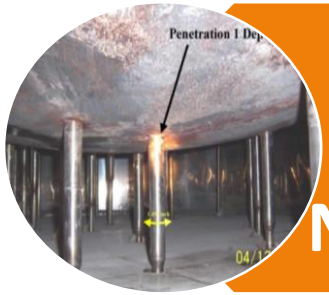

Development of Reactor Vessel Bottom Mount Instrumentation Nozzle Routine Inspection Device

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Outline of the Presentation

1. Problem statement

2. Case studies

3. BMI of RV inspection

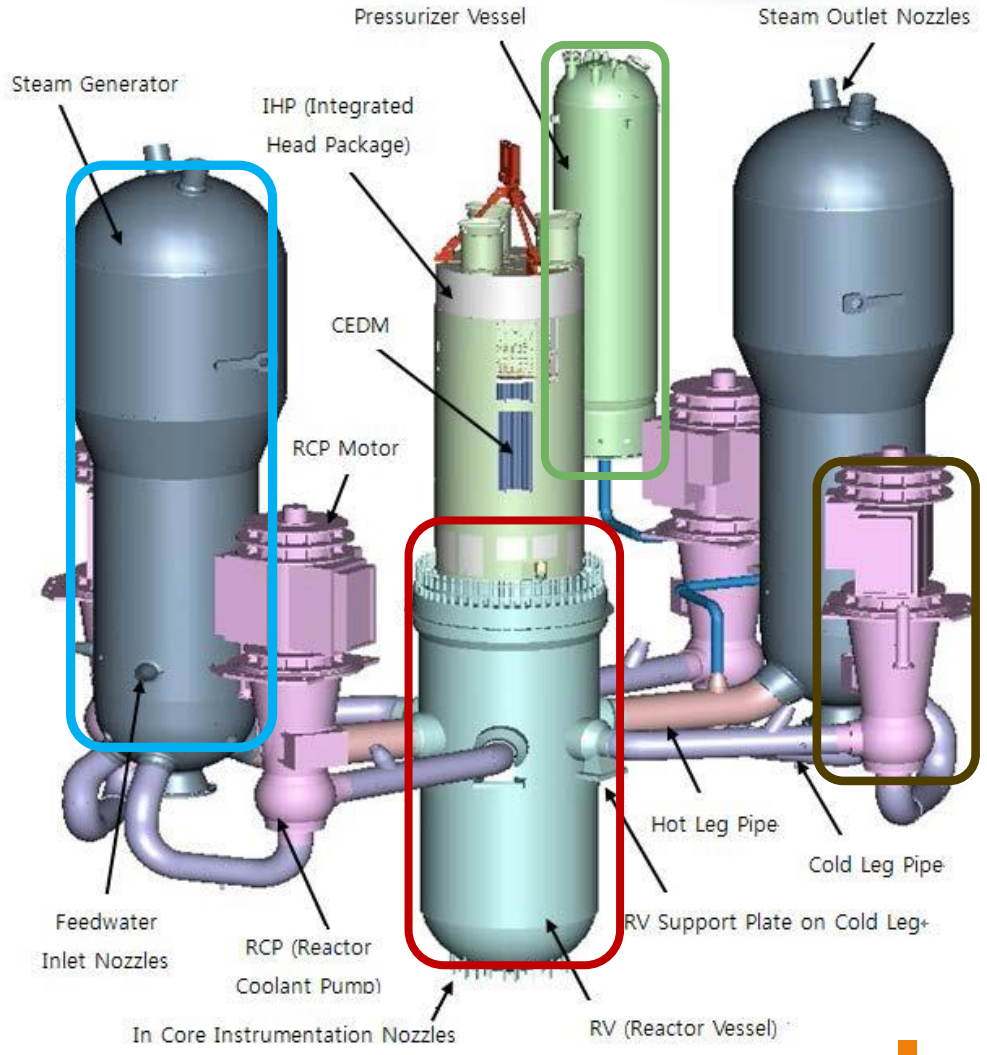
4. Results and discussions
   Conceptual design of BMI inspection tool

5. Conclusions

1 Problem statement

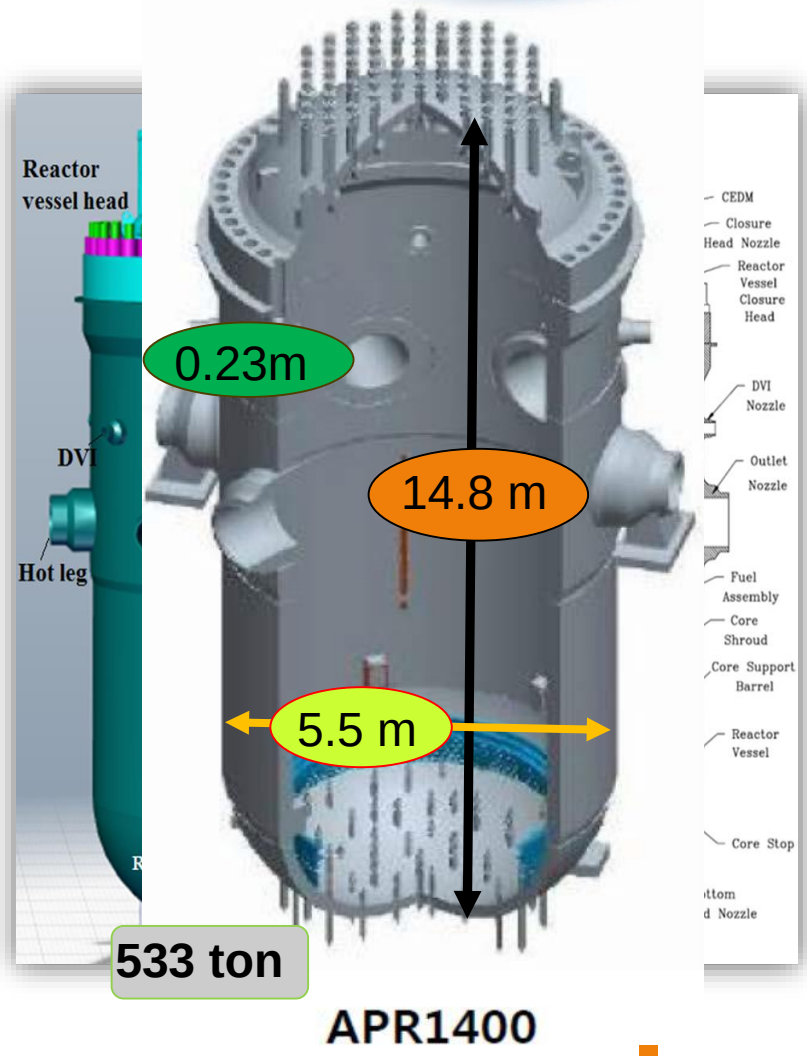
Reactor coolant System (RCS)

- Reactor Vessel (RV)
- Reactor Coolant Pump (RCP)
- Steam Generator (SG)
- Pressurizer (PZR)
- Piping, etc.

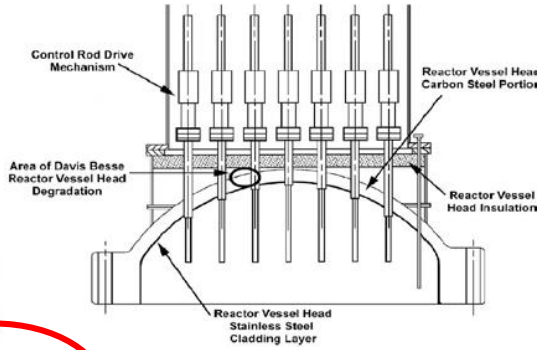


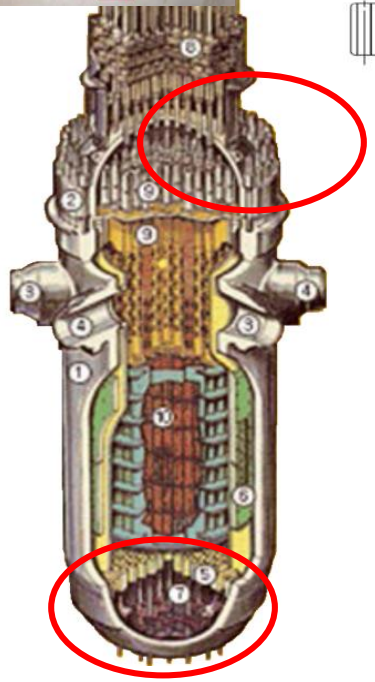
Reactor Vessel

- RV is a unique component, as :
  - Nuclear reaction is realized inside RPV
  - RV contains whole nuclear fission materials as well as practically all radioactively induced materials
  - RV cannot be practically cooled down if it ruptured
  - RV is a large and heavy component
  - RV is practically non-replaceable

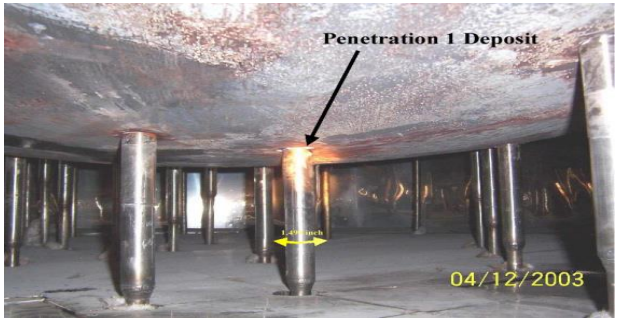


RV issues



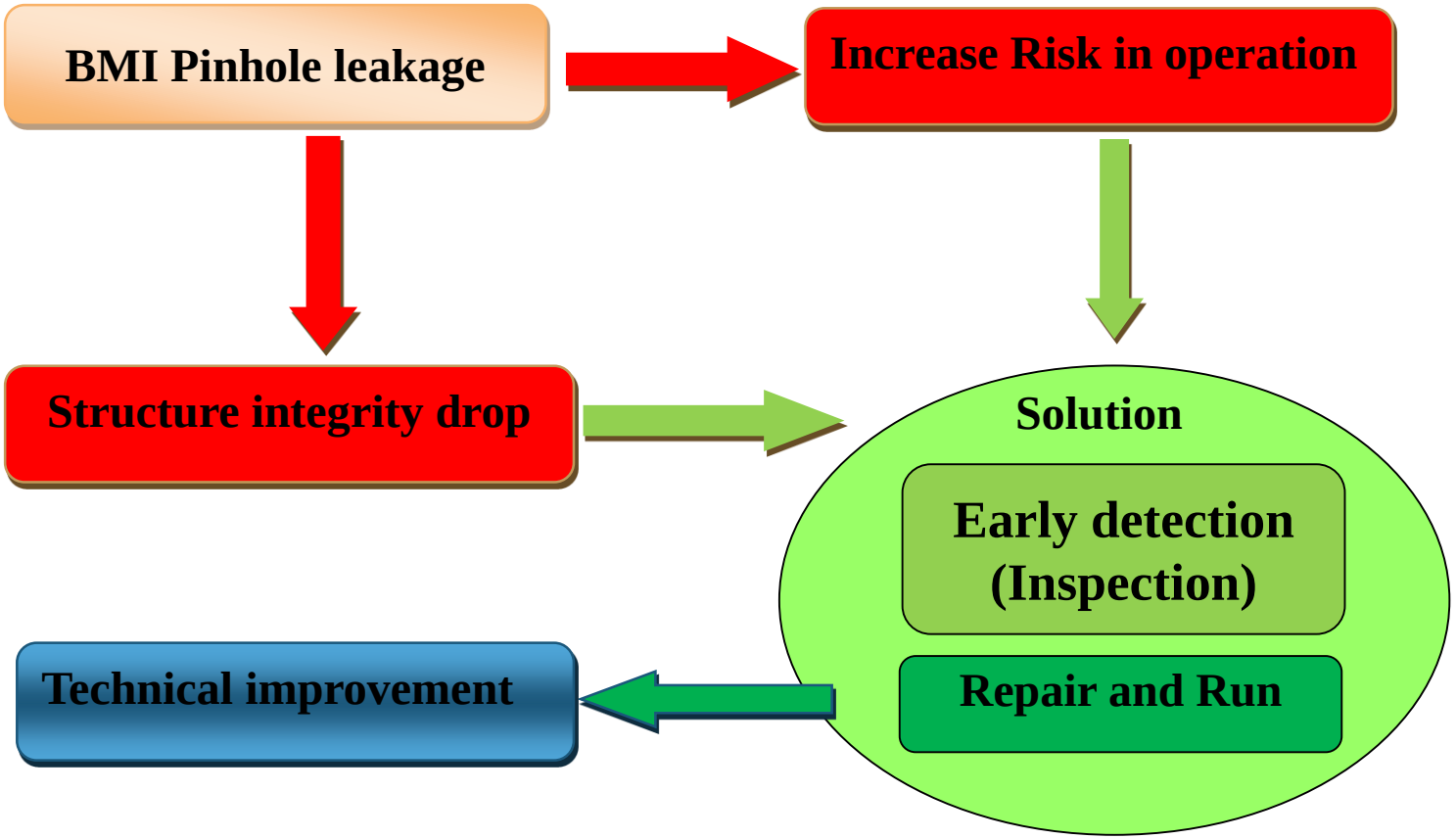


<Davis-Besse, CRDM nozzle>
- 2002.2 Crack found
- 2002.3~2004.1 Closure head replaced
- 2004.2 Resume the operation
- Repair cost: $20M
- Revenue Loss : $520M (for 2years)



<STP-1, BMI Nozzle>
- 2003.4 Crack found
- 2003.6~8 Repair
- 2003.8 Resume the operation
- Repair cost: $5~10M
- Revenue Loss : $130M(4 months)

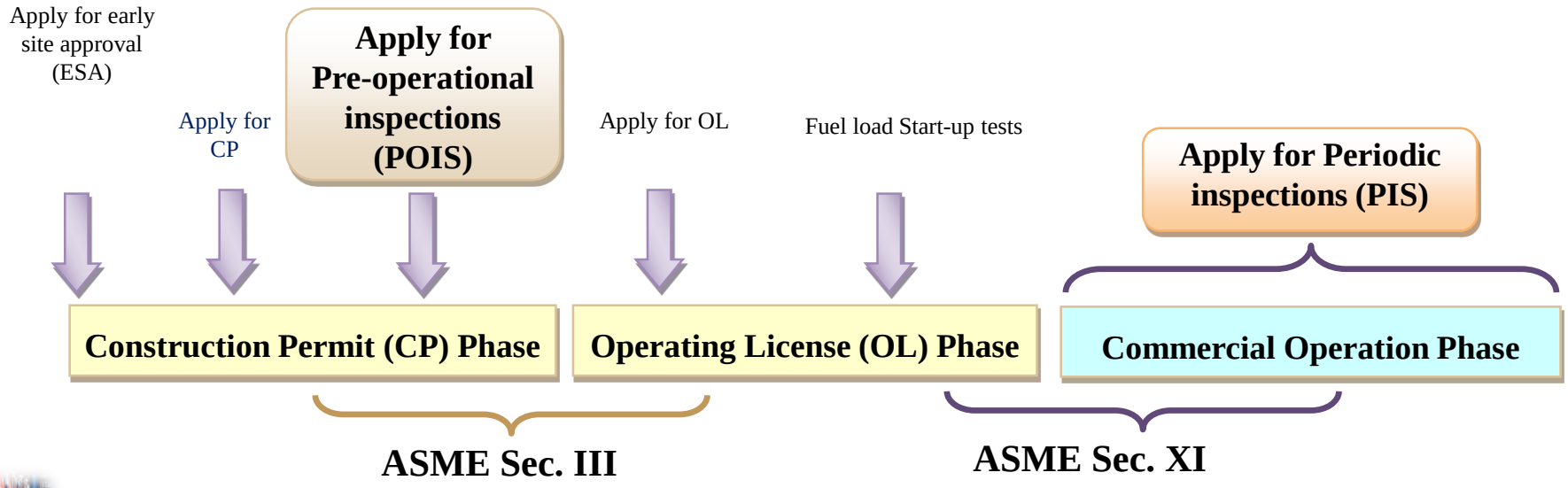
Problem formulation.



Requirement

- ASME, Section XI, provides requirements for examination, testing, and inspection of components and systems, and repair/replacement activities in a NPP.
- Application of Section XI begins when the requirements of Section III have been satisfied.

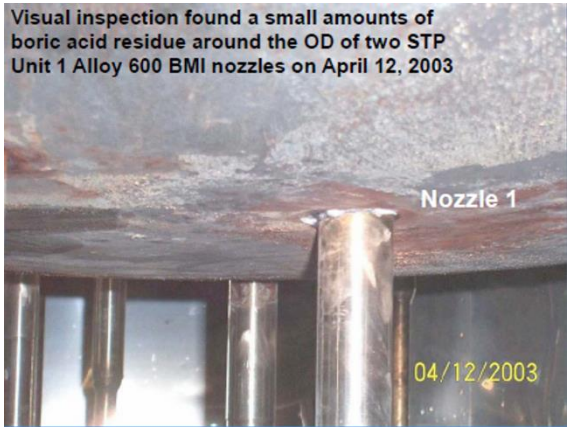
- Objective of Section XI
  - To ensure the integrity of components
  - To timely detect defects



2 Case studies

South Texas NPP

- South Texas found two leaking BMIs in April 2003
- Small amount of residue discovered on 2 BMI penetration at south Texas plant unit 1
- Deposits confirmed to be boric acid from reactor coolant
- Very small amount of deposits- 150 mg and 3 mg



Palo Verde Unit 3 (PVNGS-3) NPP

- On October 6, 2013, BMI nozzle number (#) 3 at Palo Verde Unit 3 (PVNGS-3) exhibited small white deposits around the annulus

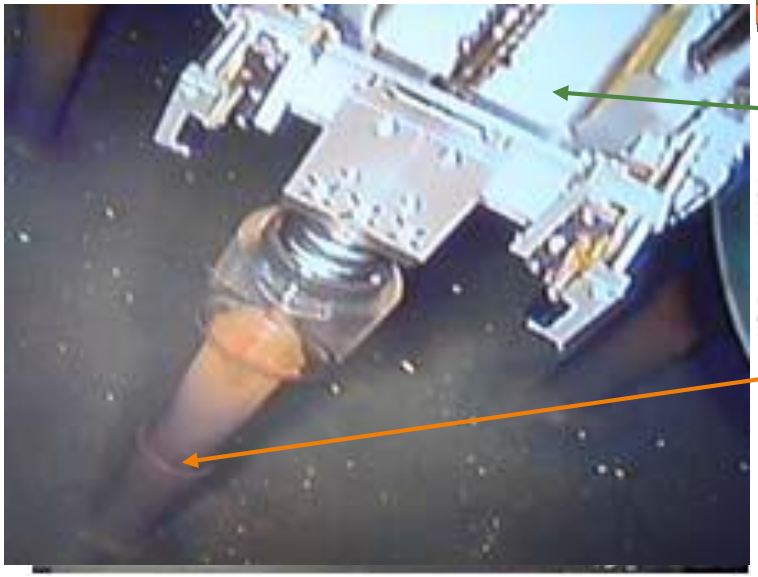
(Year 2010)

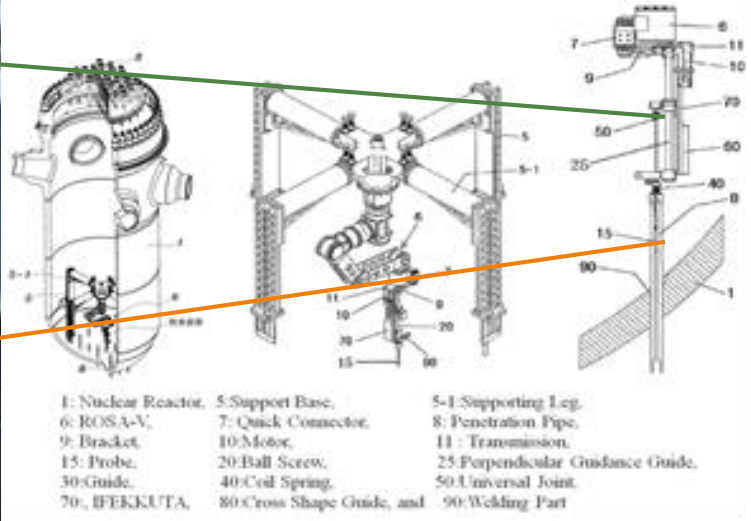
(Year 2013)

3 BMI of RV inspection

BMI OF RV Inspection

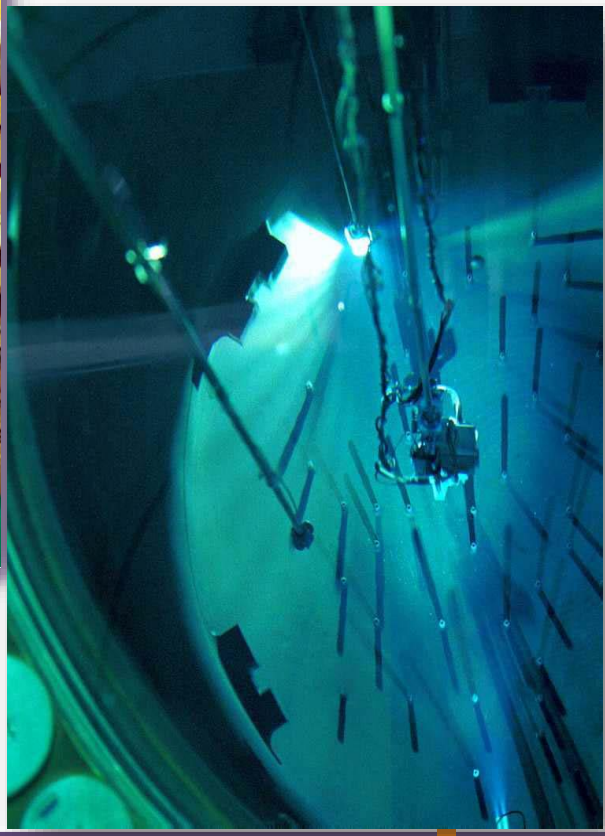
- AREVA NDE Solutions introduced an inspection system to ease the J-weld inspection challenge including improved underwater remote manual scanner
- KPS developed an inspection technique of the OPR-1000 plant



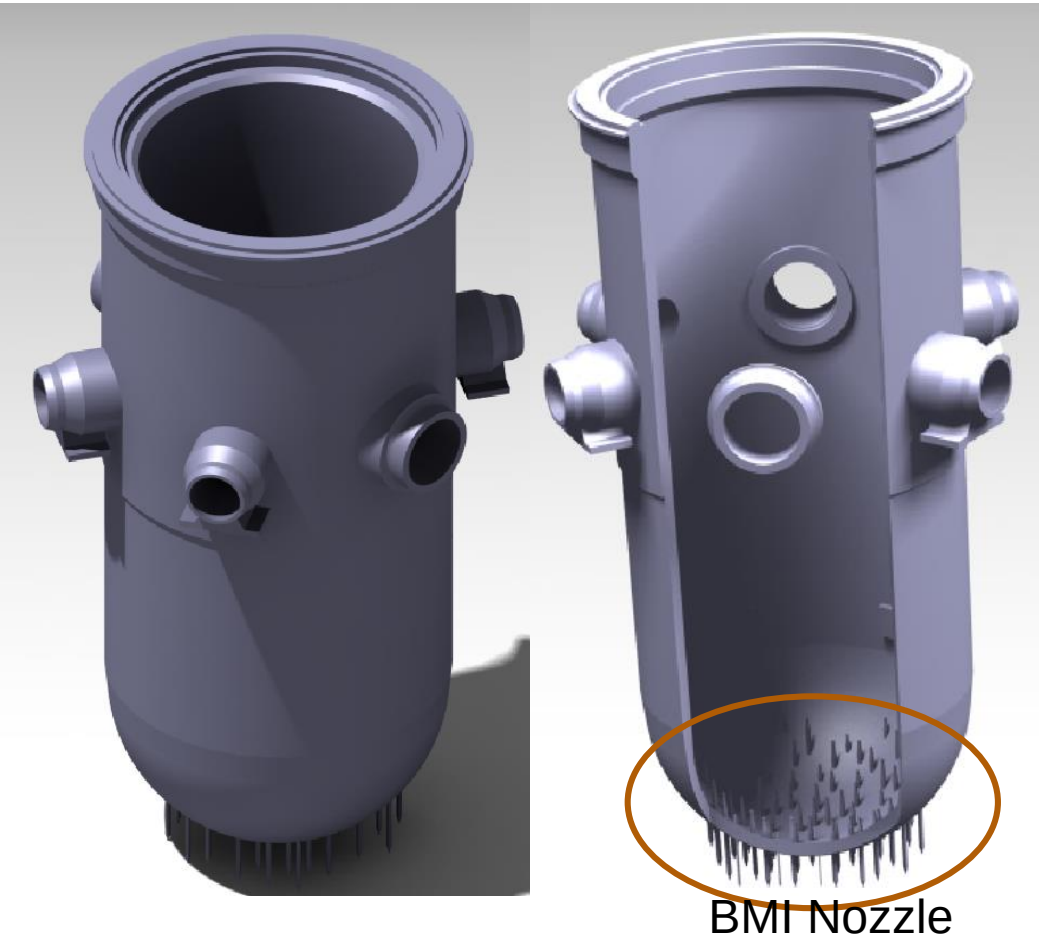


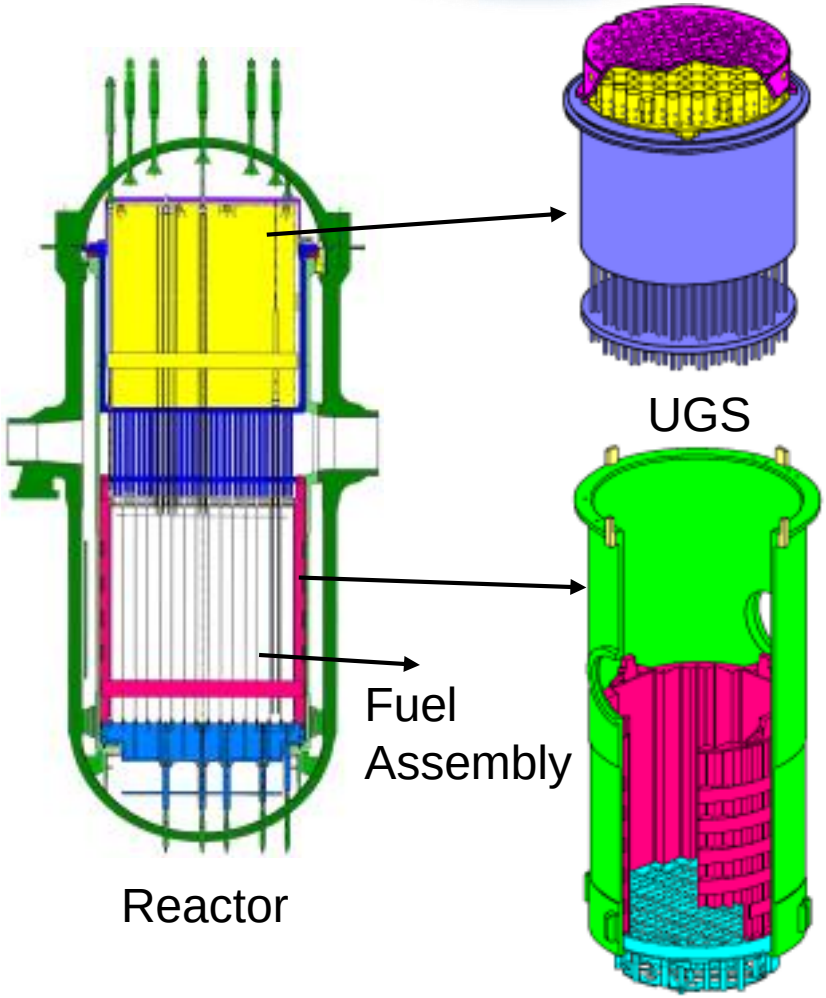
BMI OF RV Inspection

Framatome developed underwater testing probes attached to a remotely operated, 65-foot-long pole, this test have done after removing all reactor vessel internals



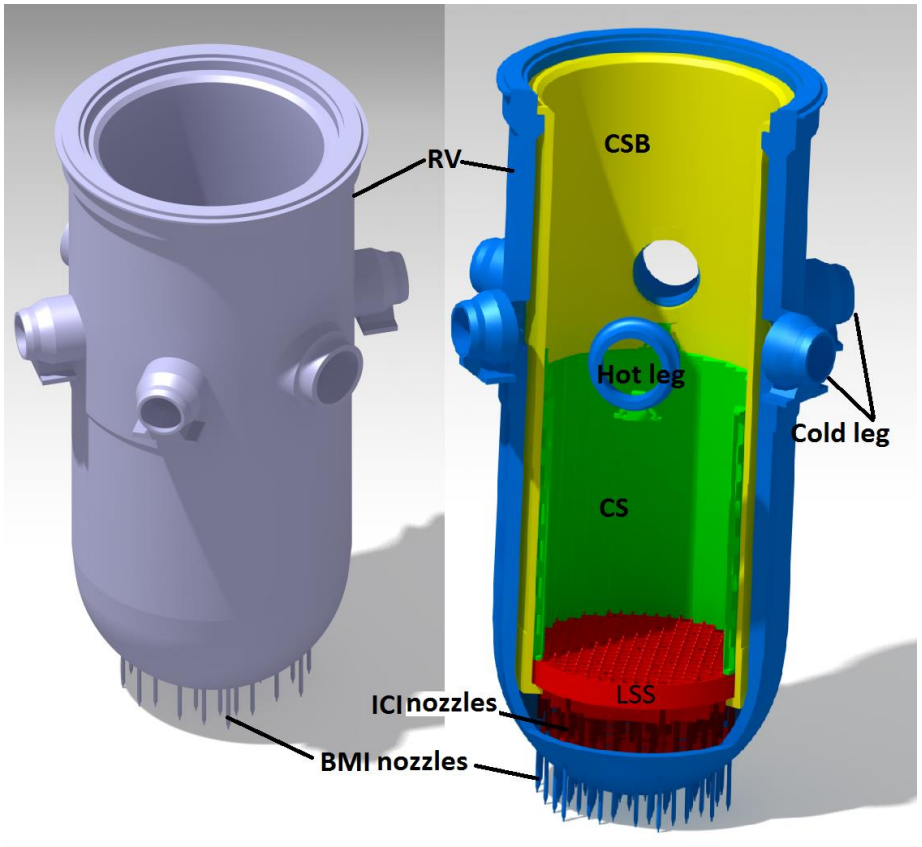
Current Bottom Head inspection conditions





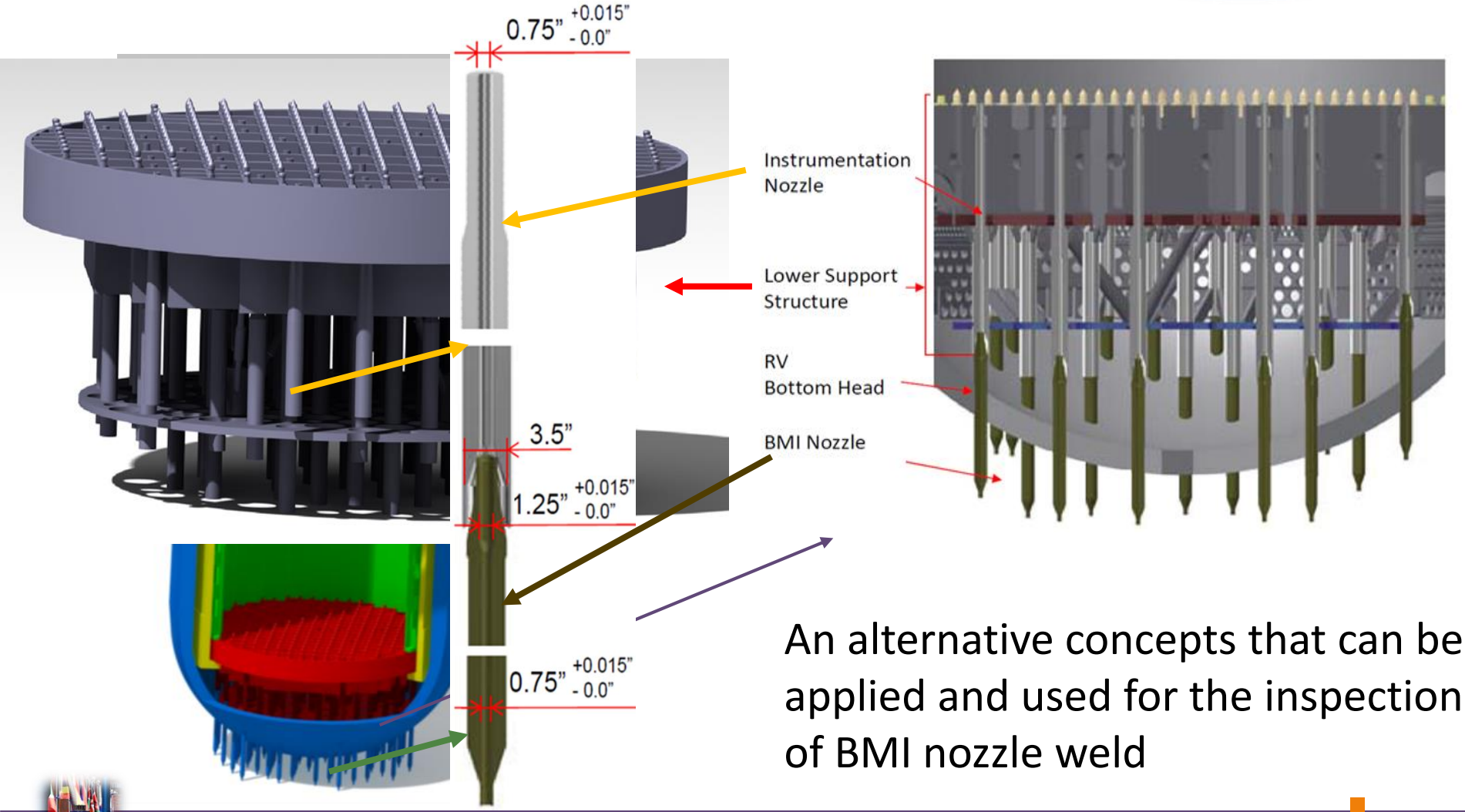
Needs Analysis

- There is a need for a system to achieve internal inspection of BMI during refueling time without removing the reactor vessel internals.
- The aim of the new design is to achieve inspection of BMI nozzle to enhance safety and reliability.



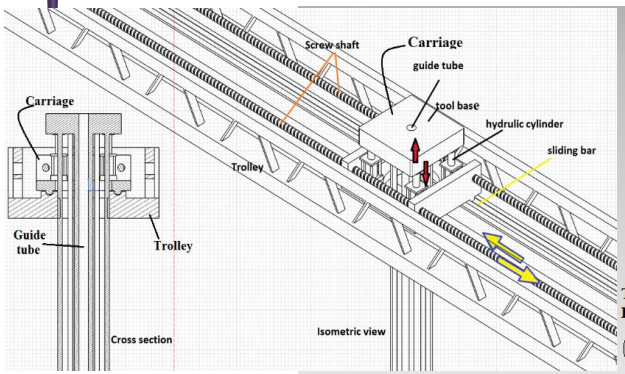
Conceptual design of BMI inspection tool

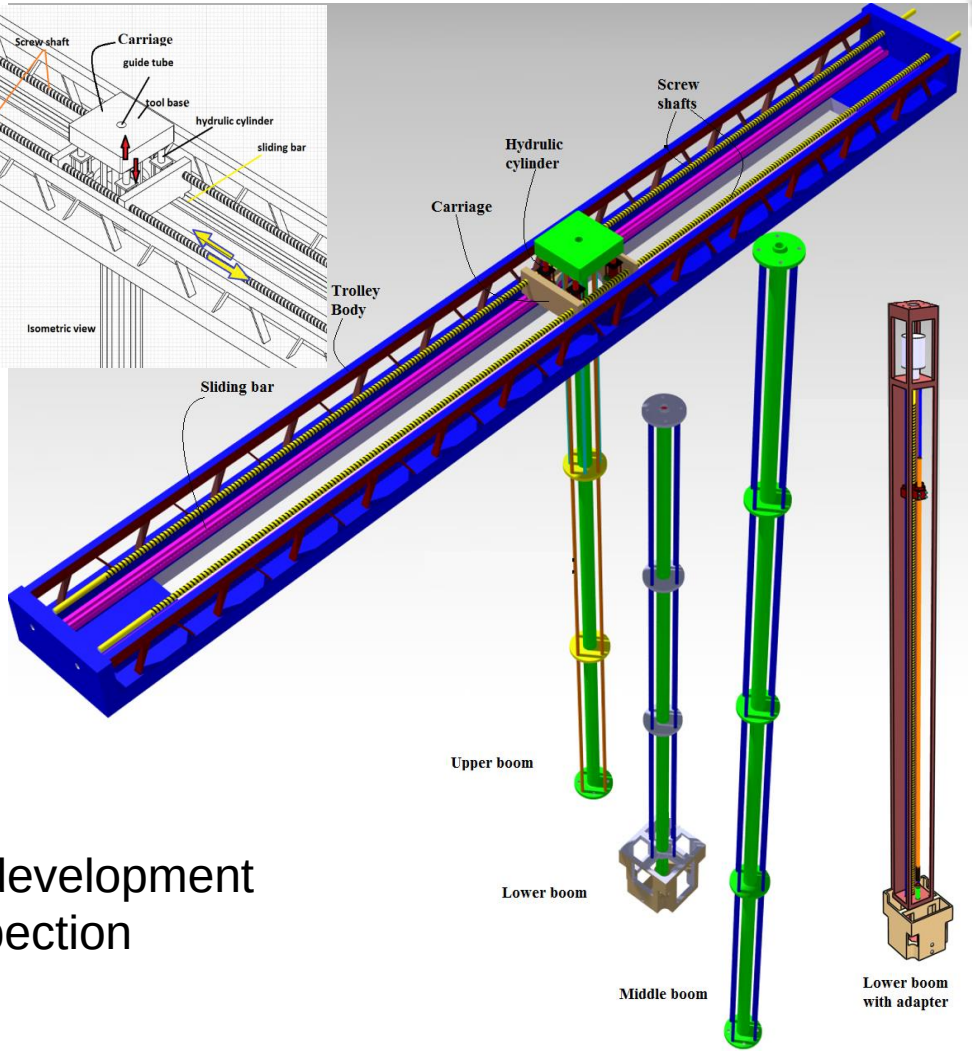
Concept Definition

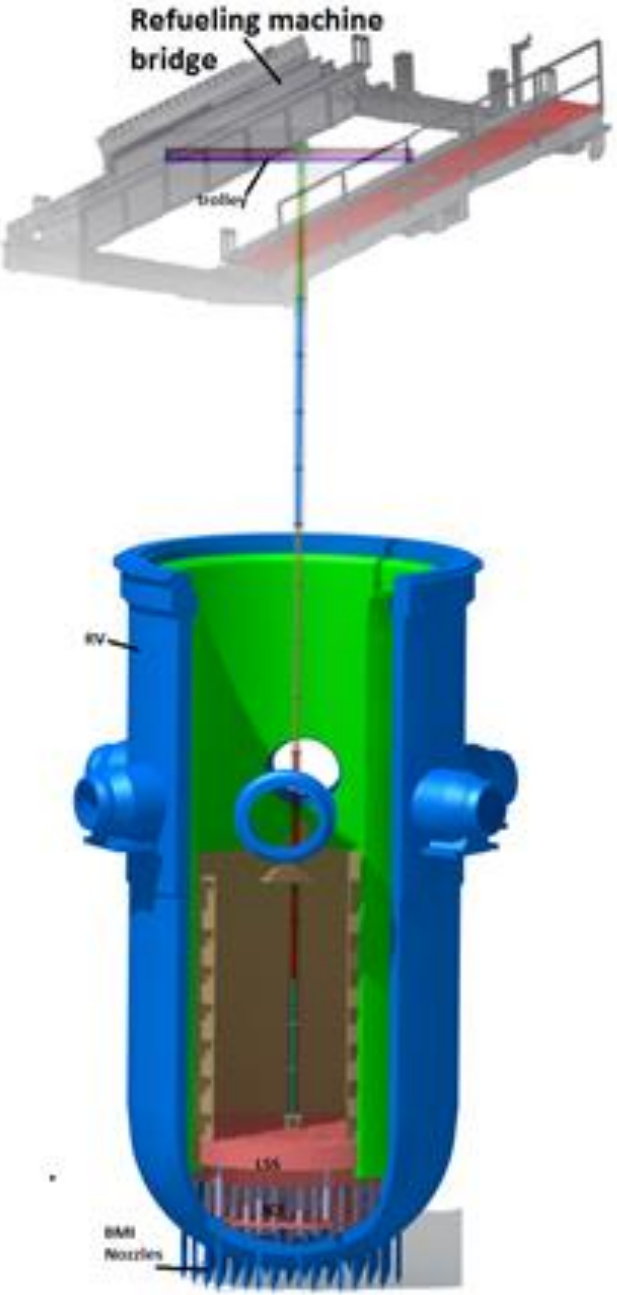


An alternative concepts that can be applied and used for the inspection of BMI nozzle weld

Concept Development of BMI Nozzle Inspection System

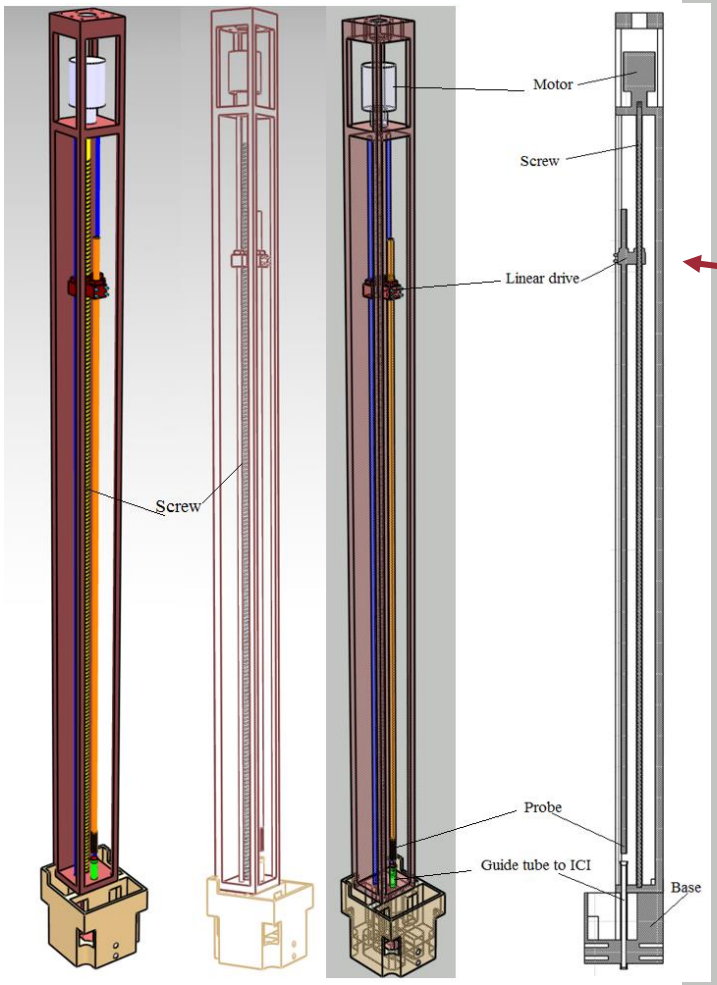


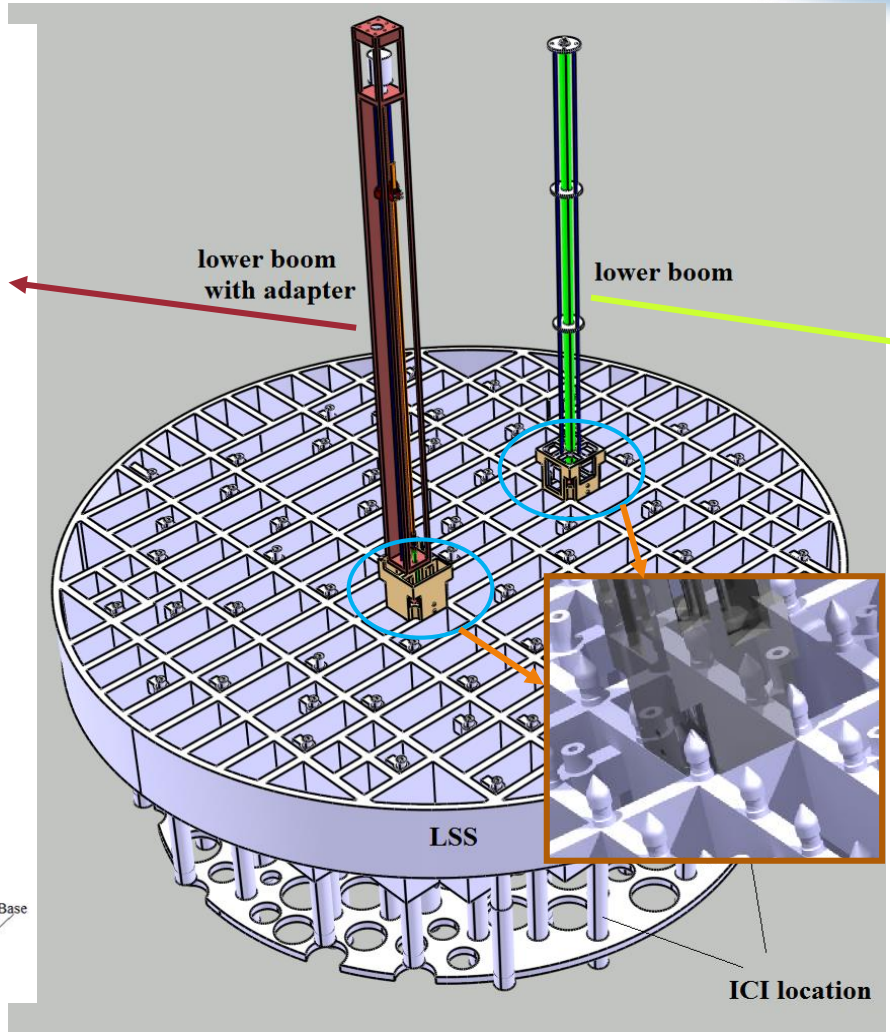




3D model development of BMI Inspection system

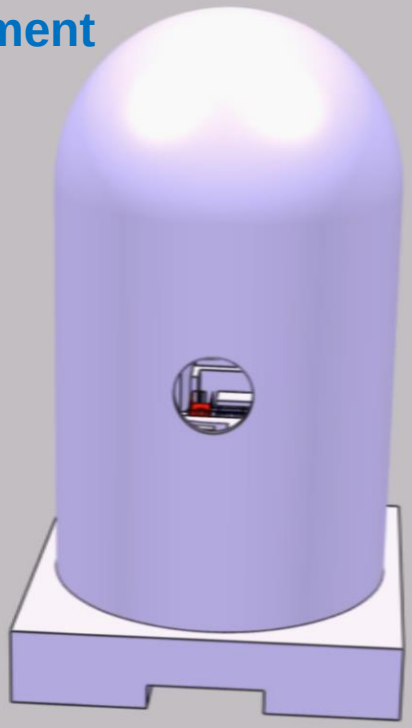
Conceptual Design of BMI installation process





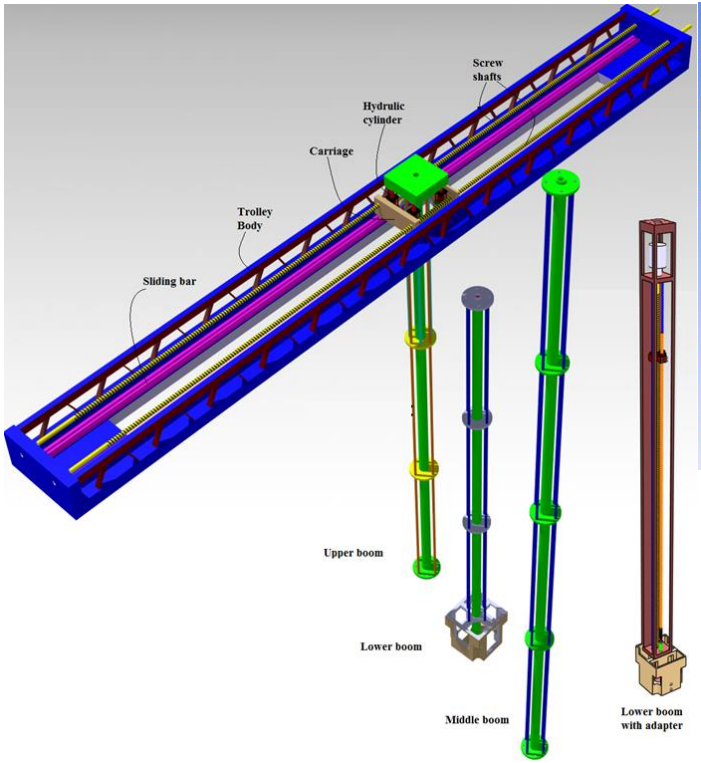
Conceptual Design of BMI

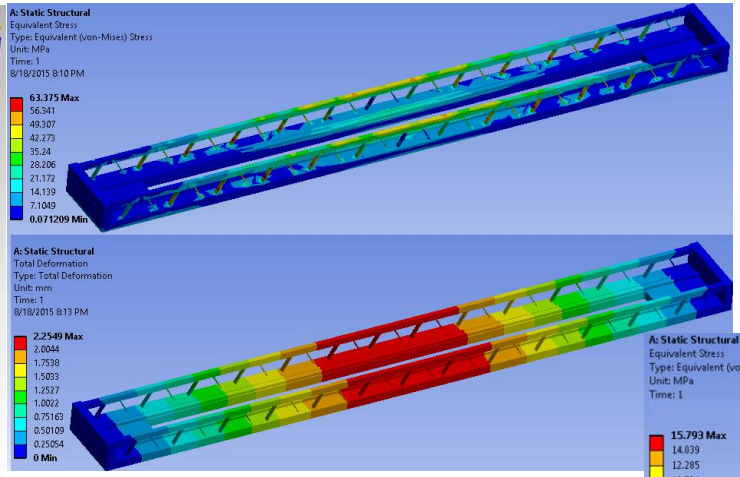
installation process video created by CATIA v5 navigator environment

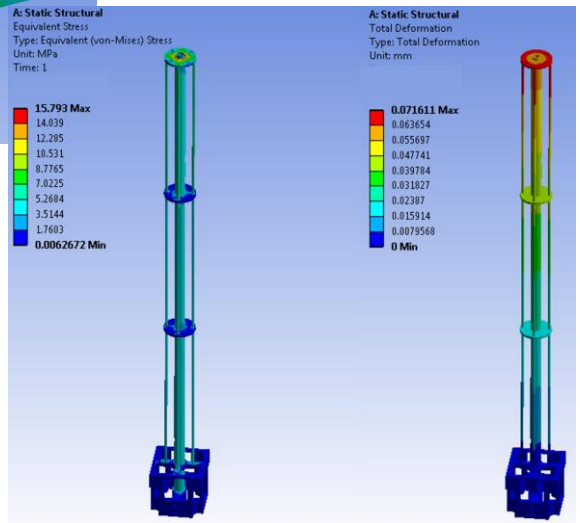


Conceptual Design of BMI Inspection Trolley

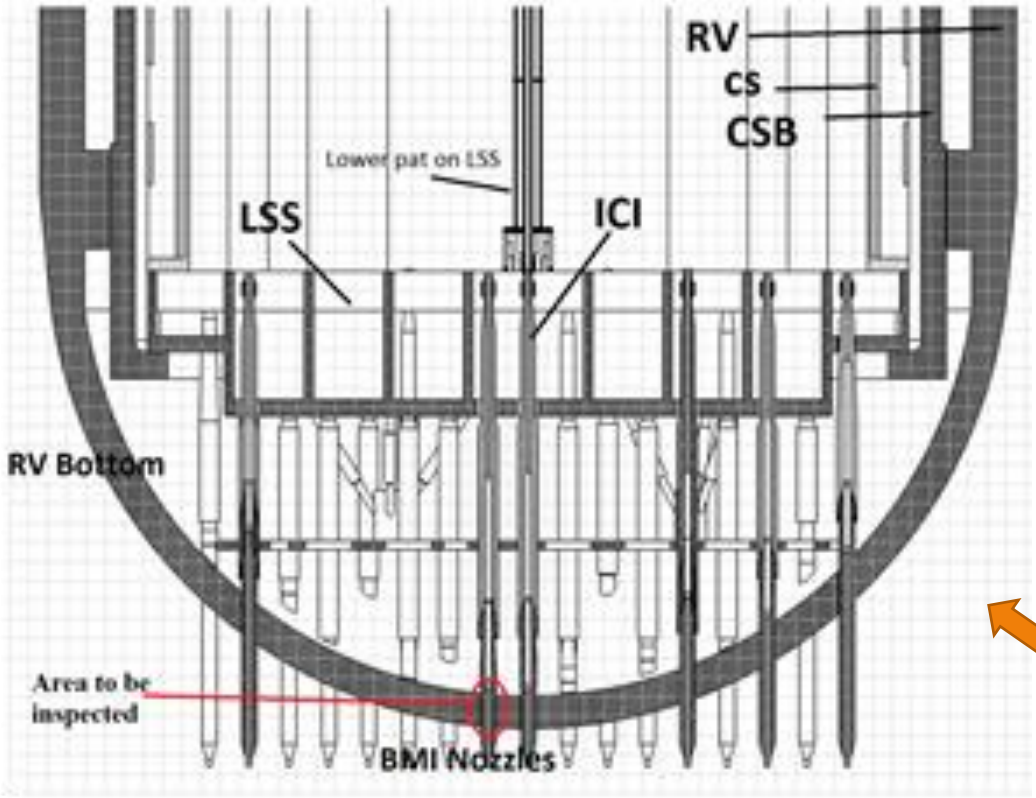
- 3D model development of BMI Inspection Trolley.
- Equivalent stress and total deformation of Trolley Body and lower part of BMI inspection tool.

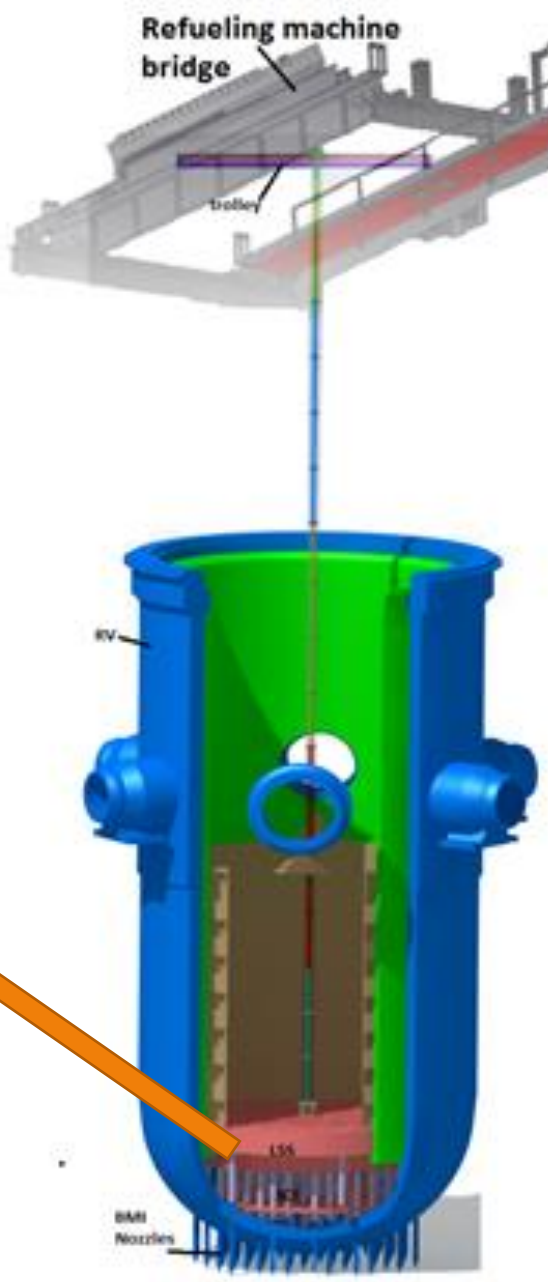






Conceptual design of BMI Inspection Module





Lower part of the new design at the RV bottom in 2D using CATIA v5.

5 Conclusions

CONCLUSIONS

- BMI nozzle inspection system was developed to enable nondestructive inspection of BMI nozzles during regular refueling outage.
- The proposed BMI nozzle inspection system can make it possible to find an early detection of BMI nozzle weld defects and lead to prevention of leakage
- A 3D model of the inspection system was developed along with the RV and internals which permits a virtual 3D simulation to check the design concept and usability of the system.

Thank You !