Exascale computing for research and the implications of quantum computing, AI and Net Zero

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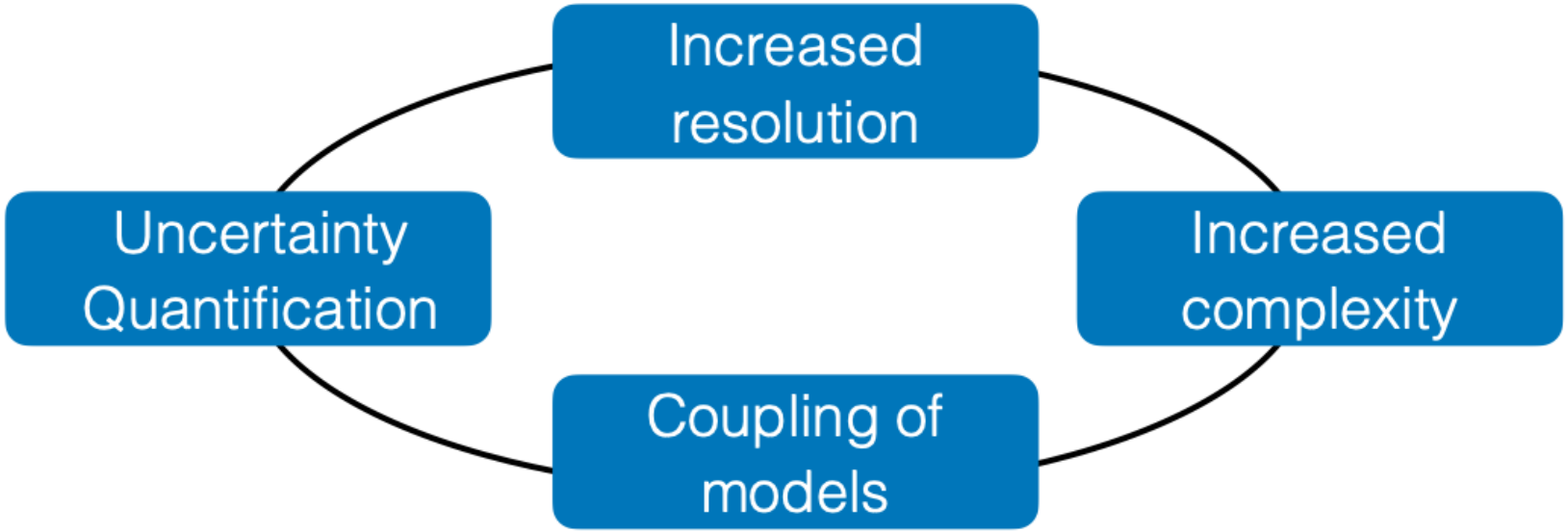
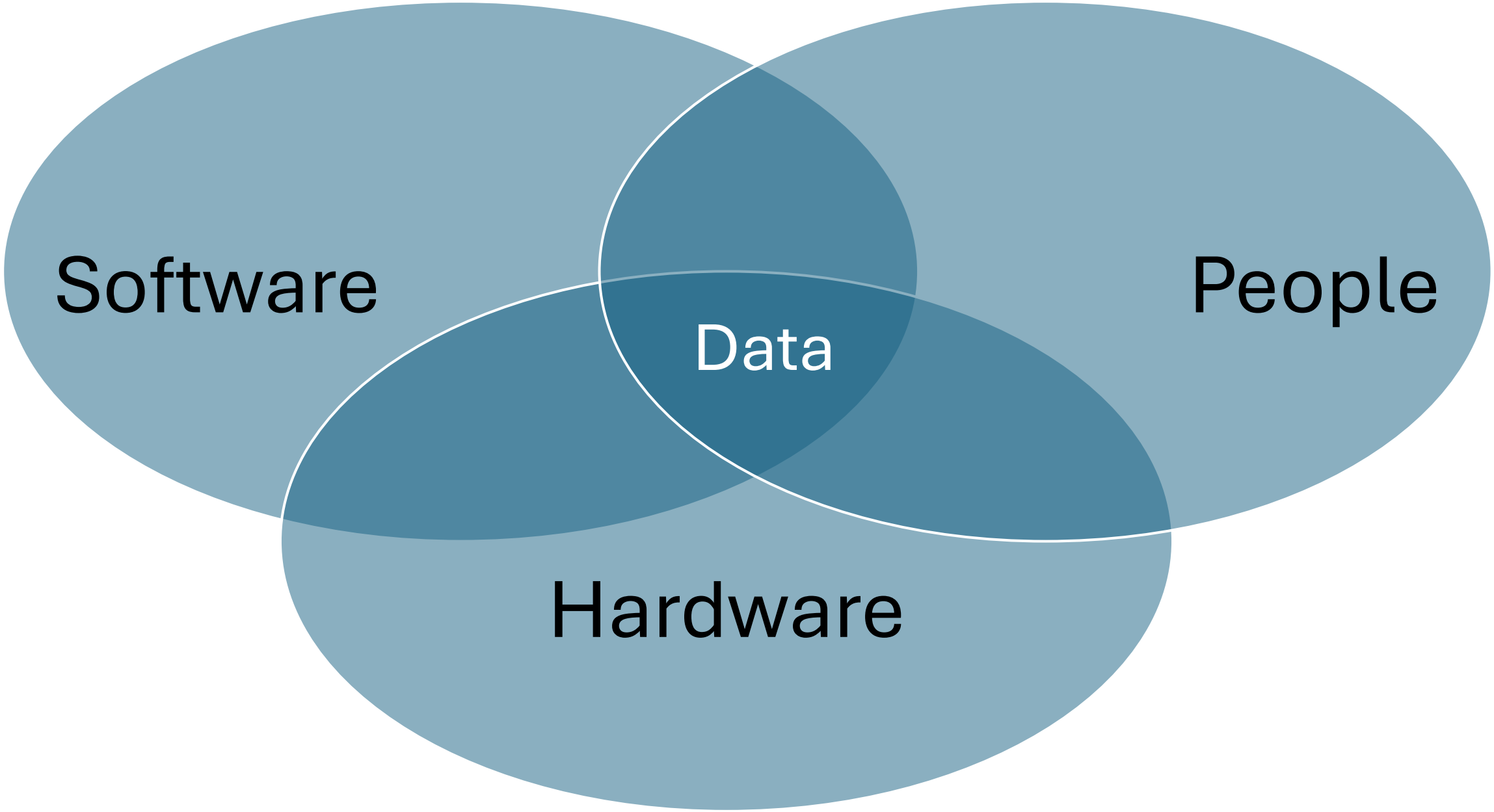
Large-scale computing for research

- Large-scale computers are research instruments
- **Challenge:** research involves constant process of evolving and refining tools



- An outcome-driven, co-design approach to defining computing services delivers a balanced ecosystem that can evolve with the research

Components of a productive computing ecosystem



Large-scale computing use-cases

- Delivery of research and innovation outcomes for industry, academia and government
- Examples:
  - In silico design of Net Zero aircraft & nuclear fusion power plants
  - Personalised medicine
  - Fundamental science discovery
  - Real-time AI models and simulations to support scenario testing
  - Robust policy-making via multi-source data assimilation (including simulations, edge, etc)
  - Generation of simulation data to train AI models and mitigate risks of training data poisoning

Complementary Technologies

Artificial Intelligence	• Exascale benefits Narrow, Deep and General AI • Significant national security benefits and threats
Quantum Computing	• Error correction for “quantum utility” • Co-location of systems may be required
Secure Computing	• Software-defined systems allow resource-sharing • Levels of required security determined by users
Urgent Computing	• Real-time calculations for extreme weather events, crises, pandemics, etc.

Threats

- Large-scale computing allows increased frequency and complexity of criminal and state-sponsored malicious activity
- Examples:
  - Cybersecurity threats
  - Deepfakes and social engineering attacks for cyber crime and espionage
  - Large Language Model poisoning
  - National security and terrorist threats
- The UK needs the computing capability to counter these threats

Co-design of computing services

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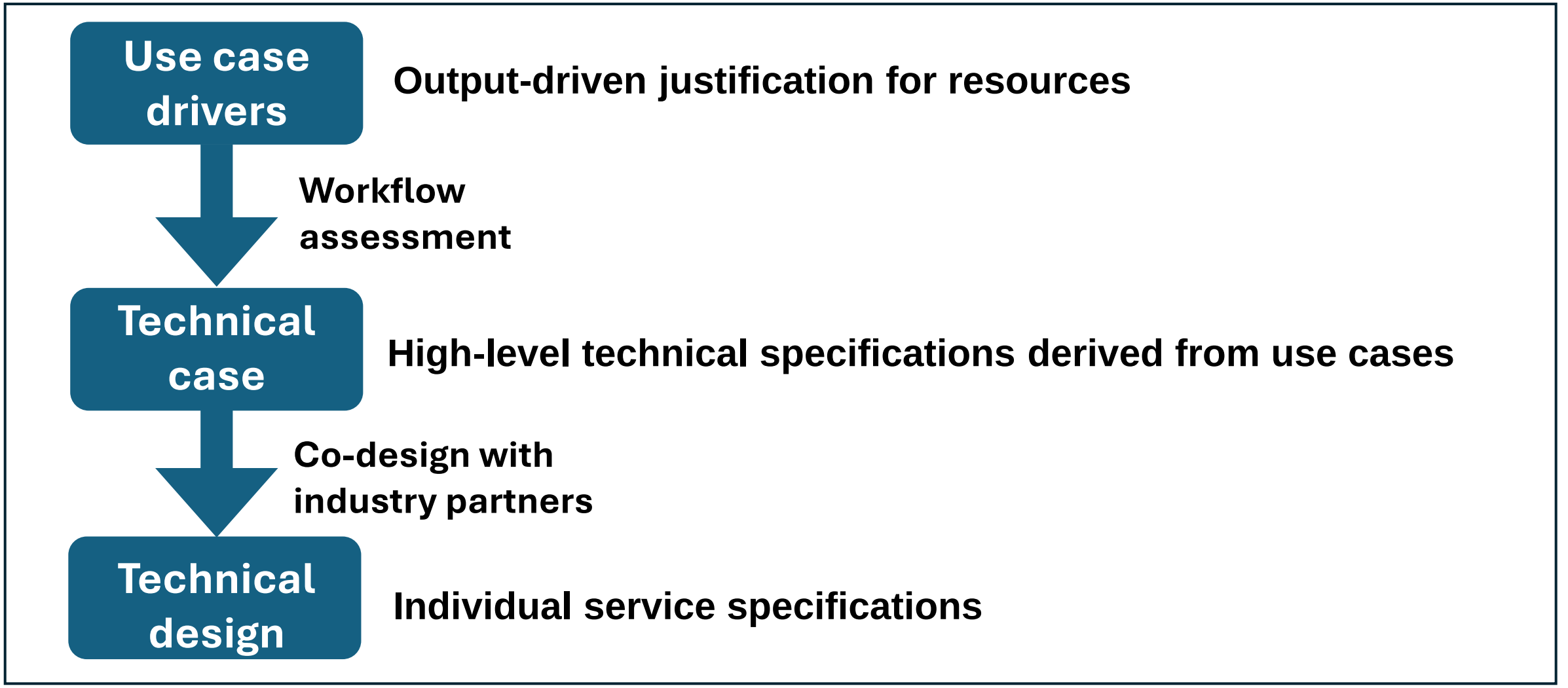

- Benefits include: increased RoI, increased productivity, minimize carbon footprint
- UK co-design successes include: DiRAC (e.g. Tursa at EPCC), IRIS, JASMIN, GridPP

The way forward

- Invest in output-defined computing ecosystem
  - Engage potential stakeholders across academia, industry, public sector and government

- Use co-design to continue to “compute above our flops”
  - Skilled UK community in place
  - ExCALIBUR programme supported UK software progress - more needed
  - World-leading UK SMEs in software-defined systems
  - Extensive UK-based training programmes

- Continue to collaborate internationally
  - UK must continue to be a “maker” not just a “taker” in large-scale computing