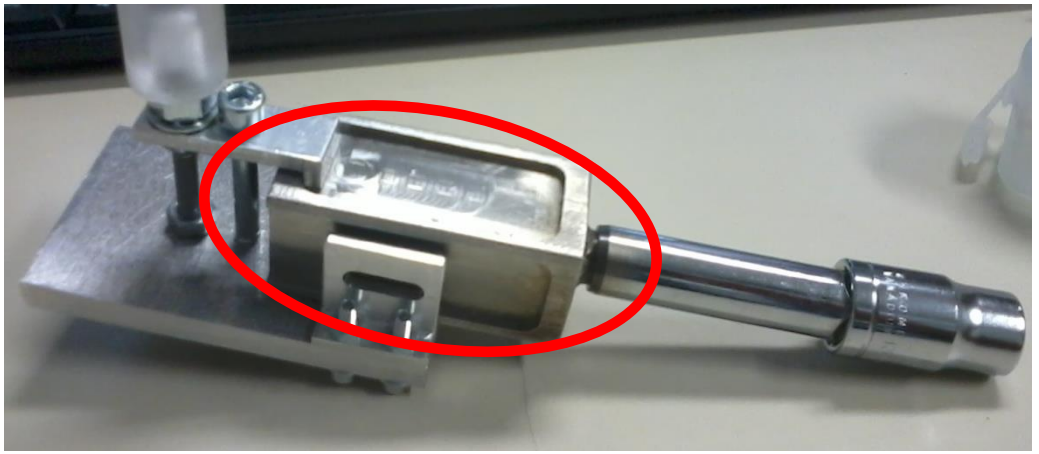


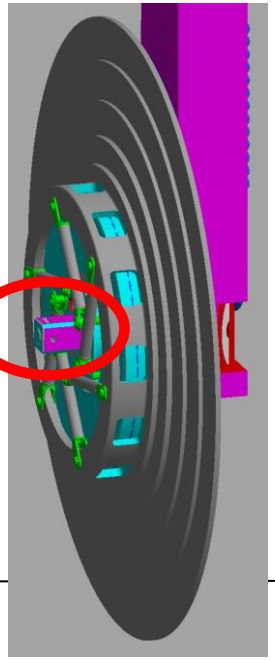


Requirements

TL_1_R-1	The tool shall be manipulated by the MT200 manipulator
TL_1_R-2	The tool shall be attachable and detachable from the target wheel
TL_1_R-3	The subassembly created by the tool and the target wheel shall be manipulated by the MT200 manipulator
TL_1_R-4	The tool shall improve the manipulability of the target wheel
TL_1_R-5	…

Design and Development Example:





Diameter of the target ≈ 600 mm

Summary

- Remote handling is required in particle accelerator facilities to conduct maintenance.
- Remote handling is necessary when working environments are inaccessible to humans.
- There is not a unified definition of remote handling.
- A framework to define, analyse and develop remote RH maintenance tasks has been proposed
- It is assumed that the proposed framework will increase our understanding about remote handling.
- Developing RH capabilities, is a complex and time consuming job.

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Merci!

Questions and comments