Integrated Nuclear Digital Environment
Safety Moment

Why worry about holding the handrail when using stairs?

In the UK there is a fall on stairs every 90 seconds.

During 2015 there were 787 deaths in England and Wales caused by a fall on and from steps or stairs.

Every year there are over 300,000 visits to Accident and Emergency units following falls on stairs.

According to a OnePoll survey in 2017, 33% of people said that they had fallen up or down the stairs in the last 12 months.

Holding the handrail makes sense!
## Agenda
John Stairmand (Wood)

<table>
<thead>
<tr>
<th>Time</th>
<th>Theme</th>
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<tbody>
<tr>
<td>11:00 – 12:00</td>
<td>Presentation</td>
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<tr>
<td>12:00 – 13:30</td>
<td>Lunch + Demos</td>
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<tr>
<td>13:30 – 14:15</td>
<td>Discussion in 4 groups</td>
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<tr>
<td>14:15 – 14:45</td>
<td>Summary statements from discussion and general comments from delegates</td>
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<td>14:45 – 15:00</td>
<td>Summary and meeting close</td>
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Overview

• **Introduction**, John Stairmand (Wood)
• **Vision and concept**, Ahmed Aslam (Wood) / Mark Bankhead (NNL)
• **Benefits I**, Chris Jackson (Rolls-Royce)
• **Benefits II**, Ionel Nistor (EDF Energy)
• **Opportunities**, Bruno Merk (NNL, University of Liverpool)
• **Progress and Development**, David Bowman (Virtual Engineering Centre)
Vision and concept
Ahmed Aslam (Wood) & Mark Bankhead (NNL)
Vision and Design

A supported environment set that:

• Enables end users to make informed decisions based on high fidelity information
• Encompasses the whole nuclear lifecycle
• Integrates data and knowledge management
• Allows running complex analysis by broader specialists
• Allows for seamless integration and plug & play
• Enables collaboration within the nuclear sector and internationally
• Promotes the cultural change to enhance innovation
• Adds benefit across the energy sector
Integrated Nuclear Digital Environment – Concept

**NEW BUILD:**
20% cost savings target

**DIGITAL TWIN:**
100s Millions cost savings

**DECOMMISSIONING:**
30% cost savings target
Time / risk reduction

Roadmap

- Working procedures defined
- Stakeholder organisations supporting culture change
- Continued development
- Commercial model defined
- Requirements discussed with stakeholders

Development Versions:
- Release 0.1: Successful proof of concept
- Release 1.0: Agreed architecture design
- Release 1.1: Initial data management & code coupling
- Release 1.2 .. 1.9: Continued code integration
- Release 2.0: Enhanced data management
- Release 2.0: System enhancement
- Release 2.0: Continued development

- Continuous engagement to ensure feedback from users
- New codes developed in parallel
- Parallel BEIS Programmes

Value chain

2018 2021 2030
Value Roadmap

Cost reduction benefits to UK plc build, operation, decommissioning

- 2018
  - Requirements input
  - Commercial model defined
  - Working procedures defined
  - Stakeholders support culture change

- 2030
  - Users begin using tools to share information
  - Integrated industry standard codes
  - Critical adoption point – digital framework available to wider community
  - Framework becomes industry standard

Programme Milestones
Design Considerations

- **Architecture**
  - Collaborative environment
  - Flexible meshing
  - Code coupling
  - Switchable modules
  - Uncertainty analysis / propagation
  - Integration of codes

- **Quality Assurance**
  - Quality management
  - Framework and user QA

- **Integration with other programmes**

- **Modelling**

- **Infrastructure**

- **Safety and Security**
  - Validation and verification
  - Code and Data control

- **User Experience**
  - Information Management
  - User Interface
  - Visualisation
  - GUI
  - Accessibility

- **Audit trails**

- **Plant data (BIM, OPEX...)**

- **Data sharing and handling**
  - Safety systems
  - Fuel behaviour
  - Cooling
  - Structural mechanics
  - Reactor core
  - Processes
  - International considerations
  - IP protection
Stakeholders

- Collaboration is key – “UK Plc”.
- Every stakeholder has their own contributions and benefits.
- Interaction with stakeholders to create new ideas.
Key Benefits

• Reduced HMG investment requirements through sector efficiencies
• Reduced cost
• Entire value chain modelling and simulation – digital twin
• Flexible analysis paths - better verification
• Reduced manual intervention – error reduction
• Plug ‘n’ play codes – increased flexibility and design of new tools
• Knowledge capture & management – a single available source for reference
• Easy to use for current and potential sector stakeholders
• Creating belief in Nuclear, creating confidence
Benefits
Chris Jackson (Rolls-Royce)
Why are Rolls-Royce interested?

- Small ModularReactors
- Operational Services
- Submarines
Short Term Benefits

• More accurate predictions → safer plant
  • Integrations support analyses of a greater range of physics at one time
  • Increases the accuracy and confidence in results

• More robust designs → lower through-life costs
  • Automation will better enable design studies and optimisations
  • 1000s of points run automatically to help us understand the overall design space (not just the peak performance)

• Shorter lead times → faster to market
  • Will remove some of the initial slog in setting up analyses
  • Still allow expert users to understand the detail they need
Long Term Benefits

• Rolls-Royce Supply Chain Engagement
  • Many hurdles to overcome to gather outside support (particularly from start-ups/SMEs)
  • A common platform will aid communication and knowledge sharing

• Knowledge Management
  • Expertise currently held by individuals
  • Common platform will help to store this information and teach the next generation

• Learn from Best Practice
  • Different projects often hit the same issues
  • Gives a clear route to implementing lessons
Benefits
Ionel Nistor (EDF-Energy)
AGR Pod Boiler Spine Digital Twin (EDF Energy)

**Complex Geometry**
- 10m structure
- >700 pipes

**Multi-scale**
e.g. manufacturing imperfections, turbulent boundary layer flow around tubes

**Multi-Physics**
- Primary Gas flow
- Secondary steam flow
- Heat transfer with structures

**Multi-tools**
- Legacy engineering tool (1D)
- Advanced CFD tool
- Thermal tool

**Different parameters of interest**
- Temperature at welds (creep, stress corrosion cracking)
- Impact of carbon deposition
- Impact of tube blanking
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Digital Twin for Components

• Expected benefits from the framework
  • Numerical tools to access to parameters for which one can have experimental data in operation
  • Uncertainty quantification
  • Support to safety cases for life extension
  • Decision tools to avoid replacements when not necessary (justified by reliable prediction)
  • Capitalization of the experimental and numerical data to be valorized later

• What is missing / what can be improved
  • Increasing speed to development with an integrated platform rather than ad-hoc approach
  • All the physics present in the numerical model
  • Quality Assurance
Hinkley Point C 3D / 4D Models

Bespoke MEH (Mechanical, Electrical, HVAC) 4D modelling

3D modelling for rebars (design, identification of clash, procurement)
Digital Twin for design, O&M and decommissioning

• Expected benefits from the framework
  • Integrated digital environment allowing for early identification of clash, reduction of the risk in construction/deconstruction
  • Mastering the cost
  • Knowledge management / knowledge transfer tool
  • Easier and faster preparation of the outages
  • Common tools for the Responsible Designer / Licensee / Contractors
  • Communication

• What is missing / what can be improved
  • Extension from CAD / BIM to numerical models
  • Evolving the existing tools/models from as designed to as built and as operated
Opportunities
Bruno Merk (NNL / University of Liverpool)
Opportunities for Development

Elements

Development of Framework
- Integrating existing codes
- System Integrator
- Cutting edge Multi-scale + multi-physics
- Uncertainty Propagation
- HPC deployment

Information Management
- Quality Assurance
- Data security
- Knowledge capture processes
- Standardising outputs
- Data analytics
- Knowledge preservation and education

Software Development
- Operational use defined
- Networks and data transfer
- Open and flexible commercial model
- Code development
- Standards (Security, Quality, Licensing)

Context

R&D Landscape
- Next generation nuclear design
- Validation data and processes
- Making best use of stakeholder expertise
- Aligning current developments with INDE
- Defining requests for development

Culture Change
- Data sharing across supply chain driving down costs
- Encourage innovation from Universities and SME’s
- Open and flexible model
- Integrative working environment
The System Integrator Role

- Enable end users to make informed decisions based on high fidelity information
- Maximising benefits:
  - Learning and linking of individual programmes
  - Managing expectations vs. possible delivery – avoiding duplication
- Common platform for development and knowledge exchange
  - Improving ROI for UK plc
Opportunities for Development

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Progress and Development
David Bowman (Virtual Engineering Centre)
Plant Architecture – System, Sub-System
Framework Architecture

- Uncertainty Quantification
- GUI
  - User Access
  - Configure
  - Start federation
- Analysis Config
- Federation Configs
- Results
- Database
- Link
- Visualisation
- Design Parameter and Metadata
- Start Federation
- Federation Configs Results
- Start Federation
- Analysis-Specific Sim Manager
- RTI
- Code 1
- Code ...
- Code N
- Recorder
- Visuals?

Analysis Specific Federation (Many federations in parallel if needed)
## Arrangements for Lunch / Demos

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<tr>
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<th>AGR demo</th>
<th>PWR demo</th>
<th>Lunch</th>
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<td>12:00 – 12:20</td>
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<td>4</td>
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<tr>
<td>13:20 – 13:30</td>
<td>All at lunch</td>
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### Group lead
- **Group 1** – Chris Jackson
- **Group 2** – Mark Bankhead
- **Group 3** – Ahmed Aslam
- **Group 4** – Lynn Dwyer

### Demonstrator
- **AGR demo**
  - Konstantin Vikhorev
  - Albrecht Kyrieleis
- **PWR demo**
  - Dzianis Litskevich
  - Bruno Merk
Give Your Feedback

WiFi Access:
- Select “WiFi Guest” from available hotspots
- Open web browser to access the Cloud WiFi page
- Register or log-on to The Cloud WiFi

Survey:
- Go to: www.digitalnucleardesign.com/events/
- Click the survey link
- Or use the QR code:
## Outline of the Afternoon – Planning for the Future

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Afternoon Discussion Points

• Benefits
  How do you see your organisation benefitting from the project?

• Capabilities
  How do you think your organisation can contribute to the project?

• What future studies and use-cases would you be interested in?
• Who else do you think should be involved?
• Are there any considerations which you think have been missed in developing the project so far.
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https://www.digitalnucleardesign.com/