A Simulation Framework: INDE

Sharing Knowledge | Tackling Challenges | Connecting People

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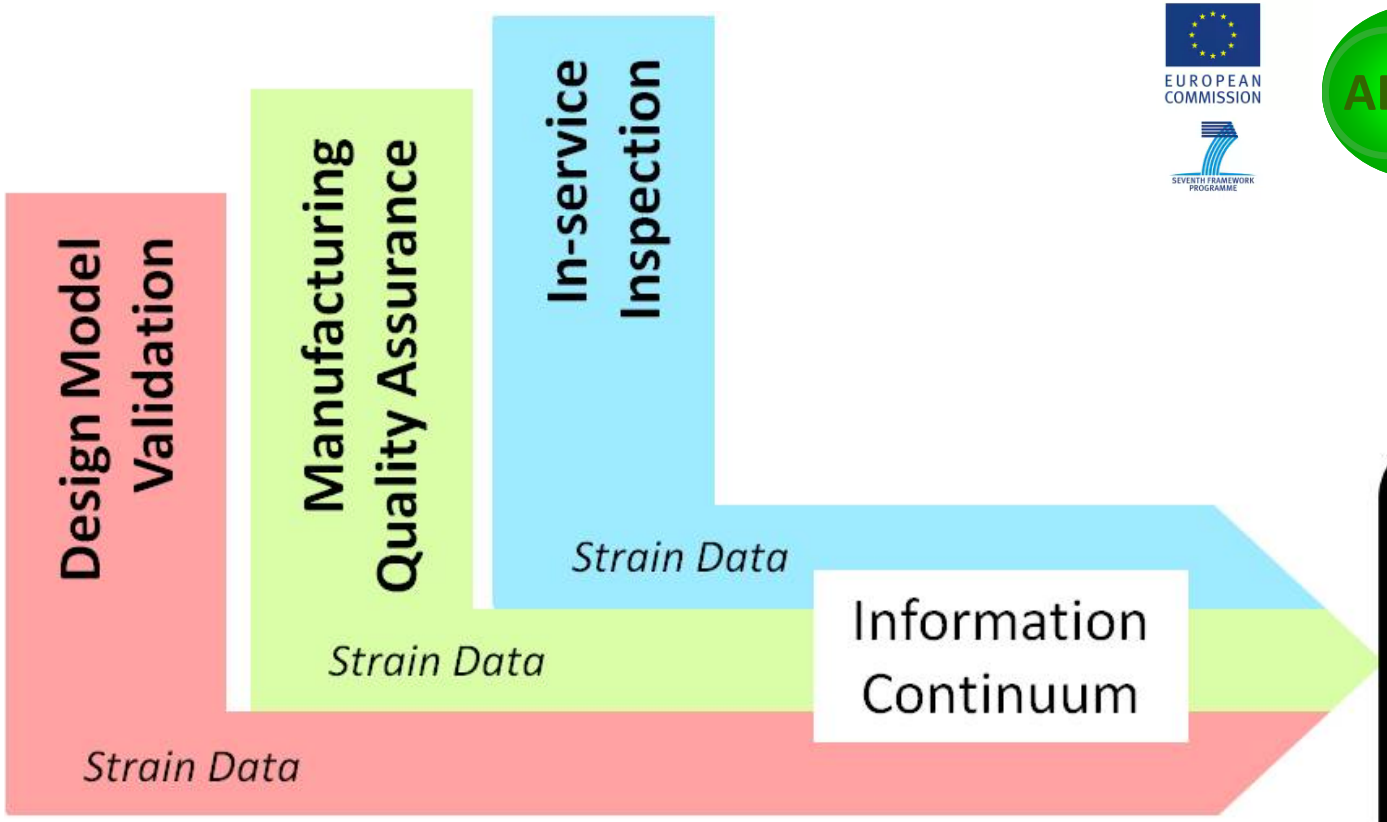
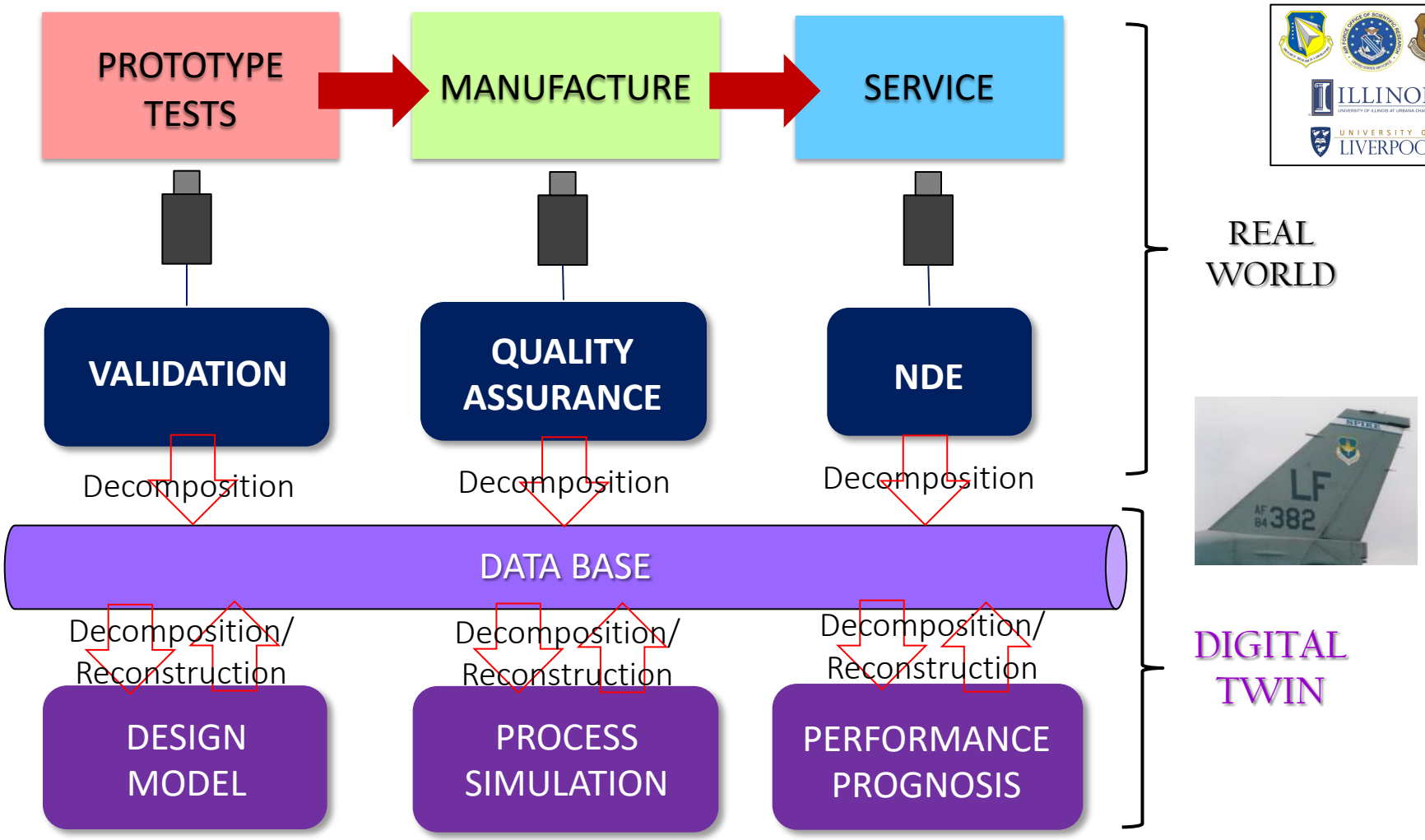
Information continuum



Patterson E.A., Feligiotti, M. & Hack, E., 2013, On the integration of validation, quality assurance and non-destructive evaluation, *J. Strain Analysis*, 48(1):48-59.

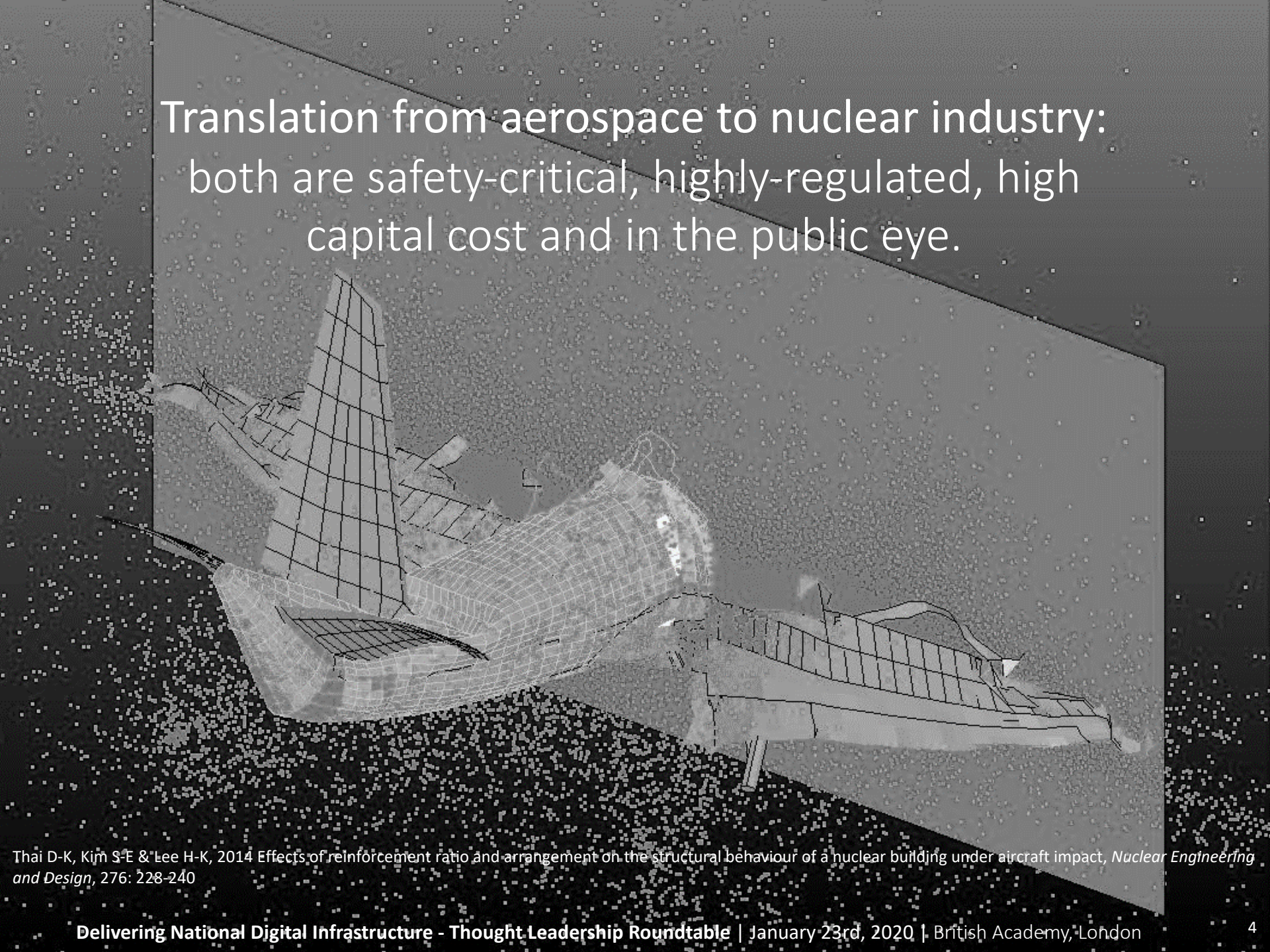
Digital string



Glaessgen EH & Stargel DS, 2012, The digital twin paradigm for future NASA and US Air Force vehicles, *Proc 53rd AIAA/ASME/ASCE/AHS/ASC Structures, Struct. Dynamics & Maters Conf.*, AIAA paper 2012-2018, NF1676L-13293.

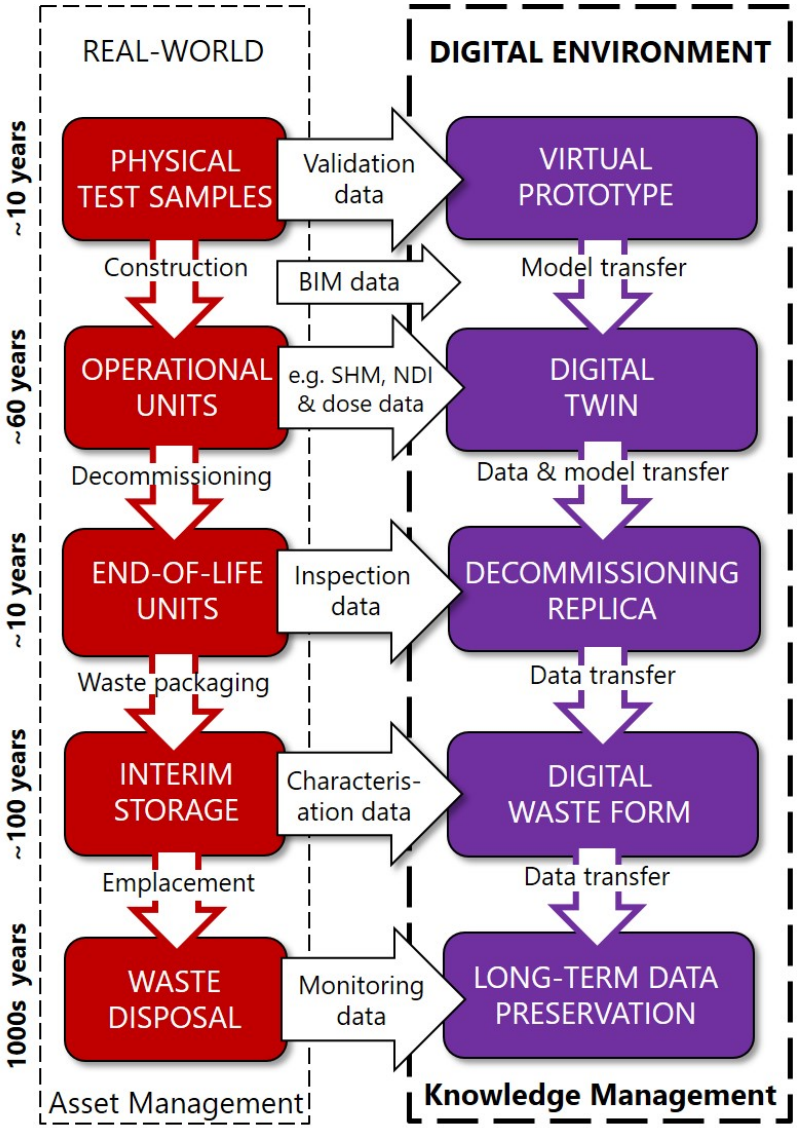
Translation from aerospace to nuclear industry:

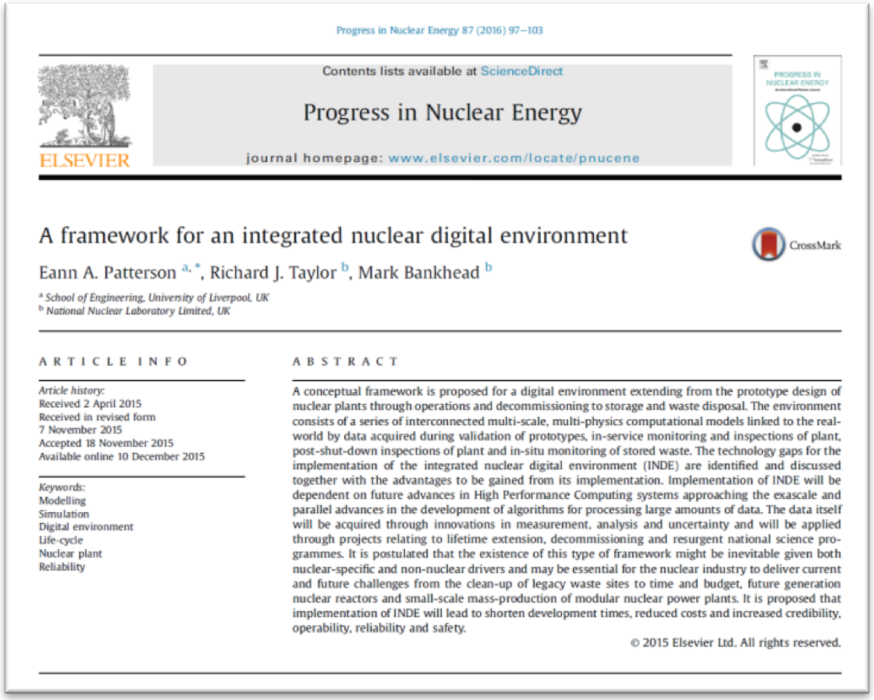
both are safety-critical, highly-regulated, high capital cost and in the public eye.



Thai D-K, Kim S-E & Lee H-K, 2014 Effects of reinforcement ratio and arrangement on the structural behaviour of a nuclear building under aircraft impact, *Nuclear Engineering and Design*, 276: 228-240

Integrated Nuclear Digital Environment





Progress in Nuclear Energy 87 (2016) 97–103

Contents lists available at ScienceDirect

Progress in Nuclear Energy

journal homepage: www.elsevier.com/locate/pnucene

ELSEVIER

A framework for an integrated nuclear digital environment

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ARTICLE INFO

Article history:
Received 2 April 2015
Received in revised form
7 November 2015
Accepted 18 November 2015
Available online 10 December 2015

Keywords:
Modelling
Simulation
Digital environment
Life-cycle
Nuclear plant
Reliability

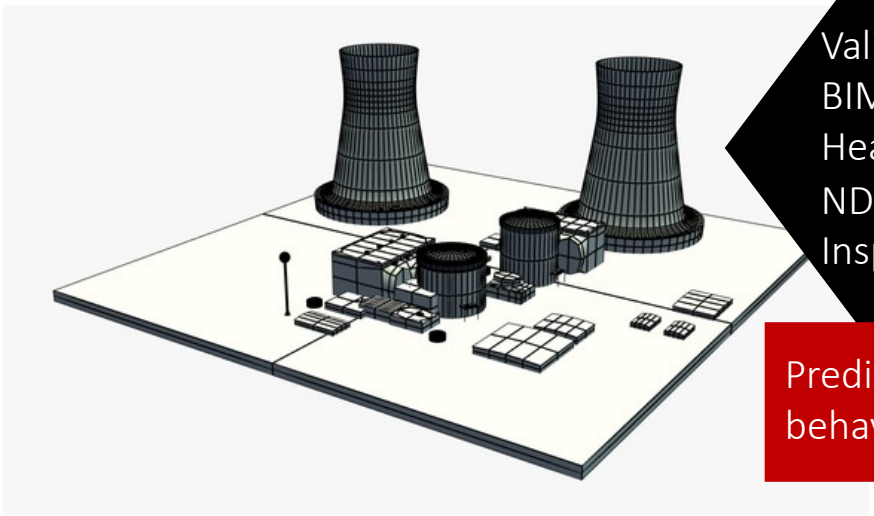
ABSTRACT

A conceptual framework is proposed for a digital environment extending from the prototype design of nuclear plants through operations and decommissioning to storage and waste disposal. The environment consists of a series of interconnected multi-scale, multi-physics computational models linked to the real-world by data acquired during validation of prototypes, in-service monitoring and inspections of plant, post-shut-down inspections of plant and in-situ monitoring of stored waste. The technology gaps for the implementation of the integrated nuclear digital environment (INDE) are identified and discussed together with the advantages to be gained from its implementation. Implementation of INDE will be dependent on future advances in High Performance Computing systems approaching the exascale and parallel advances in the development of algorithms for processing large amounts of data. The data itself will be acquired through innovations in measurement, analysis and uncertainty and will be applied through projects relating to lifetime extension, decommissioning and resurgent national science programmes. It is postulated that the existence of this type of framework might be inevitable given both nuclear-specific and non-nuclear drivers and may be essential for the nuclear industry to deliver current and future challenges from the clean-up of legacy waste sites to time and budget, future generation nuclear reactors and small-scale mass-production of modular nuclear power plants. It is proposed that implementation of INDE will lead to shorten development times, reduced costs and increased credibility, operability, reliability and safety.

Patterson EA, Taylor RJ & Bankhead M, A framework for an integrated nuclear digital environment, *Progress in Nuclear Energy*, 87:97-103, 2016

Digital Environment

- **‘a series of interconnected, multi-scale, multi-physics computational models’**

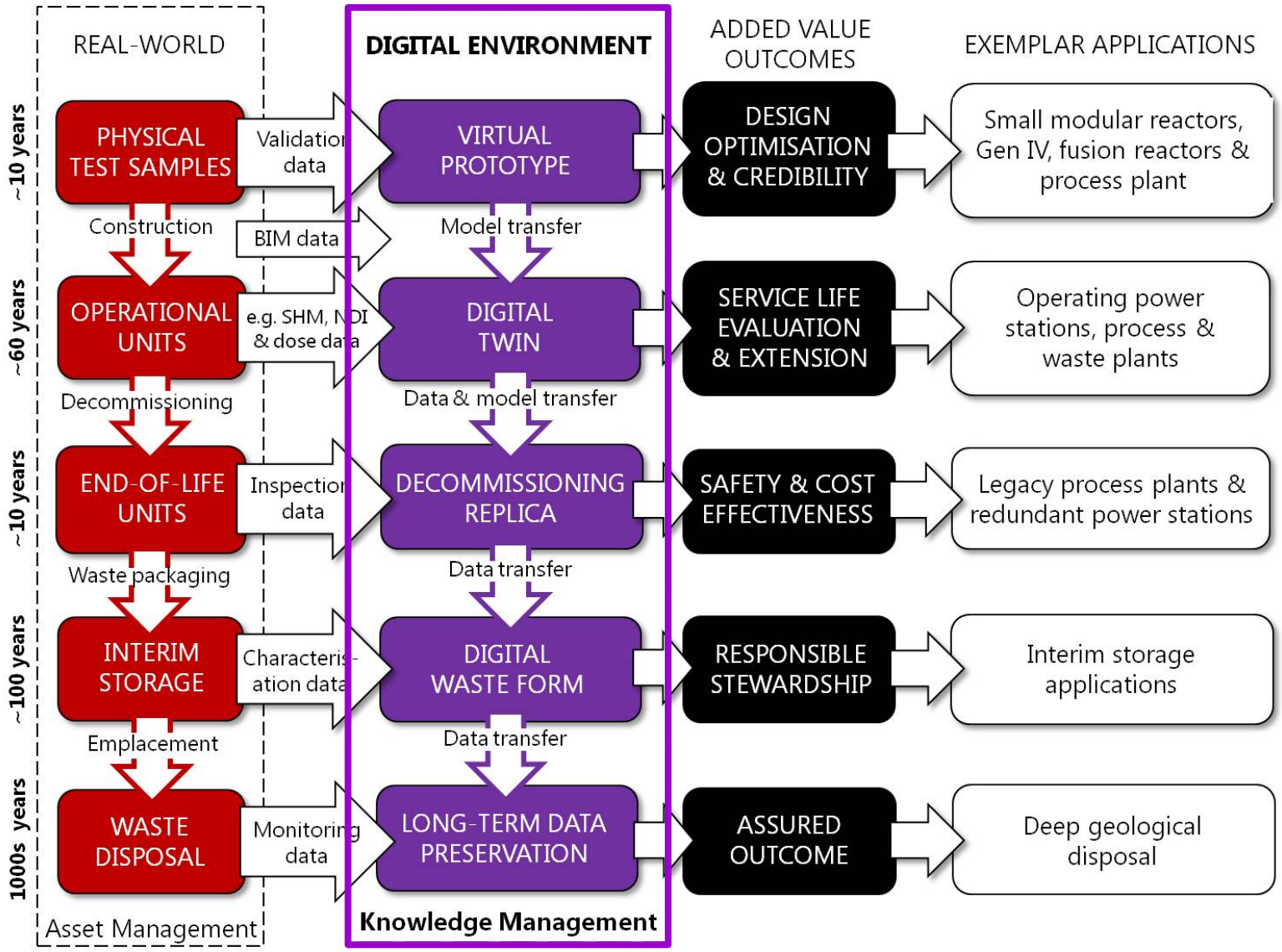


Validation data
BIM data
Health monitoring data
NDI data
Inspection data

Predictive performance / behaviour / outcomes

- **Implementation dependent on closing technology gaps in**
  - HPC developments in exascale
  - Innovation in measurement technologies
  - Development of data & model credibility, connectivity & integration

Integrated Nuclear Digital Environment



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Tensions

- **Access/Availability**
- **Sustainability/Ownership**
- **Adoption/Enforcement**
- **Public/Commercial**

Tensions

- **Access/Availability**
  - *desirability of making INDE available to a wide range of stakeholders* ***vs.*** *controlling access to protect national, commercial and IP interests*
- **Sustainability/Ownership**
  - *Sustaining the availability & relevance of INDE (e.g. open source framework)* ***vs.*** *recognising that someone has to pay for it and may want to own it*
- **Adoption/Enforcement**
  - *voluntary adoption of INDE by supply-chain and plant life-cycle is probably required to yield its anticipated benefits, in terms of costs and reliability* ***vs.*** *its disruptive nature is likely to inhibit this process and enforcement is likely to lead to minimum compliance rather than widespread adoption*
- **Public/Commercial**
  - a *digital twin of an individual plant will be a commercial asset established by the plant vendor and transferred to the operator with the physical plant* ***vs.*** *INDE framework will be a national asset that defines the anatomy / physiology of all digital twins that allowing them to be accessed & shared by all*