The history of High Performance Computing from centralization to resource distribution

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Forum TERATEC 2023

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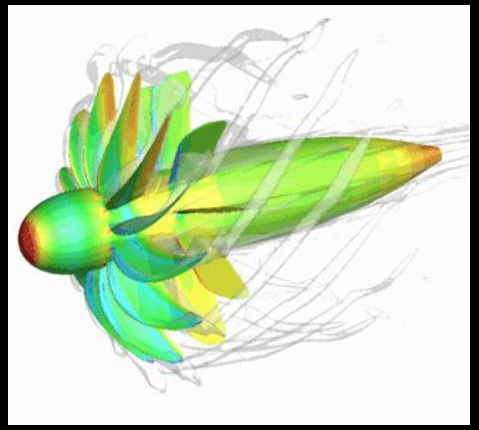
Functional design at Airbus

Functional Design is covering a large number of engineering disciplines/workstream supporting the Architecture design lifecycle

- **Aircraft Architecture & Integration**
  - Architecture, Requirements, Certification…
- **Power plant & Acoustic**
  - Propulsion system, Engine performance, Acoustic platform…
- **Flight physics**
  - Flight simulation, Aerodynamics, Weights…
- **Structure**
  - Sizing, Fatigue and damage, Static strength…
- **Systems**
  - Flight control system, System Software development, Avionics…
- **Flight & integration tests**
  - Flight tests, Ground tests
- **Scientific Computing**
  - FuD Backbone, High Performance Computing; Scientific Computing COTS (Commercial off the shelf) Software



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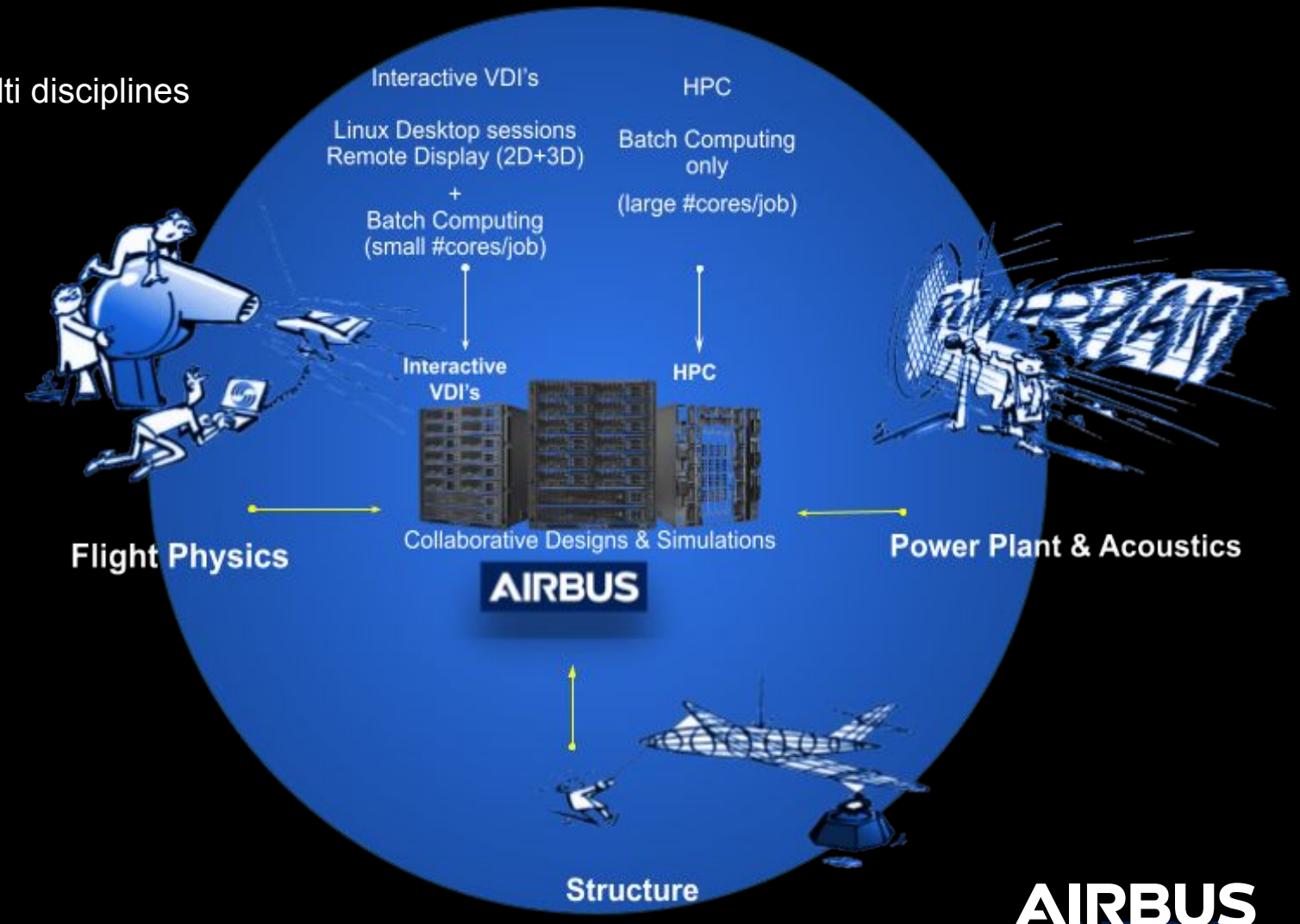
Scientific Computing at Airbus

Use Of Compute power within Airbus

- Design justification/certification
- Product Performance - per discipline and multi disciplines
- Design Exploration, R&D and Call of tender

Engineering domain using HPC

- Flight Physics:
  - Aerodynamic design
  - Aerodynamic data
- Structure:
  - Optimisation
  - Composite
  - Virtual testing
  - Global Finite Element Method
- Power plant & Acoustics
  - Noise of turbomachinery
  - CROR (Contra Rotative Open Rotor)
  - Airframe
  - Cabin & cockpit noise



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HPC from 1990 to 2005

Shrinking Processor (CPUs) to speedup (Moore's Law)
Migration from CISC (Complex Instruction Set Computing) to RISC (Reduced Instruction Set Computing) architectures
Consolidation of various Operation Systems to mainly UNIX (HP-UX and Sun Solaris) and Window on PCs
Arrival of "Supercomputing" / HPC-Systems Cray (Vector Machine) or HP Superdome or SGI Origin (Multi Processor systems / ccNUMA)
Adaptation of the Data Center to the specificity of the machines

Resources

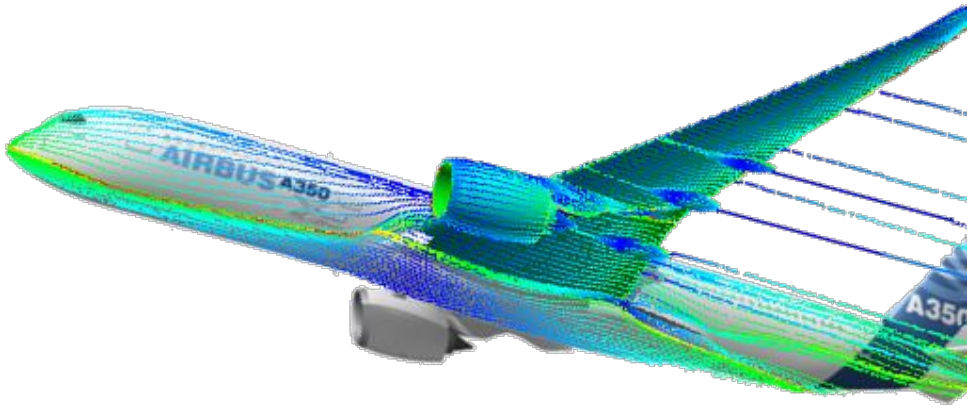
- Manage CPU, Memory, Storage disk
- Schedule job using NQS (Sterling software), NQE (CRAY), LSF
- Optimize the load for one machine

Codes

- Specific optimization to a dedicated architecture and hardware
- Limited memory
- Data transfer from low performance storage to HPC machine

Problem

- How to optimize the load of the machine/cluster
- Per job
  - Job runtime
  - Parallelism
  - Memory size
  - Data size



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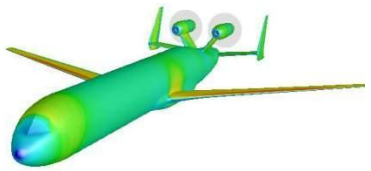
Main HPC machines in Toulouse: 1990-2005



Cray X-MP

Cray Y-MP

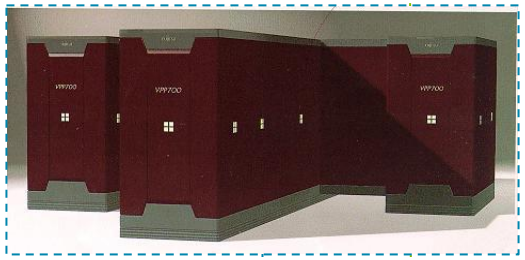
Cray
J916>J924>J932

Cray SV1

IBM P690

CDC
Cyber 2000

SGI Origin 2000



Fujitsu VPP700E

1990

2005

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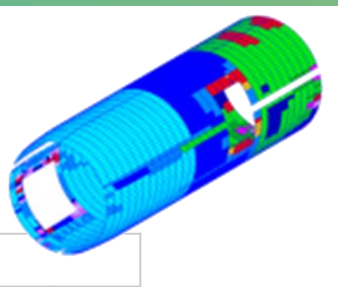
Cray: 24h job planning



CPU	Hour																							
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HPC from 2005 to 2017

Resources

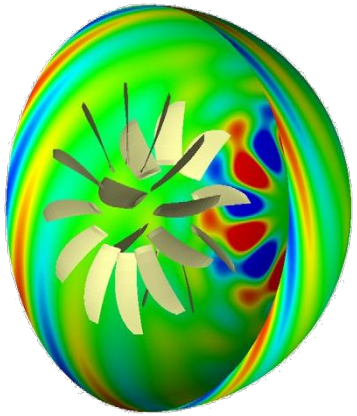
- Manage CPU, Memory, Storage disk and licenses
- Schedule job and workflow using LSF
- Manage data transfer using DataManager (LSF)
- Meta scheduler

Codes

- Specific optimization to a dedicated architecture and hardware
- Huge amount of distributed memory
- Data transfer from low performance storage to HPC machine around Europe and India

Problem

- How to optimize workflow around Europe and India
- Per job
  - Job runtime
  - Parallelism
  - Memory size
  - Data size
  - License
- Per workflow
  - Data transfer
  - Dependencies



Data Center

2006 strategy:
HPC will not longer be hosted in our Data Centers

- 2007: HPC hosted in Corbeil-Essonnes
- 2008: HPC hosted in Marignane
- 2009: HPC hosted in Toulouse and Hamburg

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HPC Toulouse - 2009

POD: Performance Optimized Datacenter

Full service contract including:

- Hardware: compute nodes, switches, storage …
- Maintenance
- Hosting: PODs, chillers, generators, electricity …
- Operation & support

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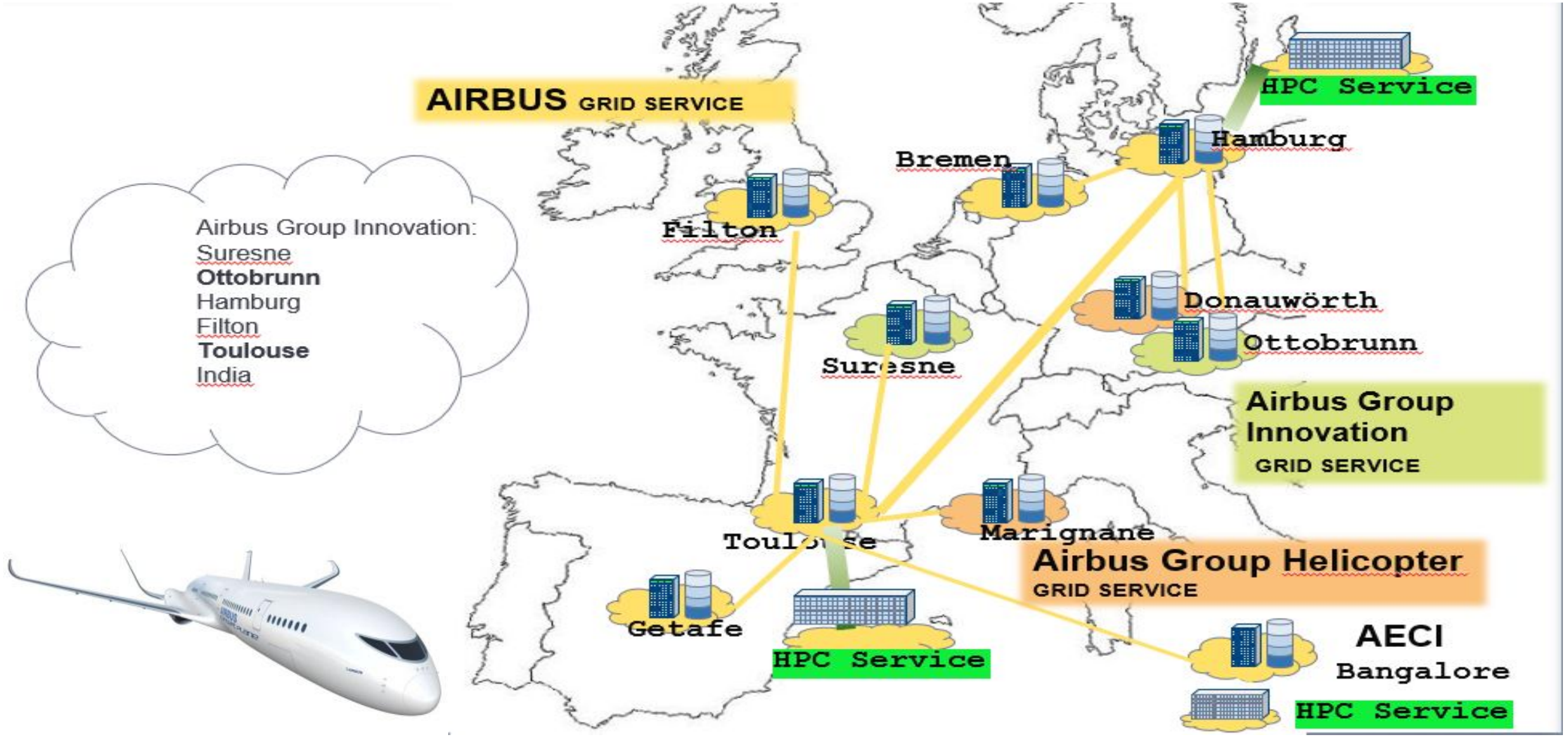
Scientific Computing Centers / HPC - 2009



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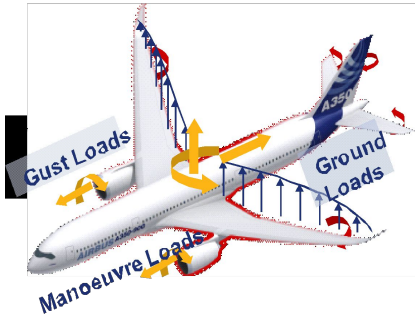
Scientific Computing Centers / HPC - 2017



IBM spectrum LSF

Meta-scheduler using fairshare to manage:

- Computing cluster
- Workflow
- Job
- Core/CPU
- Memory
- Data
- Data transfer
- License

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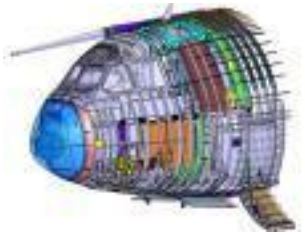
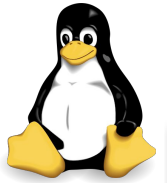
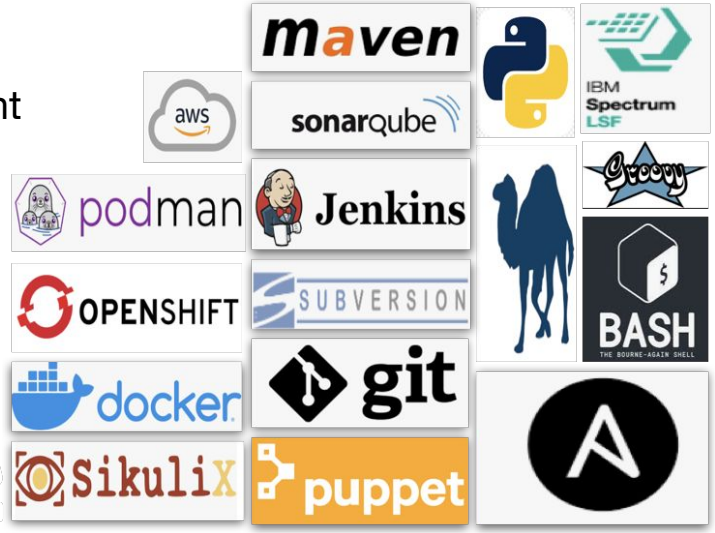
Scientific Computing Centers / HPC 2023



Technical Stack

- Configuration management
- Source Control management
- DevOps tools
- Container tools
- Cloud service





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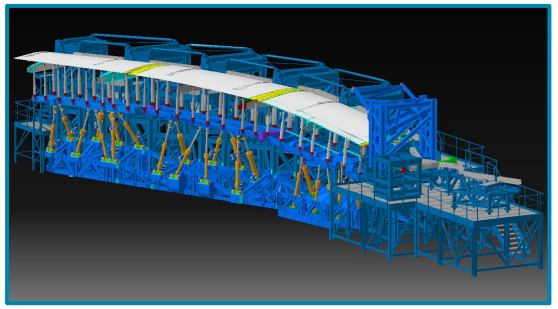
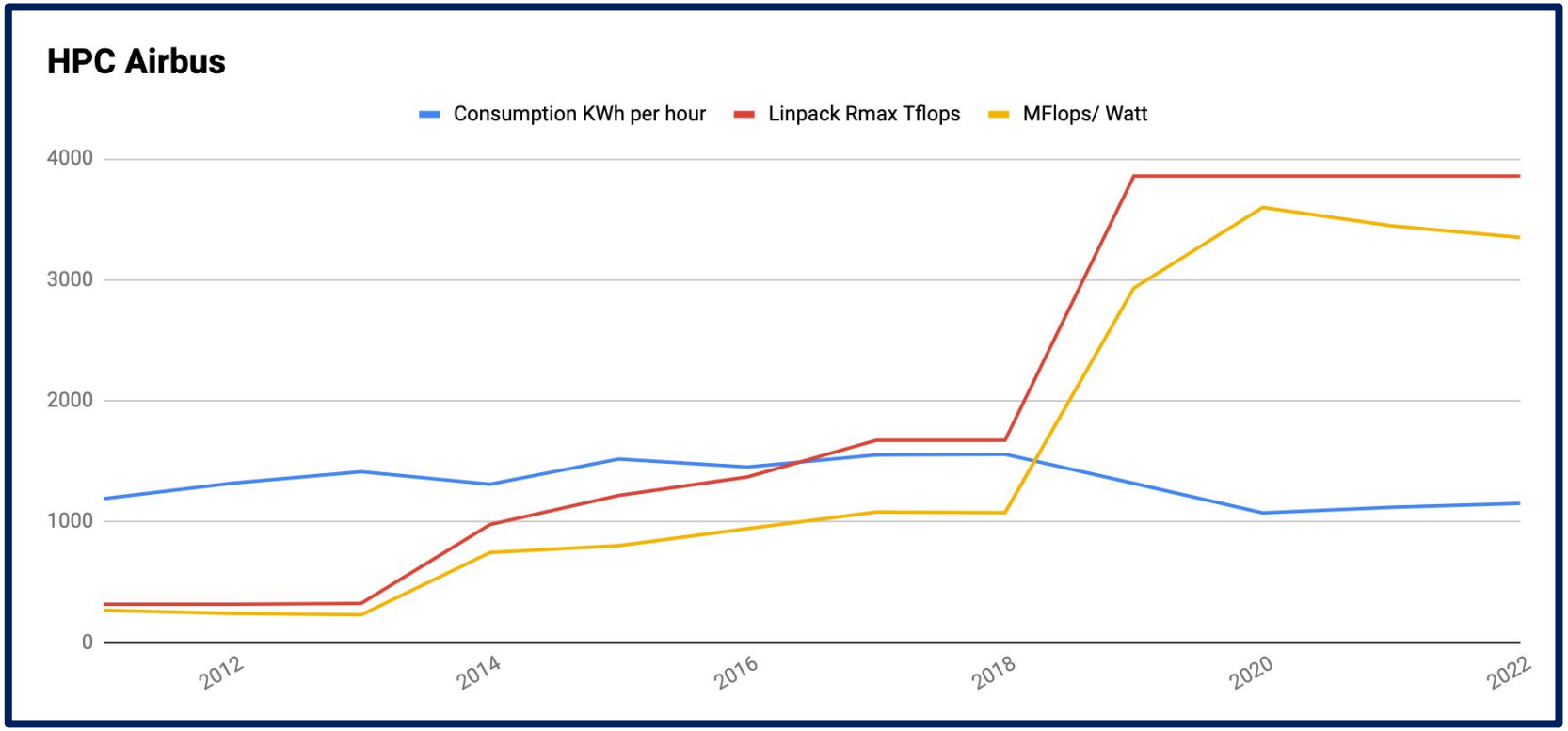
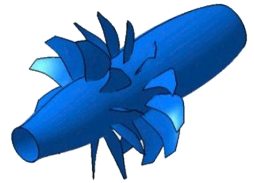
HPC & Sustainability

IT sustainability project

- HPC LCA 2018 & 2021
- Initiatives to reduce the energy consumption
- Handbook of sustainable design GR491
  - 8 families
  - 61 recommendations
  - 516 criteria







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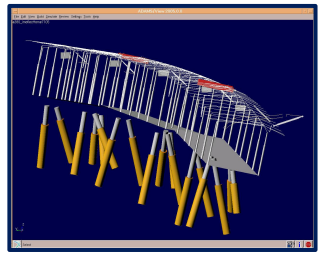
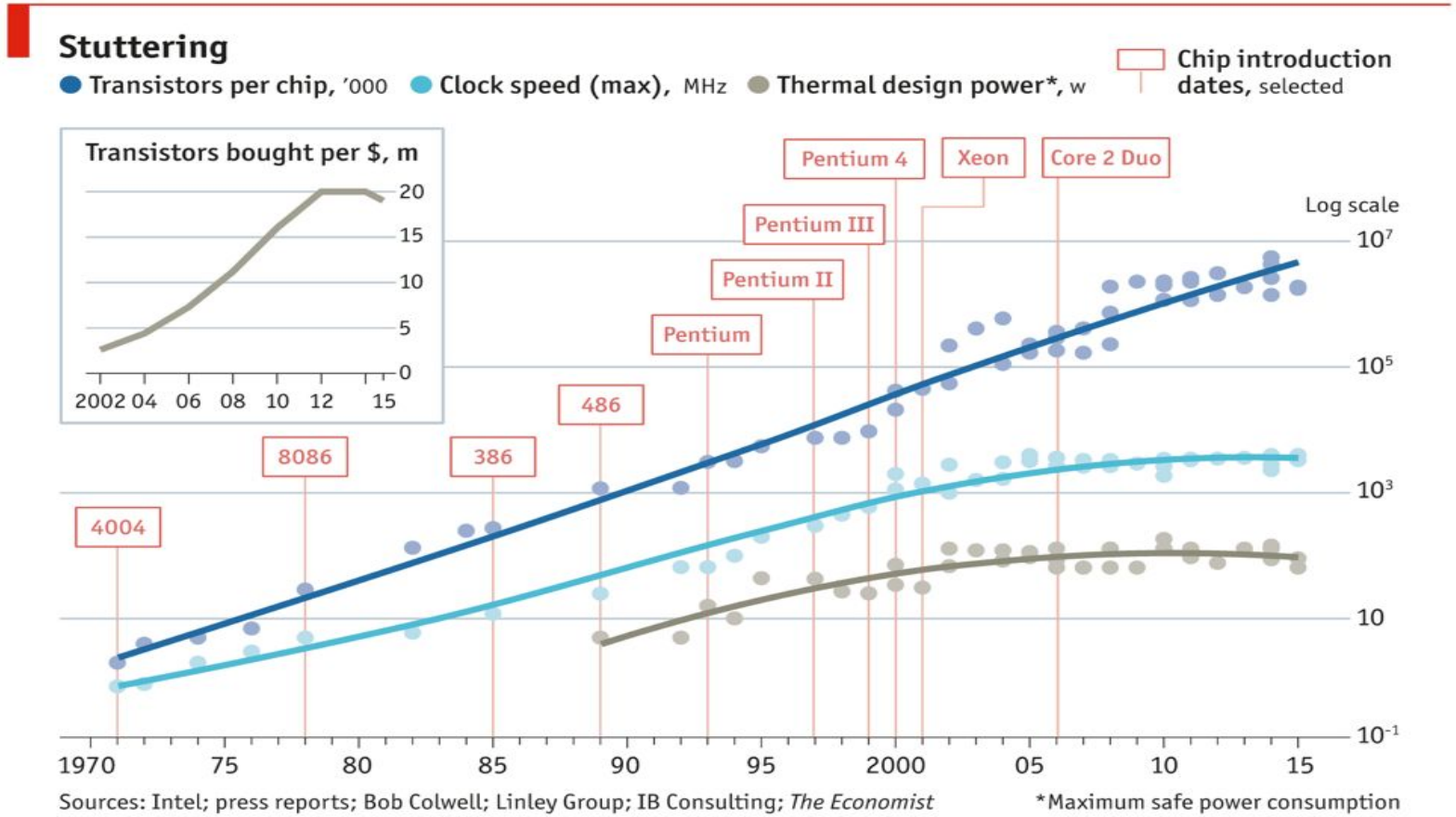
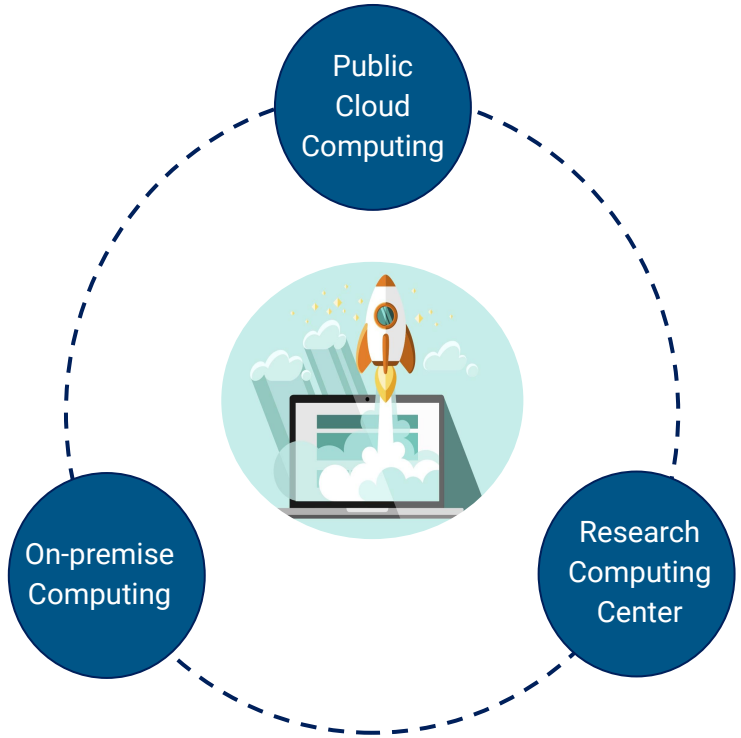
HPC – preparing a post-Moore future

"Right now Moore's Law is growing a few percent every year. Every 10 years maybe only 2X. ... So Moore's Law has finished."
Jensen Huang, CEO – NVIDIA (2019)



Global Trend: Moore's law is slowing down





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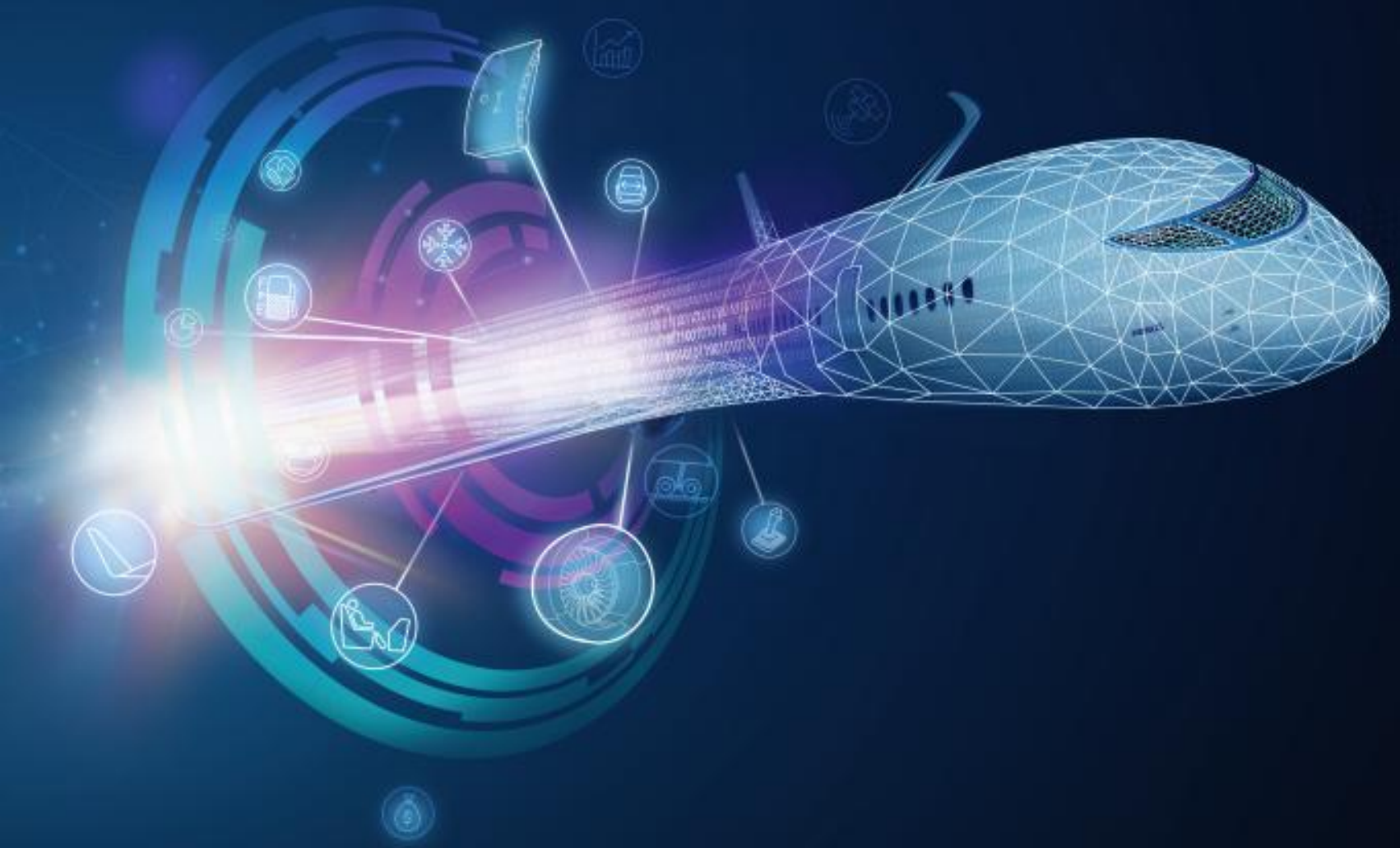
Future of compute



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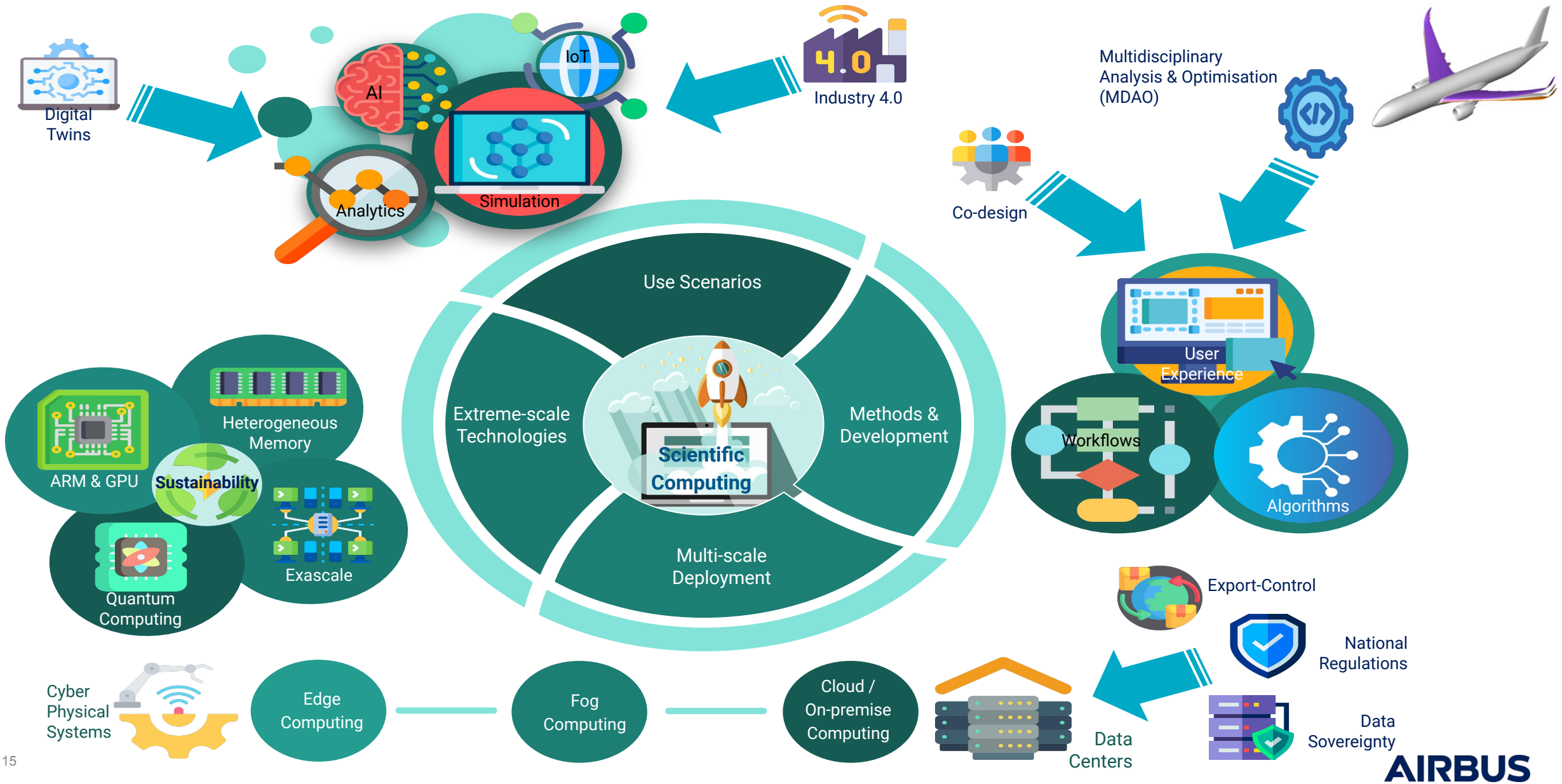
Future of compute



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