NUCLEAR VIRTUAL ENGINEERING CAPABILITY

Nuclear Virtual Engineering Capability

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NVEC Phase 2 Environment

Develop a digital design model of the plant, component or facility

Maintain a digital model of the plant, component or facility together with related design data

Securely view/ analyse/ share data

Run evaluations on common design data from remote locations

Integrate Supply Chain

NVEC Benefits

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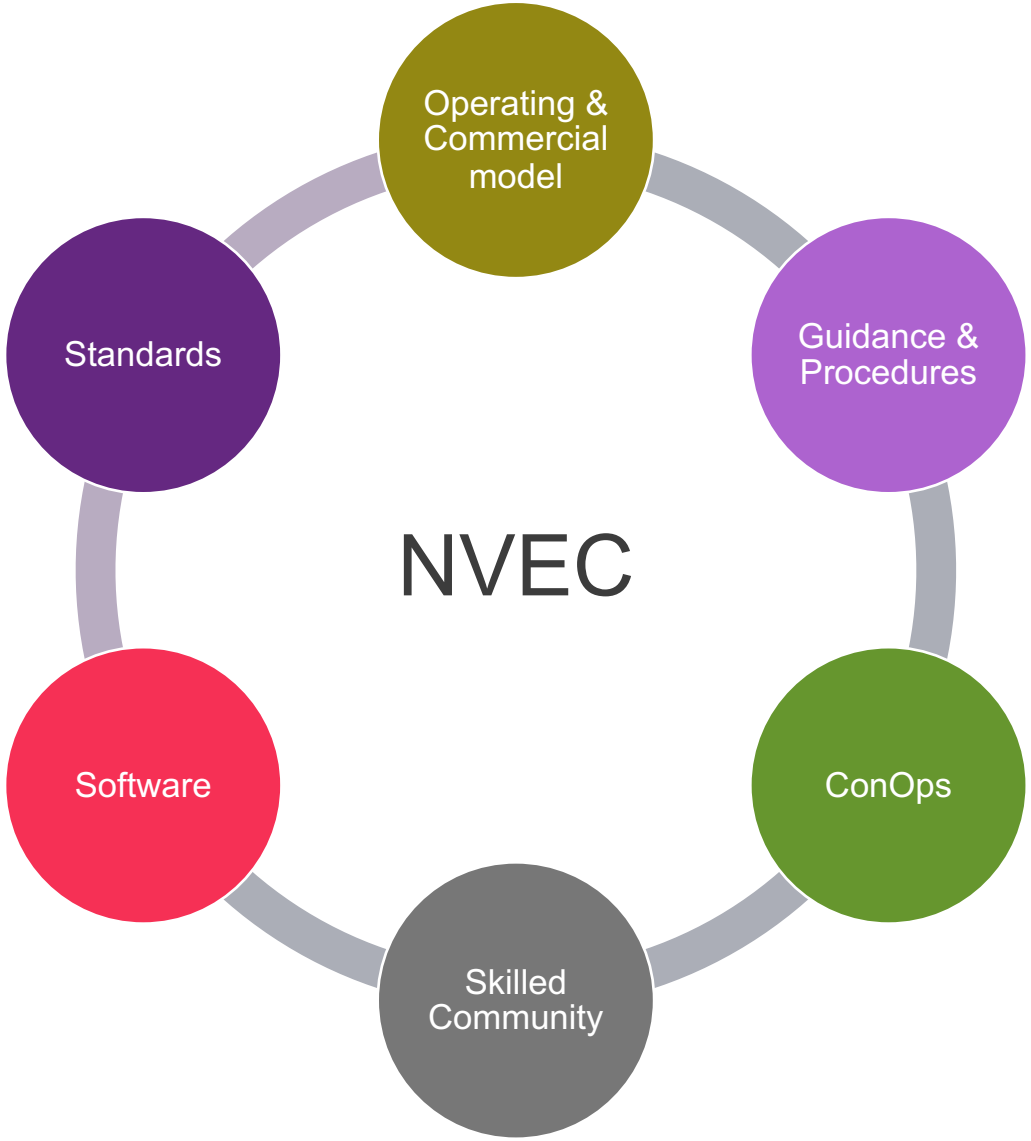
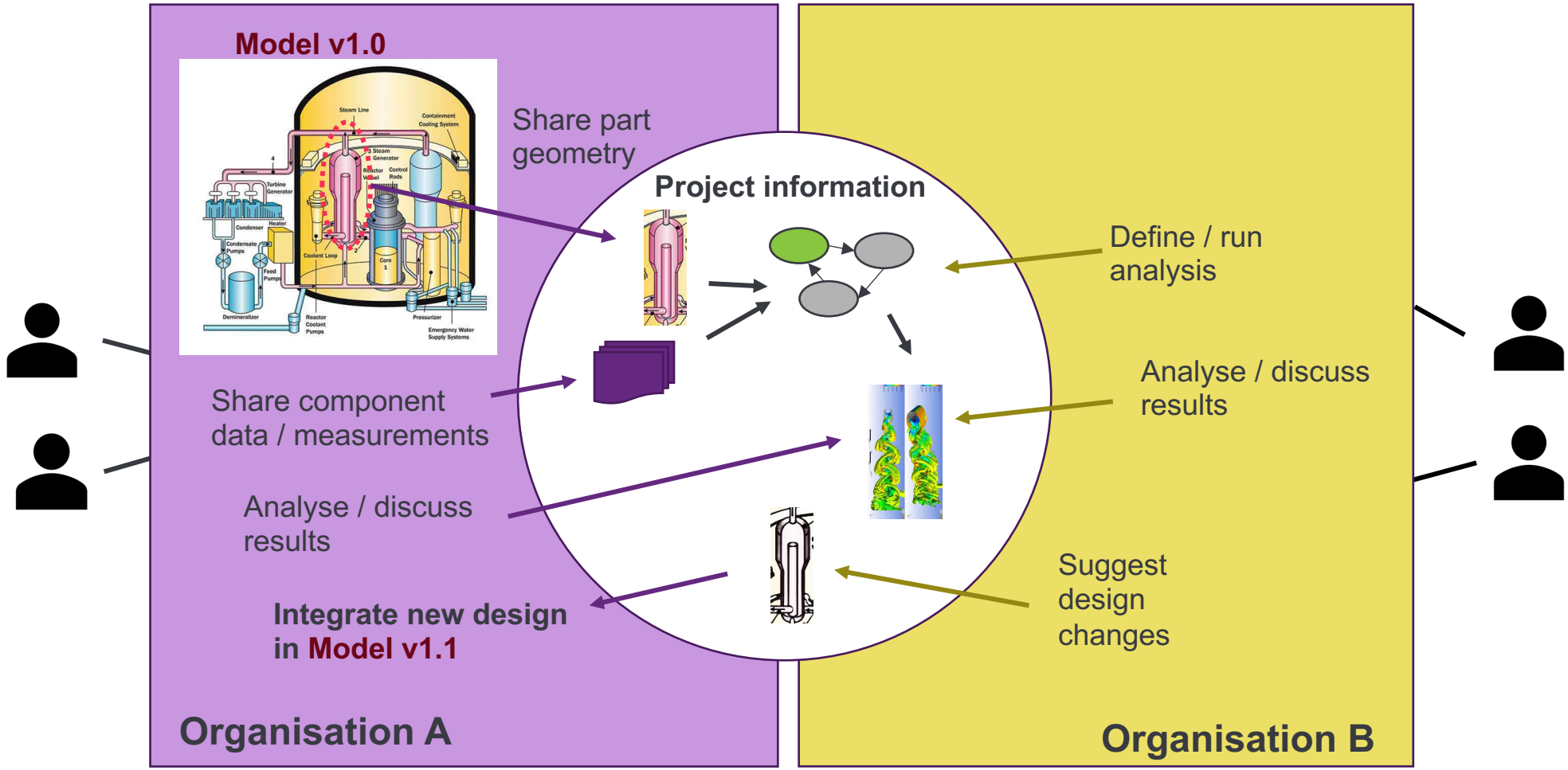
- Reduced costs
  - Single source of design data ; collaborative environment
  - Increased return on investment through efficient operation & maintenance
  - Lower risk leading to reduction in financing costs
- Shortened development times
  - Efficient Design & licensing ; Integrated multi-physics approach
  - More reliable prediction of development times, allowing better synchronisation
- Enhanced credibility, operability, reliability & safety
  - Real time understanding of Plant, better planning and predictive maintenance
  - Enhanced training & skills development
  - Reduced risk and perception of risk
- Cross-discipline transfer of expertise; Joined-up industry
- Enables innovation and new technology adoption; diverse users

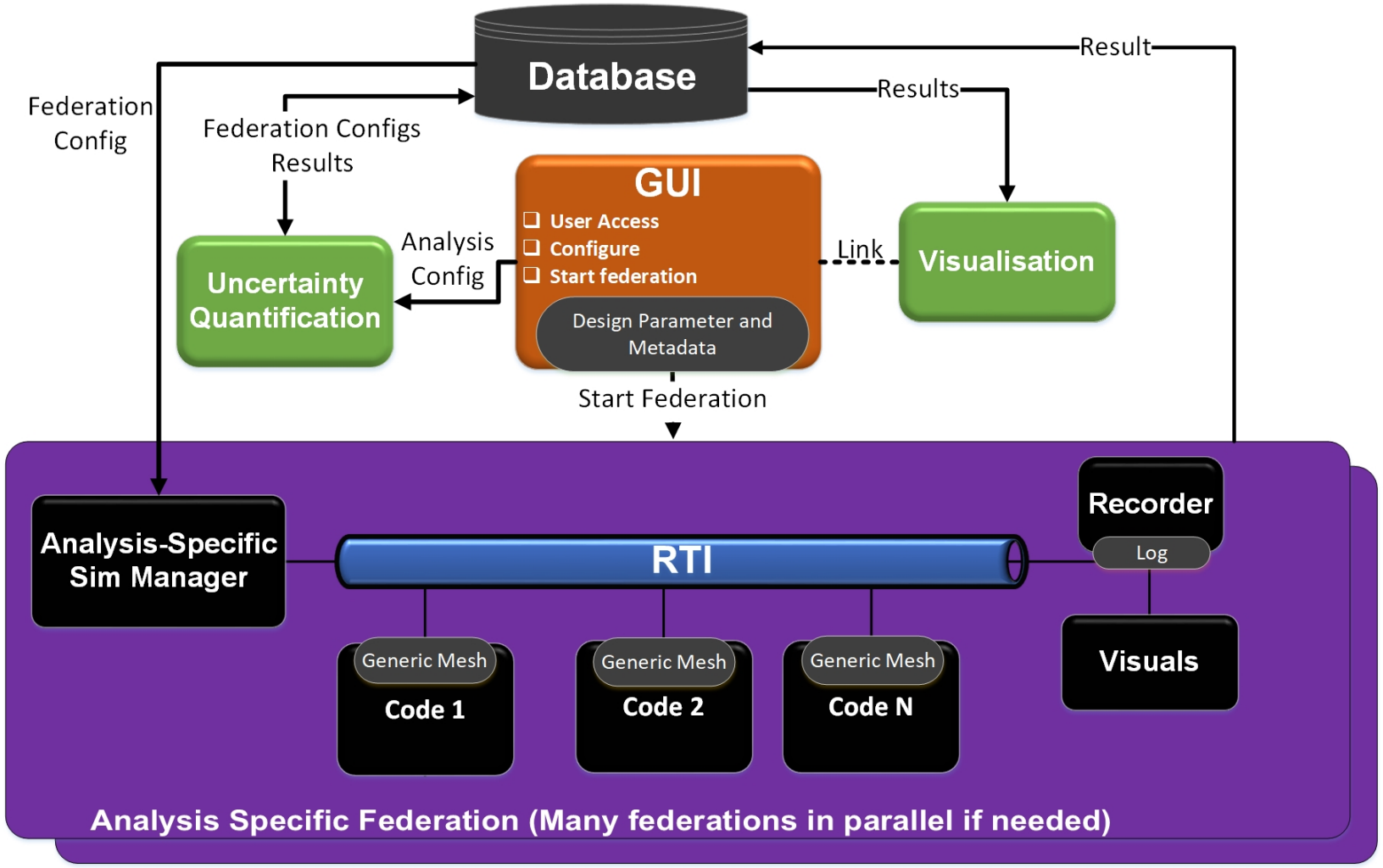
NVEC elements



Example collaborative analysis



Phase I architecture



NVEC Phase 2 Target Architecture

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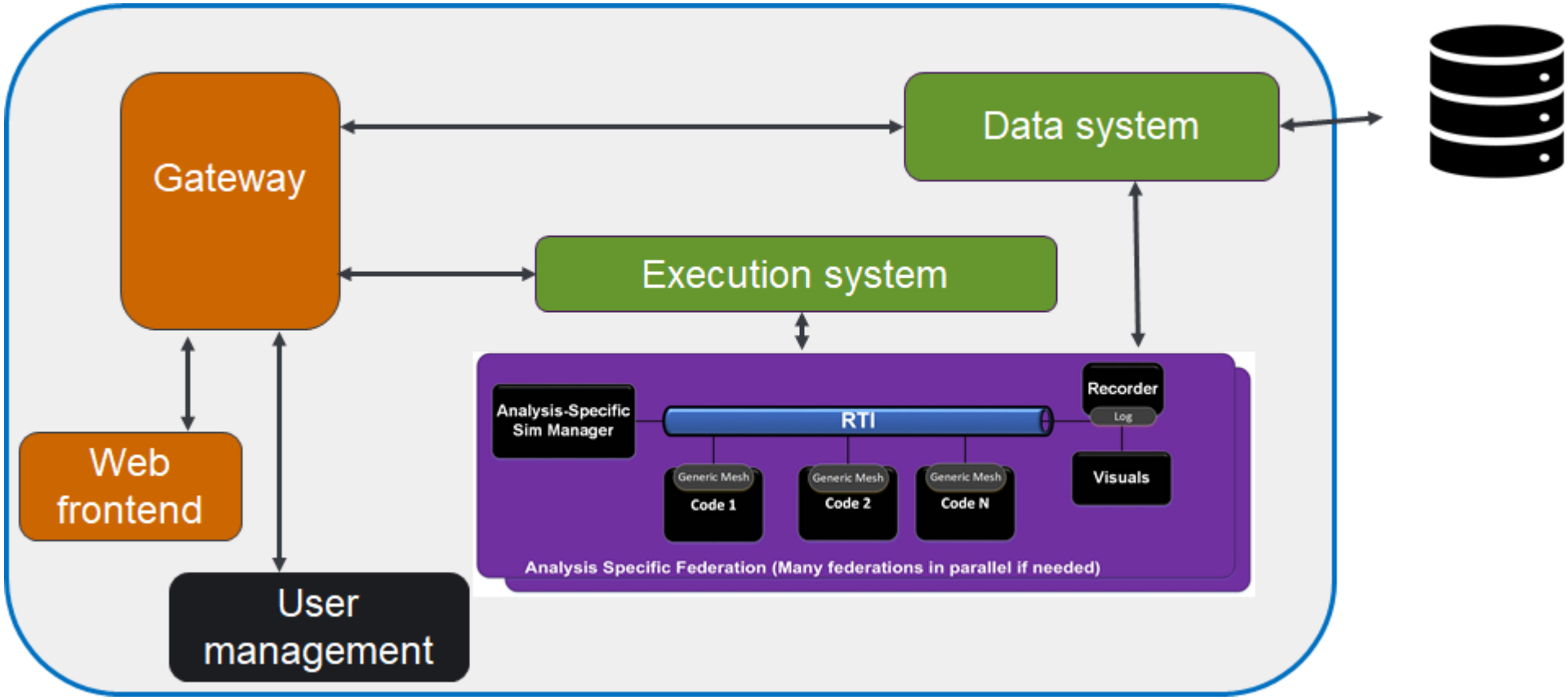
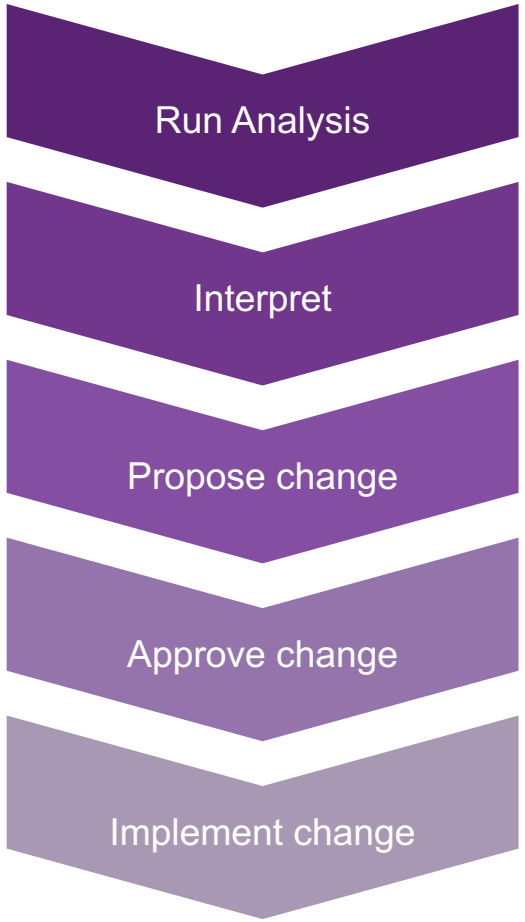


Case study: Data management / change control



Benefits from NVEC in design process

- All work based on same data
- Controlled design change process
- Provide more flexible access control to add/remove individuals and sub contractors
- Record justification for decisions
- Standard interfaces simplify links to analyses to ensure consistency and reproducibility

Case study: Data management / change control

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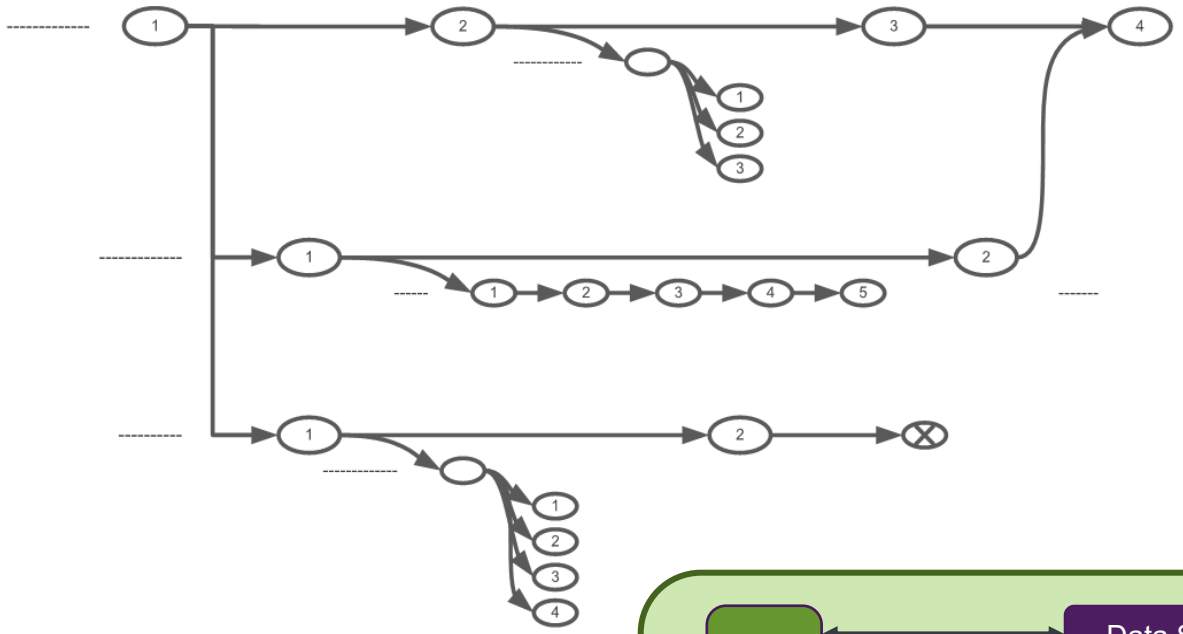
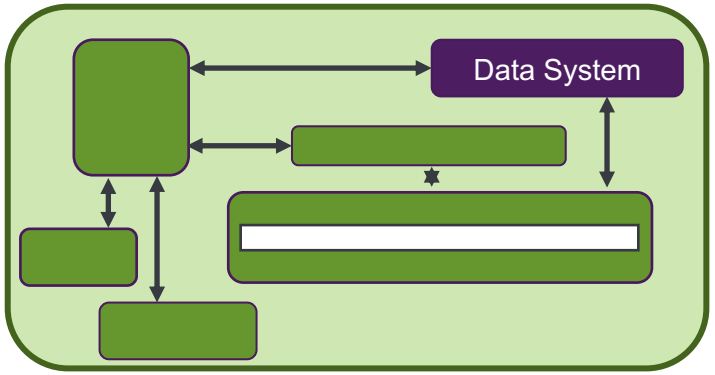
- Initial focus on geometry data
  - ‘Geometry’ has many different forms (CAD, parametric, point clouds); but difficult to manage
- Case study intends to:
  - Demonstrate change control of these different forms, from a single common source
  - Illustrate processes using this control (for example, approvals)
- To be build using open interface to Data System





Case study: System level modelling

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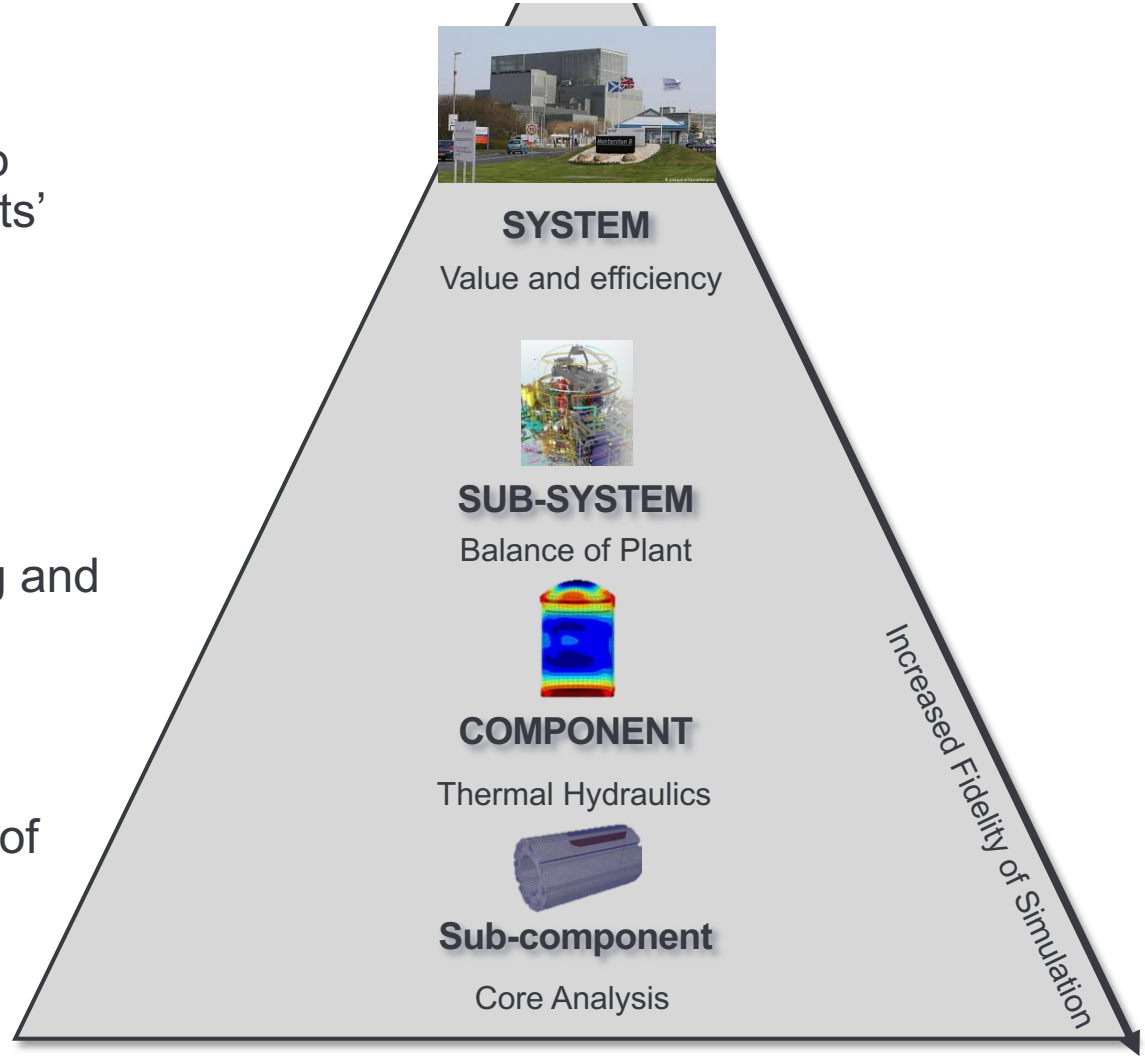
Features

Break down ‘model into hierarchy of components’

‘Equation Orientated’ modelling approach

Code coupling via ‘plug and play’ modular design

Scalable to allow deployment in a range of applications



Benefits

Single tool can analyse many different designs with few changes

Rapid turn-around from concept to outcome from an analysis

Exploit benefits from international collaboration and research

Analyse faults faster as plant simulator and control system can have common features

Case study: System level modelling

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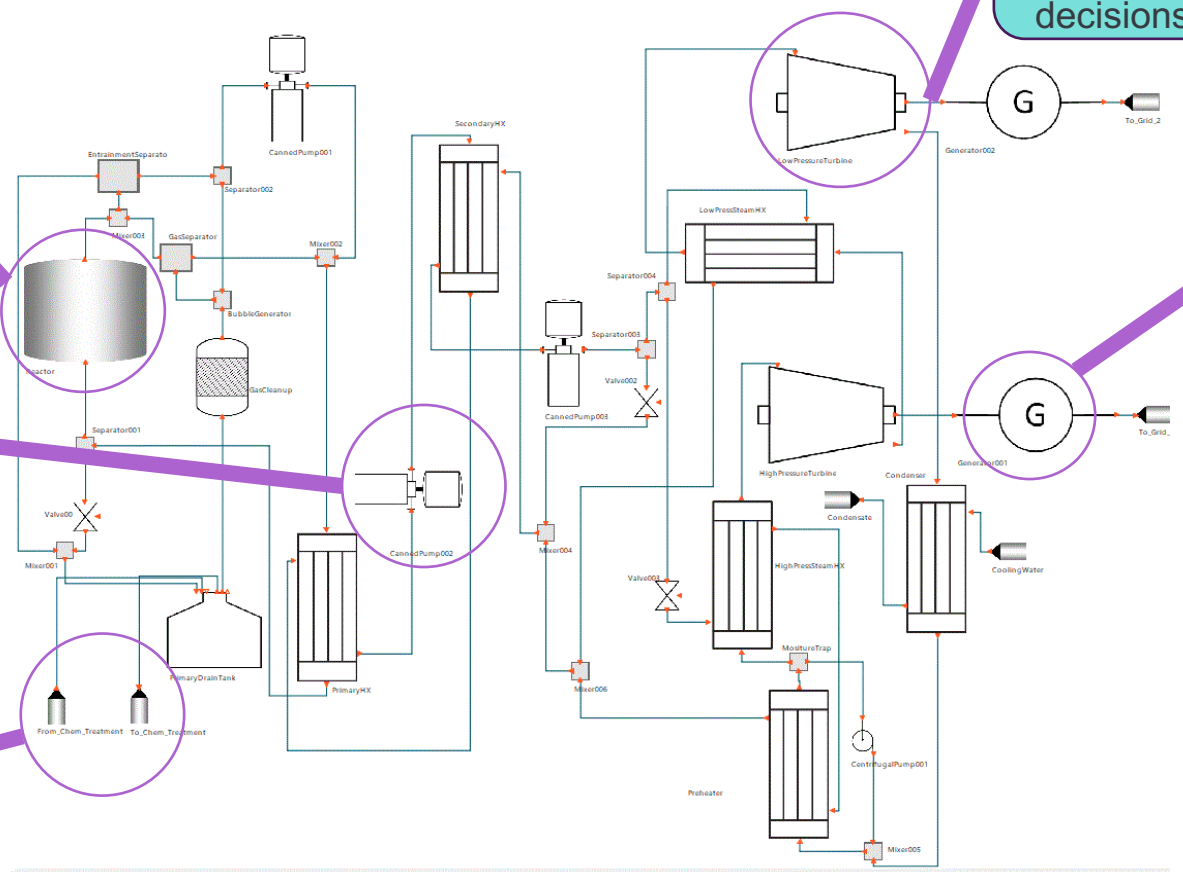
Modular components that can be 'swapped out' to reflect design decisions.

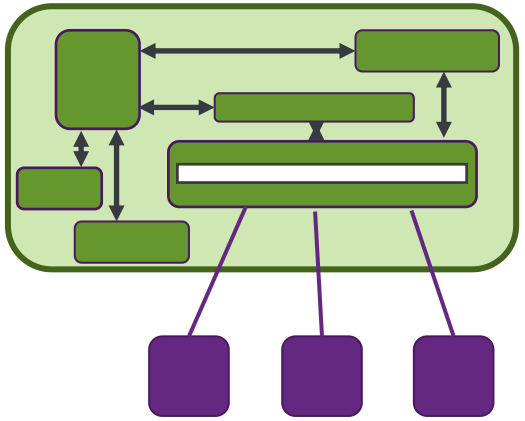
Flexible 'modules' that can be linked to lower length scale simulations (i.e. WIMS) using HLA

Component Library that can be reused for new designs – Stored in data management system

Simulate operational sequences to find most efficient way of operating the plant – set up using sim manager

Real-time output that can be linked to control systems for operational planning and fault diagnosis – stored in data management system





Example Nuclear Plant: Prototype Molten Salt AMR

Case study: AGR graphite Workbench

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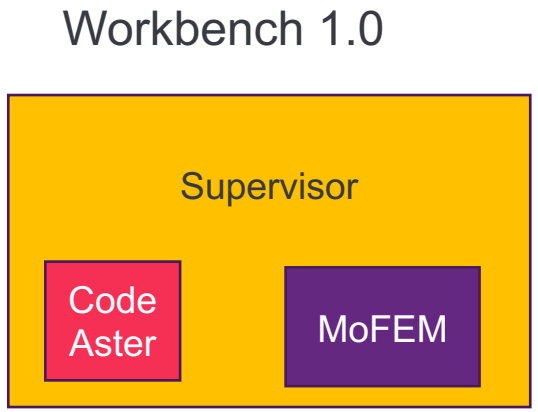
What is Workbench?

- Graphite Workbench is a tool designed to solve a technical industry need
- Its potential impact is to speed up safety cases contributing to ensure energy supply (societal and economic benefit)



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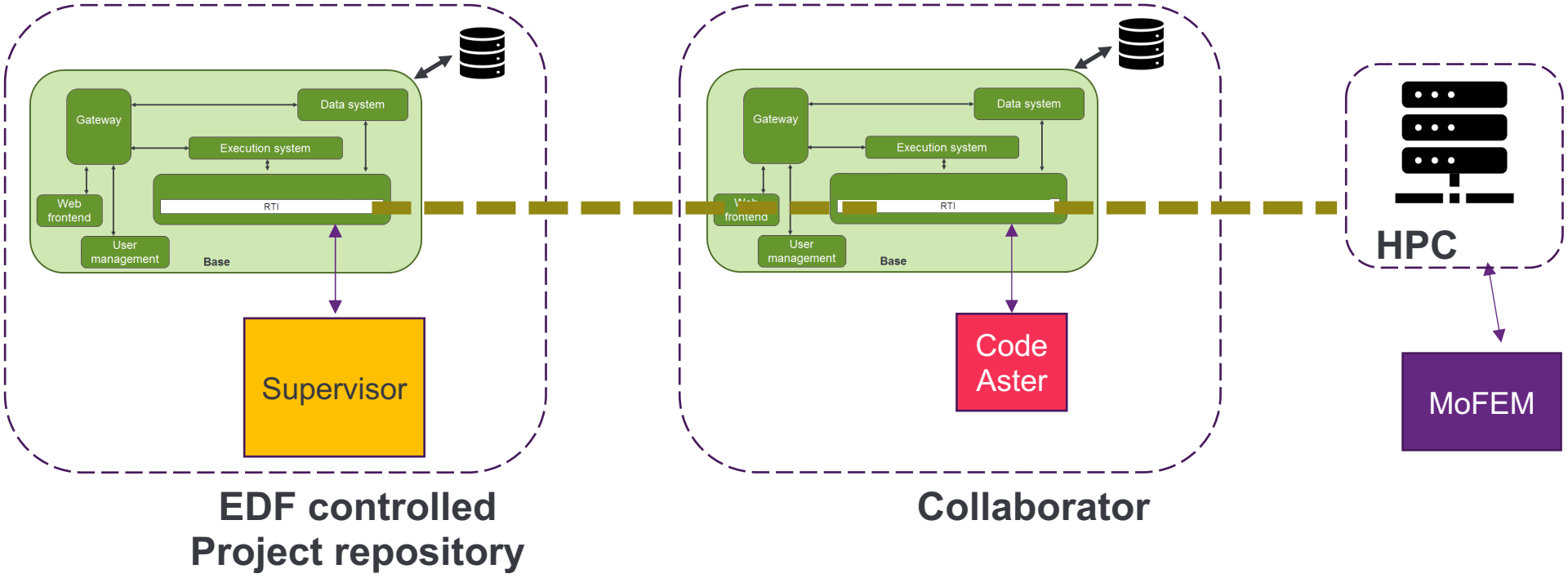
<EDF – Workbench video>

Workbench 2.0



Benefits of integration with NVEC

- HLA enables sharing of computational infrastructure
- Improvement of computational throughput and fidelity
- Leveraging government R&D investments (MoFEM developed through EPSRC)

Case study: AGR graphite Workbench (EDF)

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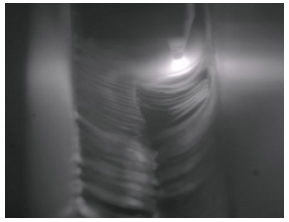
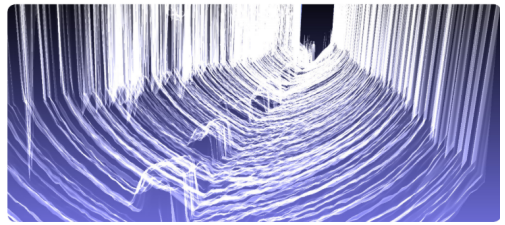
So why integrate Workbench with NVEC?

- **Performance -** Workbench is designed for standard desktops which struggle with large quantities of detailed simulations
- **Collaboration -** Sub-contract partners often deliver technical studies and a common platform eases information sharing
- **Efficiency –** Prevents OEM effort being wasted on duplication, data loss, and initialising projects
- **Standardisation -** Digital deployment to partners eases training and improves quality control

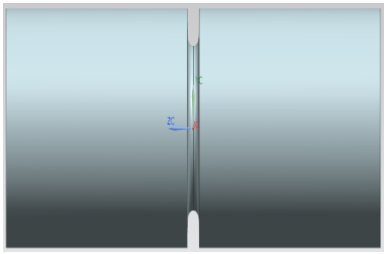
Case study: Component twin

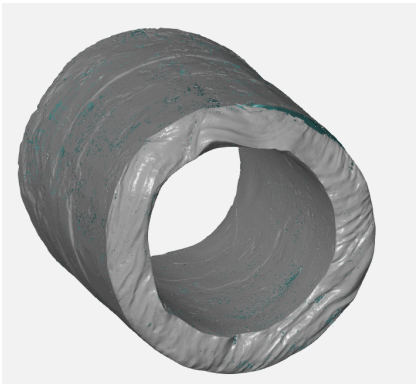
In process data



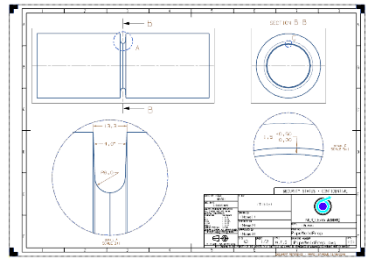


Geometry data
eg. Designed CAD, Metrology scans



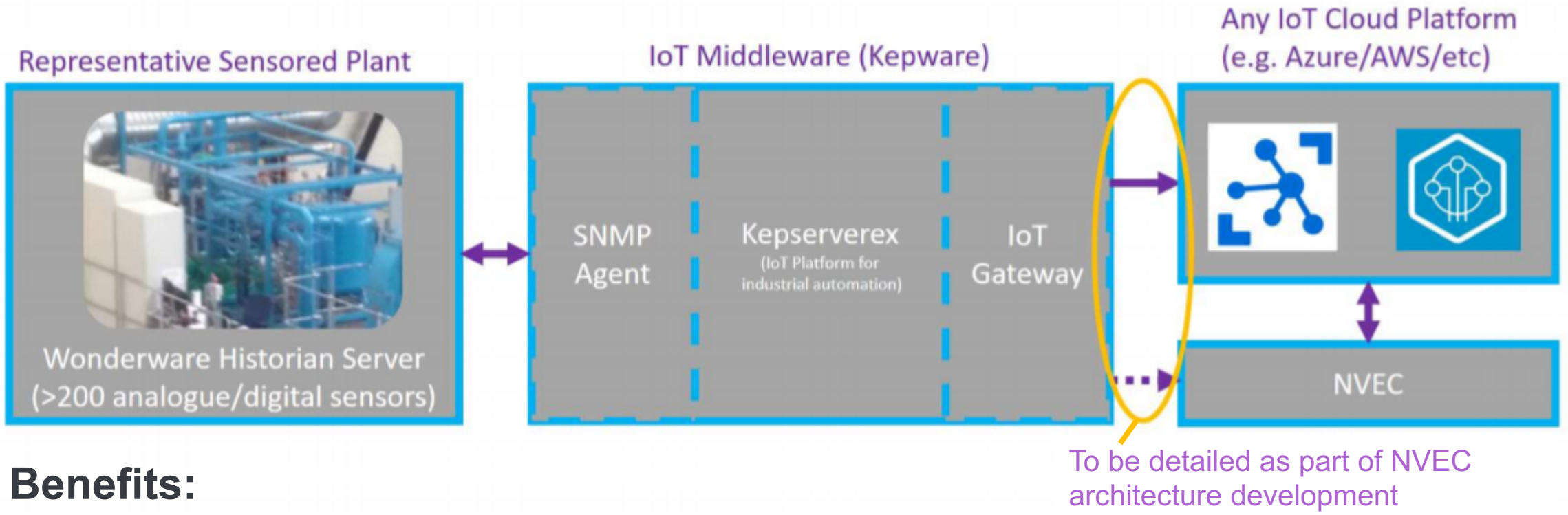


Through-life documents
Material Certs, Drawings, Through-life Inspection reports etc.



- Capture through-life data for engineering component with NVEC
- Develop data structures appropriate to handle resulting data
- **Benefits:**
  - Address challenges of future digital twin
  - Provide link to NIP advanced manufacturing

Case study: IoT / Big data



Benefits:

- Import of plant data in NVEC = key element of digital twin
- Representative Sensored Plant: similar sensors as TH facility
- Engagement with SMEs on analysis of data from plant (Big Data methods)

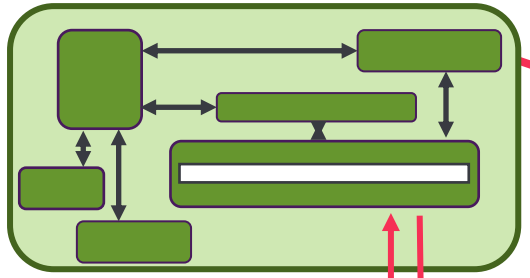
Case study: Decommissioning

Benefits of integration with NVEC:

- Enable access to external analysis
- Update model of waste with inspection data
- Support on-site operation by additional analysis and predictions

IIND – project:

- Real time planning & waste characterisation
- Integrate robotic control in seamless operation

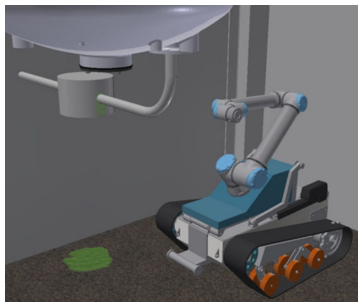


- Radiation levels for VR
- Dose maps

Autogenerated geometry + source

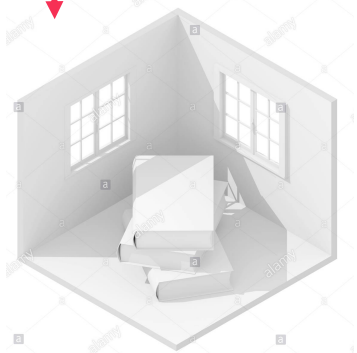
Data collection / analysis / VR

Point cloud representing room



Room inspection

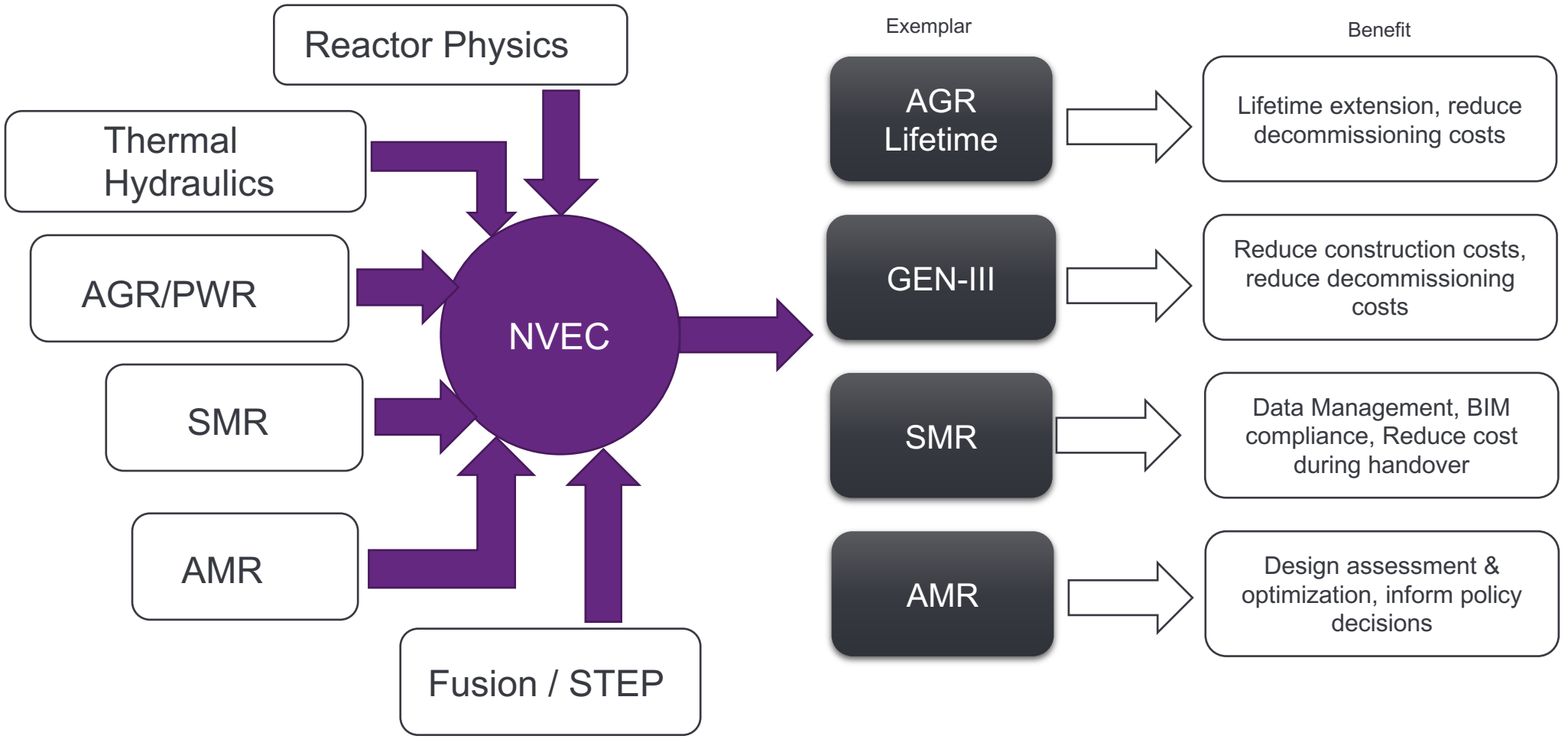
Calculate radiation levels



HPC

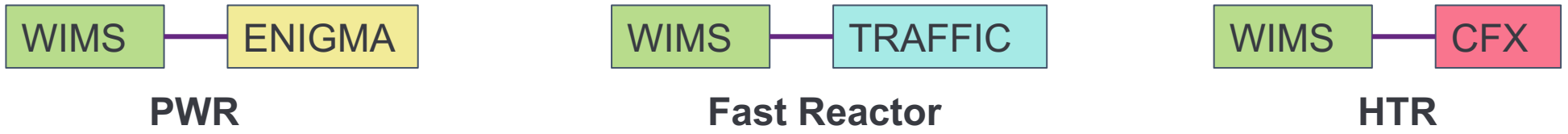
On-site

Master Programme Integrator



Link to NIP Advanced Fuels

Advances Fuels programme includes code coupling:



NVEC programme: Internal coupling to WIMS (case study **AMR** simulation)

- Development of WIMS along with NVEC
- First step towards future integration of advanced fuel analysis with NVEC
- In NVEC Phase 2: planning of integration process for WIMS-CFX

Link to NIP Thermal-hydraulics

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- On-going engagement with Frazer-Nash aligning with TH programme

- Contribution to NVEC from Bangor University to be agreed once new Bangor TH lead has started (expected end 2019)

- Thermal Hydraulic Facility: Live data from multiple thermal-hydraulic sensors in NAMRC plant to be processed in NVEC (see case study)

Link to AMR / SMR / Fusion

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SMR programme

- Engagement with SMR consortium
- Phase 2 NVEC capabilities in-line with of key requirements of SMR programme: e.g. engineering data management, design, change control

AMRs

- Benefits for SMRs also apply to AMRs
- Use NVEC to explore an AMR design (see case study)

Fusion

- On-going engagement with STEP programme.
- Identification of benefits of NVEC for STEP

Summary

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- Aims of NVEC
  - Lower costs across the whole nuclear lifecycle (incl regulation)
  - Support increased innovation and facilitate cultural change
  - Create open framework architecture for collaboration
- Phase II case studies:
  - AGR graphite assessment (EDF)
  - System level modelling (NNL)
  - Geometry management (Rolls-Royce)
  - Component digital twin / IoT (NAMRC)
  - Decommissioning (Wood)
- Links established with other NIP areas, SMR, AMR, Fusion

Acknowledgements

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