Making the future

CSC provides ICT expert services at an internationally high level of quality for

- research
- education
- culture
- public administration
- enterprises

to help them thrive and benefit society at large.

Non-profit state organization with special tasks

Turn over in 2021
56M€

Headquarters in Espoo, datacenter in Kajaani

Owned by state (70%) and all Finnish higher education institutions **(30%)**

Circa
550
employees
(mid 2022)

Our customers

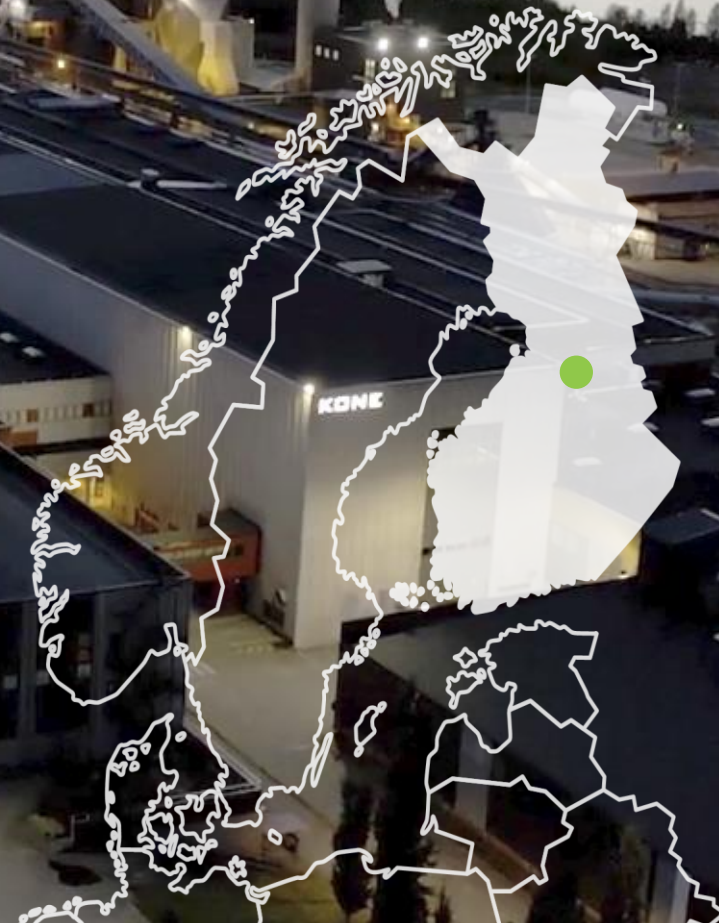Researchers,
research institutes and
organizations

Organizations providing
education

Memory organizations,
state and public
organizations

Kajaani Datacenter Ecosystem

World-Class Sustainability for Datacenters

KDC
KAJAANI DATA CENTER
POWERED BY CSC

REGIONAL COUNCIL OF KAINUU

City of **Kajaani**

Dr. Mikko Kerttula
Ecosystem Development
Kajaani Data Center Program

v. 10.11.2022

CSC

Finland

#1 – The Most Stable Country in the World – 10th year in a row
Fund for Peace, Fragile States Index 2022

#1 – No. 1 Business Environment in the World
Global Innovation Index 2021

#2 – 2nd Most Skilled Workforce in the World
World Economic Forum, The Global Competitiveness Report 2019

#8 – 8th Most Innovative Country in the World
Bloomberg Innovation Index 2021

Some Basics of DC Business

Greenfield vs. Brownfield:

- With **greenfield** investing, a company will build its own, brand new facilities from the ground up.
- **Brownfield** investment happens when a company purchases or leases an existing facility.

Electricity consumption:

- **Datacenter capacity (and size)** is primarily measured by electricity consumption in kilowatts (kW) or **megawatts (MW)**
- **Main cost in datacenter operations**

Power Usage Effectiveness (PUE):

- PUE measures the total energy use of the data center compared to the energy used by IT equipment.

$$PUE = \frac{\text{Total Facility Power} \atop \text{(Cooling+Power+Lightning+IT)}}{\text{(IT)} \atop \text{IT Equipment Power}}$$

Energy Reuse Factor (ERF):

- The ERF of a data center reflects how much energy is exported for reuse outside of data center operations.

$$ERF = \frac{E_{Reuse}}{E_{DC}}$$

Whitespace:

- Area where IT equipment are placed

Key Elements for Datacenter Location

Electricity:

- Availability
- Reliability
- Price
- Green and renewable energy sources

Heat reuse possibility

Connectivity:

- Latency, time it takes data to travel between two points

Ecosystem support:

- Personnel
- Education
- Vendors, operators
- RDI partners

Other:

- Reachability of the location (airport and flights)
- Stability and security of the area/country

Home of LUMI

Renforsin Ranta Business Park, Kajaani Finland

Greenfield (200 ha)

National grid substation (1000 MW)

Excess heat utilisation to district heat network

3 hydropower plants In Kajaani river

3x

230 MW existing transformer capacity

LUMI Euro HPC

CSC's national supercomputers

Kajaani Advantages as DC Location

Low total cost of ownership:

- Attractive electricity price, even 50% lower compared to Central and southern Europe
- Excess heat sales opportunity reduces total cost of operations

Sustainability:

- Surplus of local 100% green renewable energy sources available (wind & hydro)
  - 200 MW ready for use in Renforsin Ranta
- Excess heat utilization reduces CO2 emissions

Existing infrastructure and ecosystem:

- 4 existing reference projects, including LUMI the 3rd fastest supercomputer globally
- Local presence of HW vendors (HPE ja Atos) and education from Kajaani University of Applied Science
- Infrastructure ready for fast project start and implementation
  - Multiple brownfield (up to 50.000 m^2) and greenfield options (up to 200 ha)

Kajaani Connectivity
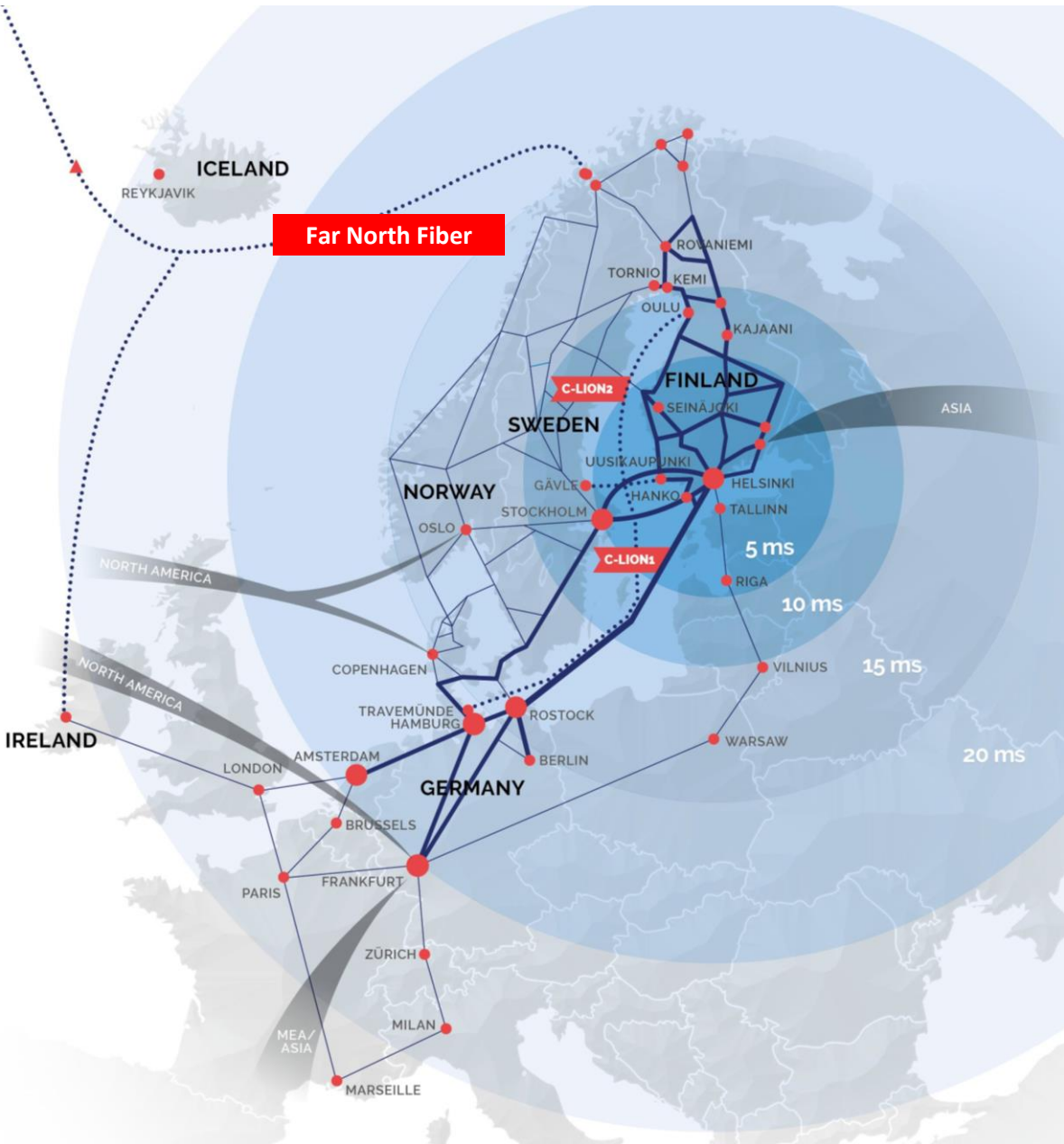
- Funet, NORDUnet & GÉANT research networks in place

- Operator neutral business park with multiple physical connectivity routes to the site

- Cinia PoP in place (multiple 100G)
  - Direct C-Lion connectivity
  - Future connectivity to Asia and US via "Far North Fiber"

- All the national operators in place

CITY	Kajaani	Helsinki	Frankfurt	Hamburg	Amsterdam	London	Berlin	Stockholm
Helsinki	6,7							
Frankfurt	26,4	**19,7**	-	-	-	-	-	-
Hamburg	21,9	**15,2**	5,6	-	-	-	-	-
Amsterdam	26,4	**19,7**	12,1	6,5	-	-	-	-
London	32,8	26,1	16,4	10,8	6	-	-	-
Berlin	22,7	**16**	11,5	5,8	12,3	16,6	-	-
Stockholm	11,9	5,2	**22,4**	12,4	19	23,2	**17,1**	-
Moscow	18,4	11,7	31,4	26,9	33,4	37,7	27,7	16,9
Tokyo	137,5	130,8	150	146	152,5	156,8	146,8	136
Hong Kong	139,5	132,8	152	148	154,5	158,8	148,8	138

Unbolded values are estimates and bolded values are measured

National Supercomputer Environment in Kajaani

Total combined computing power of 12 petaflops per second.

An environment for all national scientific computing needs in Finland, like for extensive simulations, data-intensive computing, sensitive data processing. https://www.csc.fi/en/supercomputers

PUHTI

A general-purpose super-cluster suitable for applications from interactive data analysis to medium-intensity simulations.

In operation 2019.
Ranking on Top500 list then 166

MAHTI

For medium- and heavy-intensity simulations with high computing power and a very fast switching network.

In operation 2020.
Ranking on Top500 list then 47

ALLAS

Shared data management system for storing, sharing and analysing data.

In operation 2019.

The Queen of North

LUMI

European flagship
supercomputer

Powered by

c s c

www.lumi-supercomputer.eu   #lumisupercomputer   #lumieurohpc

Visitors v 19.4.2023

The EuroHPC Joint Undertaking

Leading the way in European Supercomputing

LUMI

The EuroHPC Joint Undertaking pools EU and national resources in high-performance computing

- acquiring and providing a **world-class supercomputing and data infrastructure** for Europe's scientific, industrial and public users

- supporting an ambitious research and innovation agenda

The first generation of EuroHPC systems announced in June 2019

- 3 pre-exascale systems to Finland, Italy and Spain

- 5 petascale systems to Czech Republic, Bulgaria, Luxembourg, Portugal and Slovenia

EuroHPC Joint Undertaking

LUMI supercomputer is the first co-investment ever of this scale in scientific computing.

The total budget of the EuroHPC pre-exascale system in CSC's data center in Kajaani, Finland, is over 202 Meur (half from the EU, half from the consortium countries.)

A unique collaboration between ten LUMI consortium countries (FI, BE, CH, CZ, DK, EE, IS, NO, PL, SE) and the EU to build and operate a world-class supercomputer.

The consortium continues a solid tradition of collaboration in HPC training and education, user support and data management services.
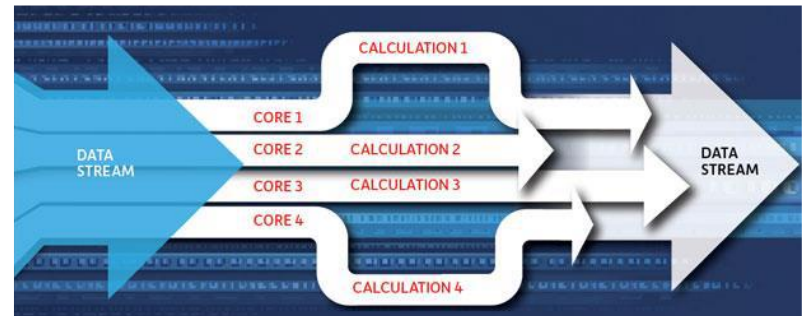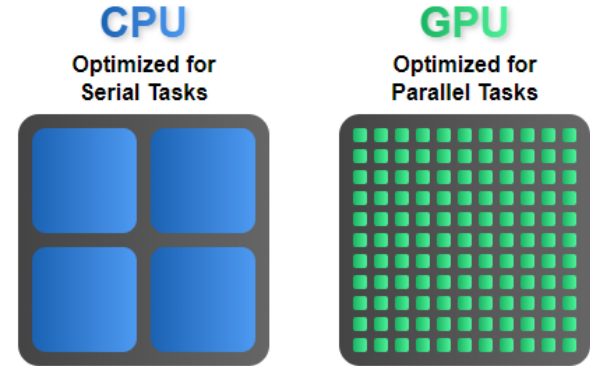
The resources of LUMI are allocated per the investments. The share of the EuroHPC JU (50%) is allocated by a peer-review process and available for all European researchers.
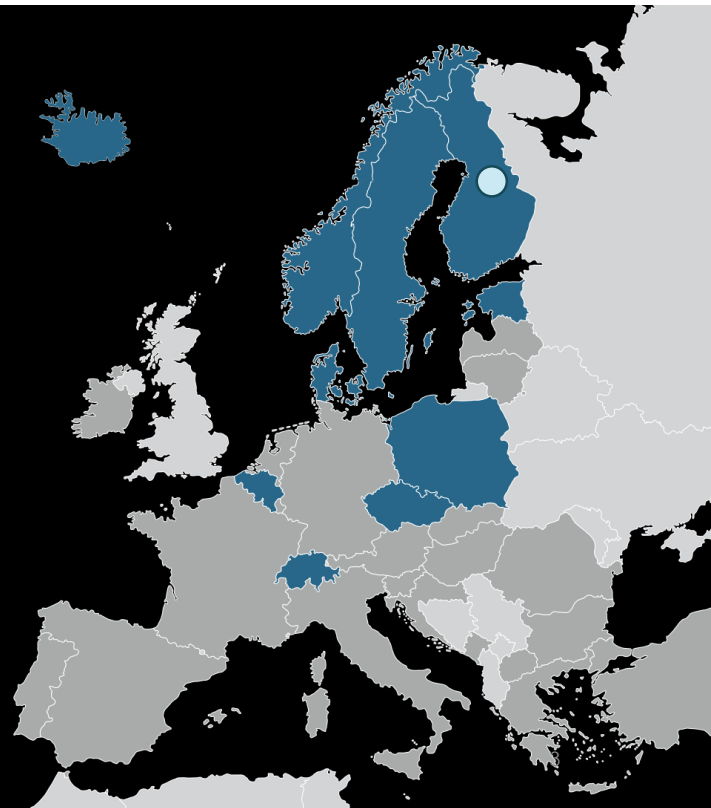
What is Supercomputing?

- Supercomputing is based on parallel computing in which several computing units are executing tasks simultaneously

- Earlier, computing was based mostly on CPUs (Central Processing Unit) enabling serial computing, i.e., executing commands one by one

- Nowadays GPUs (Graphics Processing Unit) are becoming more common. A GPU can divide computing task simultaneously to even hundreds of cores it has.

- High-Performance Computing (HPC) is often used as synonym for supercomputing

CPU
Optimized for
Serial Tasks

GPU
Optimized for
Parallel Tasks

DATA STREAM

CALCULATION 1
CORE 1
CORE 2 CALCULATION 2
CORE 3 CALCULATION 3
CORE 4

CALCULATION 4

DATA STREAM

What is a Supercomputer

LUMI

Its powerful processors can perform millions of calculations simultaneously, so it can operate millions of times faster than conventional computers and help us solve highly complex problems.

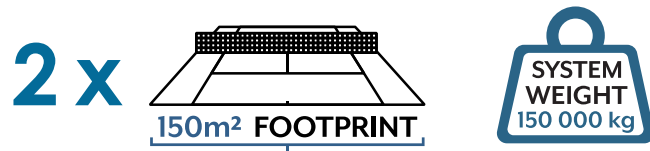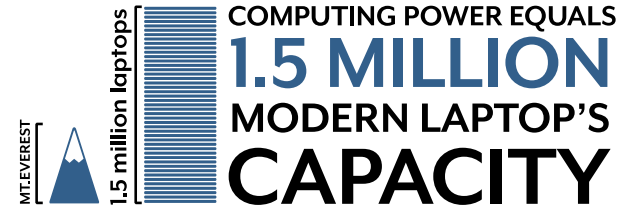LUMI is an HPE Cray EX Supercomputer

Hewlett Packard Enterprise

LUMI is 3rd Fastest Supercomputer in the World Operating 2022-2026

L U M I

SUSTAINED PERFORMANCE

375 PETAFLOP/S

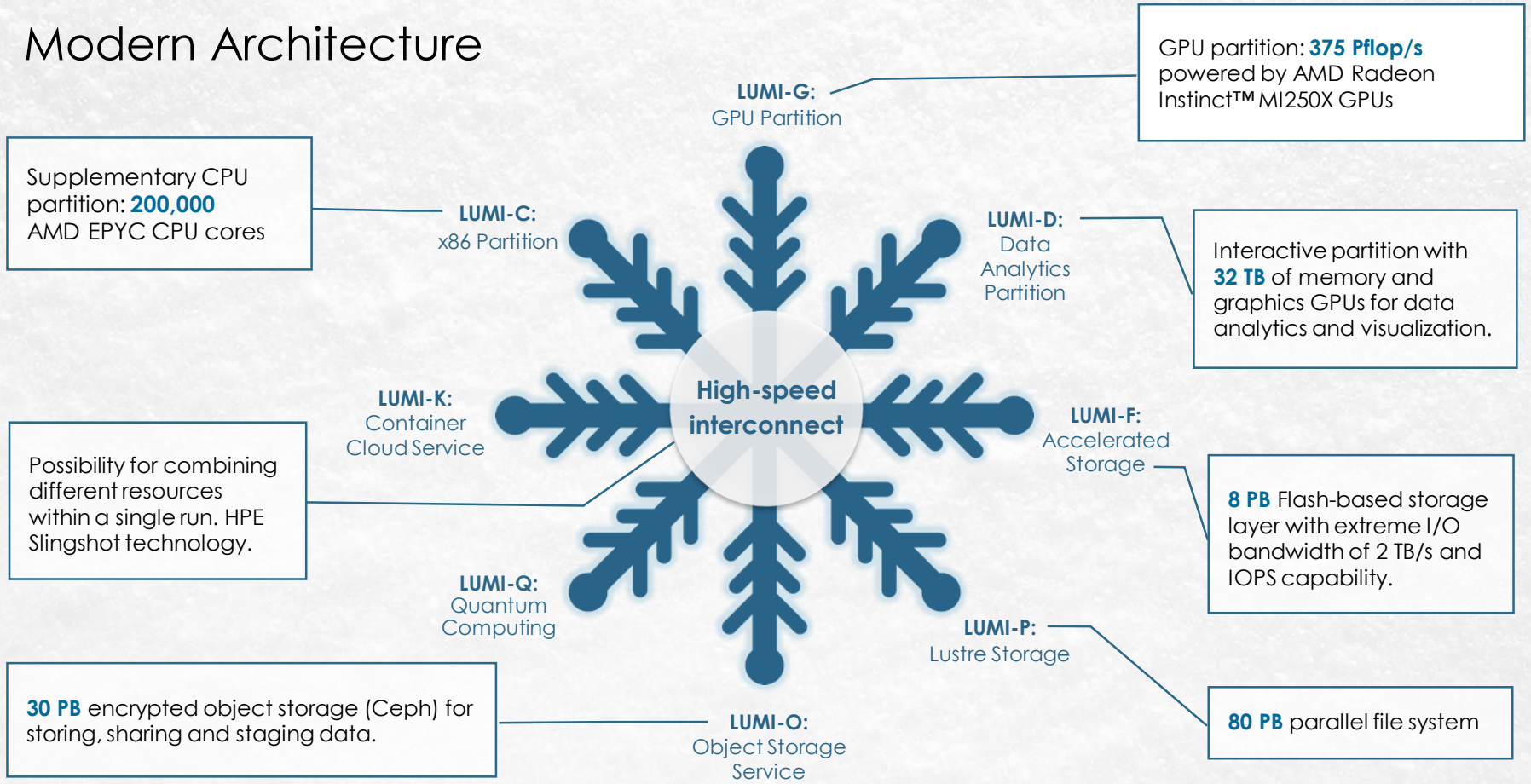= performs 375 x 10^{15} calculations per second

MT.EVEREST

1.5 million laptops

COMPUTING POWER EQUALS

1.5 MILLION
MODERN LAPTOP'S
CAPACITY

2 x

150m² **FOOTPRINT**

SYSTEM WEIGHT 150 000 kg

High-performance computing

AI

Data analytics

Modern Architecture

GPU partition: **375 Pflop/s** powered by AMD Radeon Instinct™ MI250X GPUs

LUMI-G: GPU Partition

Supplementary CPU partition: **200,000** AMD EPYC CPU cores

LUMI-C: x86 Partition

LUMI-D: Data Analytics Partition

Interactive partition with **32 TB** of memory and graphics GPUs for data analytics and visualization.

LUMI-K: Container Cloud Service

High-speed interconnect

LUMI-F: Accelerated Storage

Possibility for combining different resources within a single run. HPE Slingshot technology.

8 PB Flash-based storage layer with extreme I/O bandwidth of 2 TB/s and IOPS capability.

LUMI-Q: Quantum Computing

LUMI-P: Lustre Storage

30 PB encrypted object storage (Ceph) for storing, sharing and staging data.

LUMI-O: Object Storage Service

80 PB parallel file system

LUMI timeline

LUMI

System procurement:
11/2019 – 08/2020

In customer
use 01/01/2022

Pilot use

Operations

2019   2020   2021   2022   2023   2024   2025   2026

Data center
preparation
ready Q1/2021

Q4/2021
1st phase
Early Access
Platform

Q2/2022
Gradual
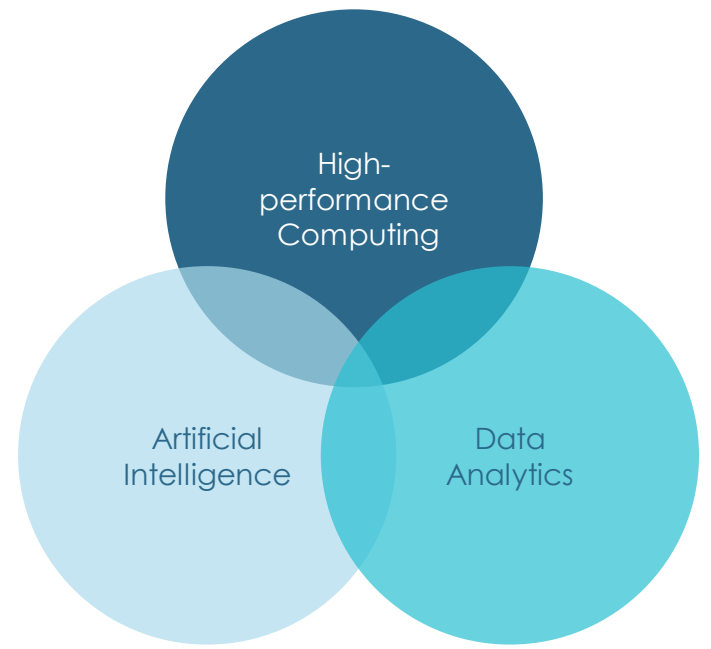deployment
of LUMI

Q4/2022
Final
Configuration
General
availability

The convergence of High-performance Computing, Artificial Intelligence and Data Analytics will be key for solving the great scientific and societal challenges.

L U M I

High-performance Computing

Artificial Intelligence

Data Analytics

LUMI

Enabling top research and scientific breakthroughs

- Climate change
- Climate simulations
- Digital modelling (e.g. Destination Earth)
- Treatment of diseases
- Personalized medicine
- Life sciences
- Time-critical modelling
- Arfificial Intelligence: self-driving vessels and cars, natural language processing (NLP)
- Data analytics

How to start using LUMI in RESEARCH?

L U M I

A potential LUMI user has two routes to apply for the resources:

1. National capacity in Finland is free for Finnish academic users affiliated to Finnish higher-education or research institutes
   - Read mode about the Access Modes and Open Calls at
     https://www.lumi-supercomputer.eu/get-started-2021/users-in-finland/

2. Half of the LUMI resources are allocated by the EuroHPC Joint Undertaking.
   - Researchers in European countries can apply for the resources in this pool.
   - For more information, see " Users in Europe" at
     https://www.lumi-supercomputer.eu/get-started-2021/users-in-europe/

Up to 20%

of LUMIs capacity
is reserved for
European industry
and SMEs

LUMI

For companies LUMI offer

- **A world-class supercomputing capacity with cost-efficient pricing**

- **Superfast product development and new business opportunities** in areas such as data analytics and AI

- **Top technical expert and training support from LUMI User Support Team** from LUMI User Support Team

- **A way to initiate or strengthen cooperation with universities and research institutes**

- **Data security based on ISO/IEC 27001 standard**

Typical industrial applications

LUMI

Heavy simulation of complex systems

- Material sciences
  - Development of new materials
  - Development of new medicine

- Climate & weather forecasting, numerical weather prediction

- Understanding different physical phenomena, e.g.
  - Fluid dynamics
  - Structural mechanics
  - Electromagnetics
  - Heat transfer
  - Acoustics
  - Fire dynamics simulation

AI models with massive data sets

- Large language models

- Generative AI, e.g. text-to-image, text-to-video

- Speech-to-text and text-to-speech

- Machine learning:
  - Image Recognition, e.g. for defect detection
  - Autonomous vessels and cars

23
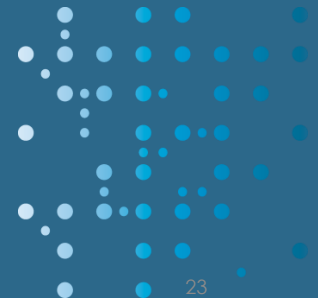
DISIOR

Disior Oy is a Finnish company that develops software for medical image analysis as a tool for the treatment of bone fractures.

CHALLENGE

Optimization of the jaw reconstruction involves calculation of the correct size and location of an implant to be installed in the joint, minimization of the loads between bone and the implant screws, and the amount of metal used in the implant.

The individual computations are not demanding per se, but since there is a huge number of computations to be optimized, the need for computing cores rises up to several thousands.

SOLUTION AND IMPACT

Thanks to help from supercomputing, the optimization of jaw bone reconstruction was approximately ten times faster than initially.

GROKE®

Groke Technologies Oy is a Finnish company that focuses on developing intelligent methods for autonomous navigation to improve maritime safety.

CHALLENGE

How do you create an awareness system that monitors the environment and detects and recognizes objects around a vessel, from the side of another vessel to a far-away sea buoy? How can machine learning models be programmed for object detection with an optimal trade-off between accuracy and performance.

SOLUTION AND IMPACT

By building scalable data processing pipelines for training, evaluating and optimizing machine learning algorithms, and running large-scale training on a GPU-equipped HPC system, better training speed and better target detection were achieved leading to lower unit costs.

Speechly

Speechly Oy, a Finnish start-up company, has developed technology that allows software developers to easily add an intuitive voice interface on different platforms, whether it be Android, iOS, website or video game.

CHALLENGE

How to achieve better voice control thorough real-time natural language recognition? Training and testing modern deep machine learning algorithms to find the best speech recognition models, requires large quantities of computing capacity. Model training can take anything from days to weeks.

SOLUTION AND IMPACT

During the nine-month project, Speechly improved the accuracy of its speech recognition model by almost 60% in terms of word error rate. The unprecedented HPC computing capacity enabled Speechly to work faster than before and with significantly more data.

WB-Sails Ltd. designs and manufactures sails, specializing in top-end racing products. From the beginning WB-Sails has relied on technology, research and development to become one of the very few sailmakers in the world present at the Olympic level. In London 2012 their sails, designed and manufactured in Finland, won a gold and a bronze medal in two different disciplines (boat classes). In Rio 2016, a silver medal was won

CHALLENGE

WB-Sails wished to utilize HPC resources to perform simulations of sailboats using the XFlow software. In addition to simulating airflow around sails, two phase studies with free surfaces and realistic motion of the hull in seaway were performed. Ultimately, the goal was to combine CFD with structural analysis of sails.

SOLUTION AND IMPACT

The CFD code XFlow was successfully deployed at CSC. WB-Sails was well educated into the use of HPC.
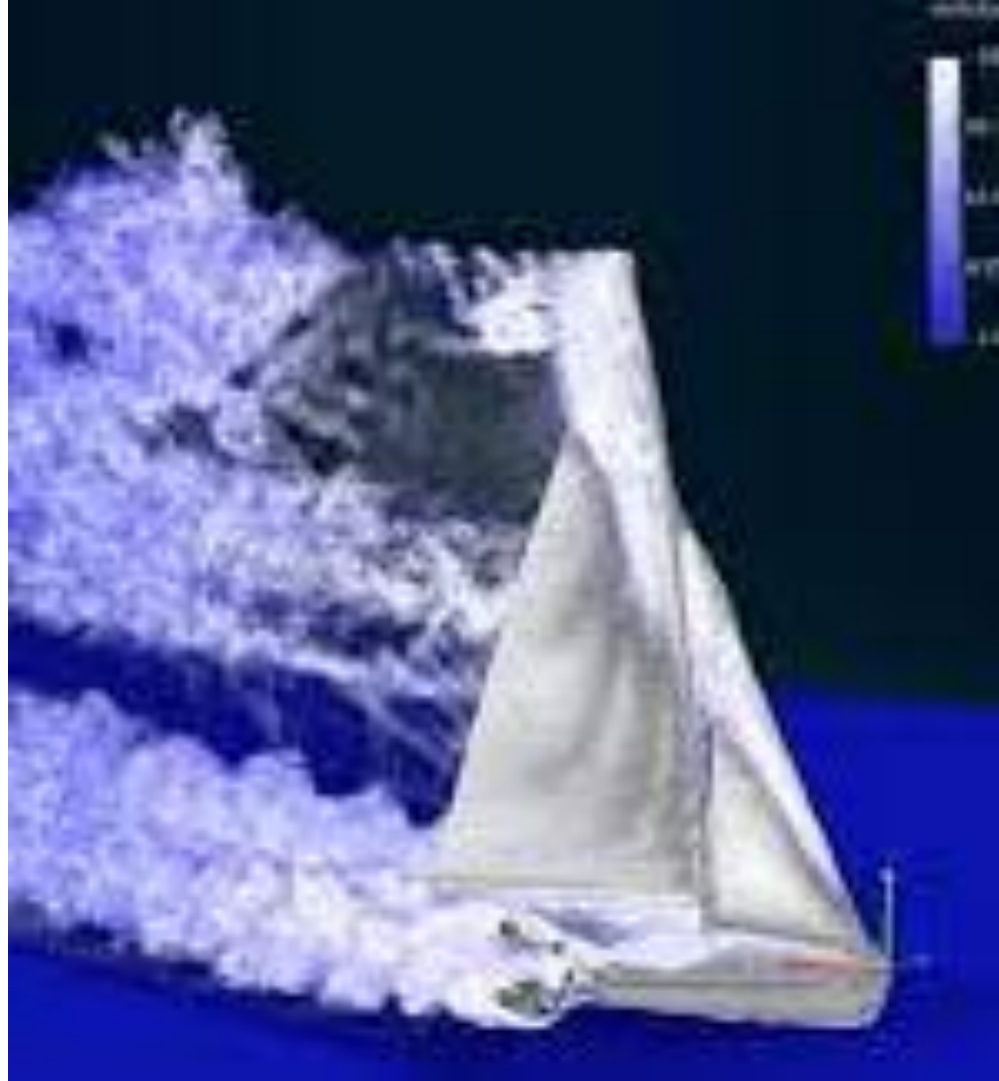
How to start using LUMI in a COMPANY?

LUMI

PRIVATE–PUBLIC ENGAGEMENT	PAY PER USE	BUSINESS FINLAND FUNDING
• Project in cooperation with Finnish university or research organization (academic partner) • Project lead (PI) assigned from academic partner • Free of charge if results are published • Market price charged if results are closed	• **National LUMI capacity:** Company pays market price to CSC • **EuroHPC JU capacity** Company pays market price to JU. Funding possible through PRACE SHAPE and EuroHPC JU programs for SMEs	• **Start-up and SMEs** can request HPC grant at a value of 30,000-100,000€. Can be added to an already running project. • **Large and mid cap** companies can include computing capacity into their R&D project budget, 40% of costs covered • Capacity is valued at market price

More information at
https://www.csc.fi/en/solutions-for-business
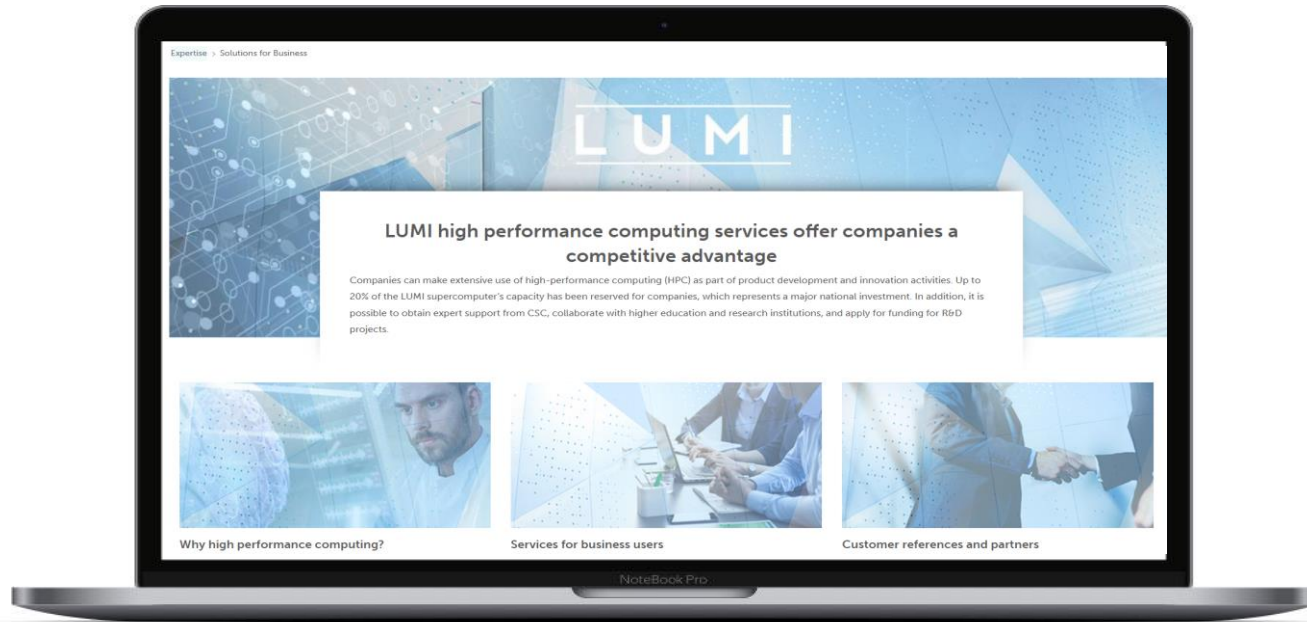
L U M I

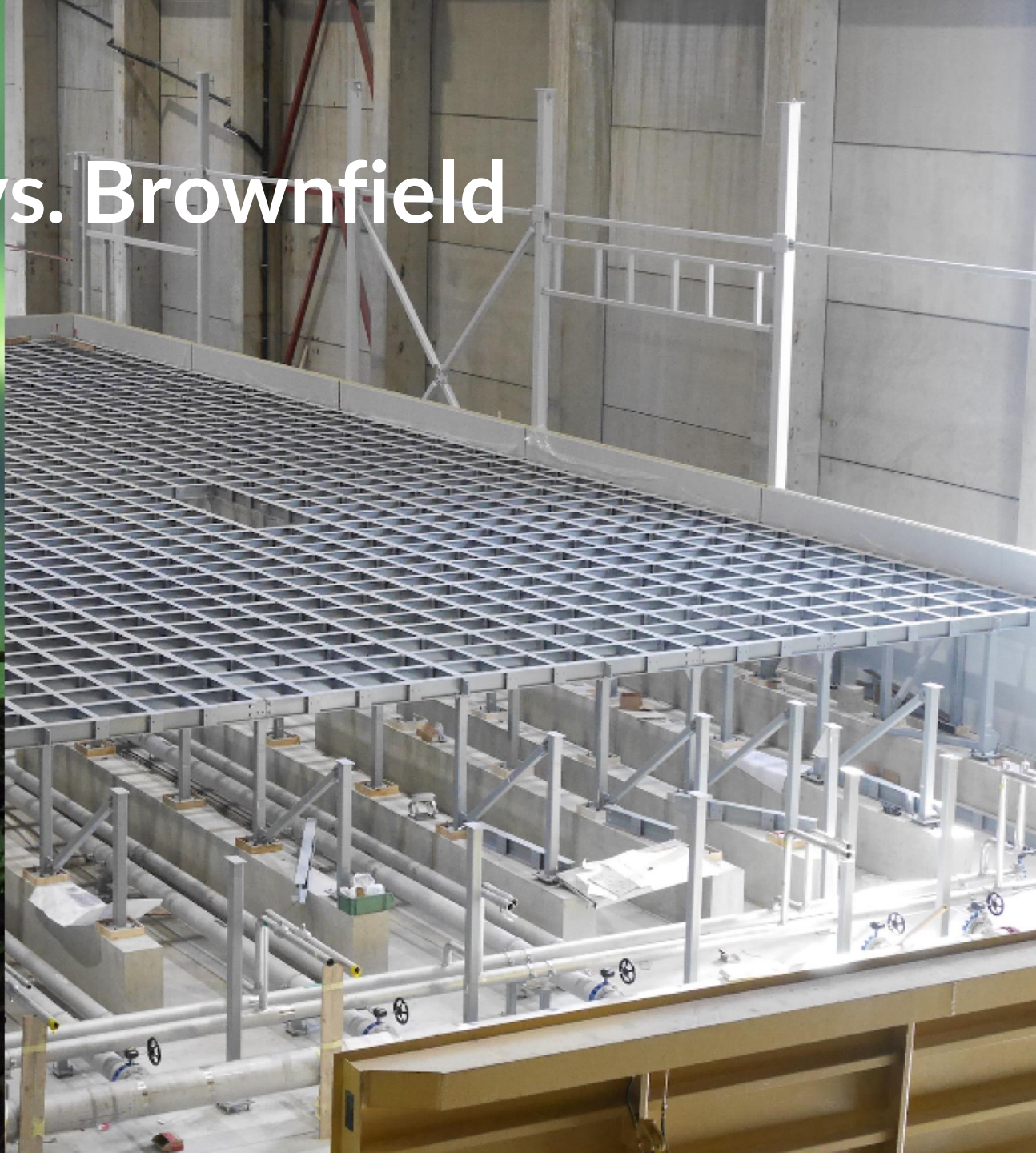# Towards Zero Emissions with LUMI EuroHPC Data Center

HPC System's Carbon Footprint

- **Building phase**
  - Greenfield vs. Brownfield
- **Operations**
  - Design & Efficiency (PUE)
  - Consumed electricity
  - Waste Heat utilisation (ERF)
  - Hardware "Science per watt"

Greenfield vs. Brownfield

Benefits of the Brownfield Solution

- 80% reduction of CO_2 footprint in LUMI data center construction project

- Saved ~1 000 tonnes of CO2eq

- Flexibility to start whenever

- Cost savings

Materials - building shell 5,700 ft² (530 m²) office facility	Tonnes of CO_2	Percentage of total
Foundation (concrete)	4.7	4%
Flooring (concrete slab, insulation)	39.9	31%
Ceilings (plaster board)	2.3	2%
Structure (steel beams)	15.4	12%
External walls (brick, insulation)	32.1	25%
Internal walls (wood frame and plasterboard)	8.7	7%
Stairs (concrete)	1.1	1%
Windows (glass and frame)	0.59	0.4%
Internal doors (particle board)*	-0.4	-0.3%
External doors (plastic)	0.6	0.5%
Roof (wood, concrete, insulation)	23.4	18%
TOTAL	**128.3**	**100%**

For a 1 MW DC, source: Schneider-Electric white paper 66

LUMI DESIGN IMPACT

PUE 1.04 & 1.24

Support of Excess Heat Utilisation

Carbon <u>Negative</u> Operations

Use of Local Renewable Energy

20 % of annual need

40 % impact to total cost of energy
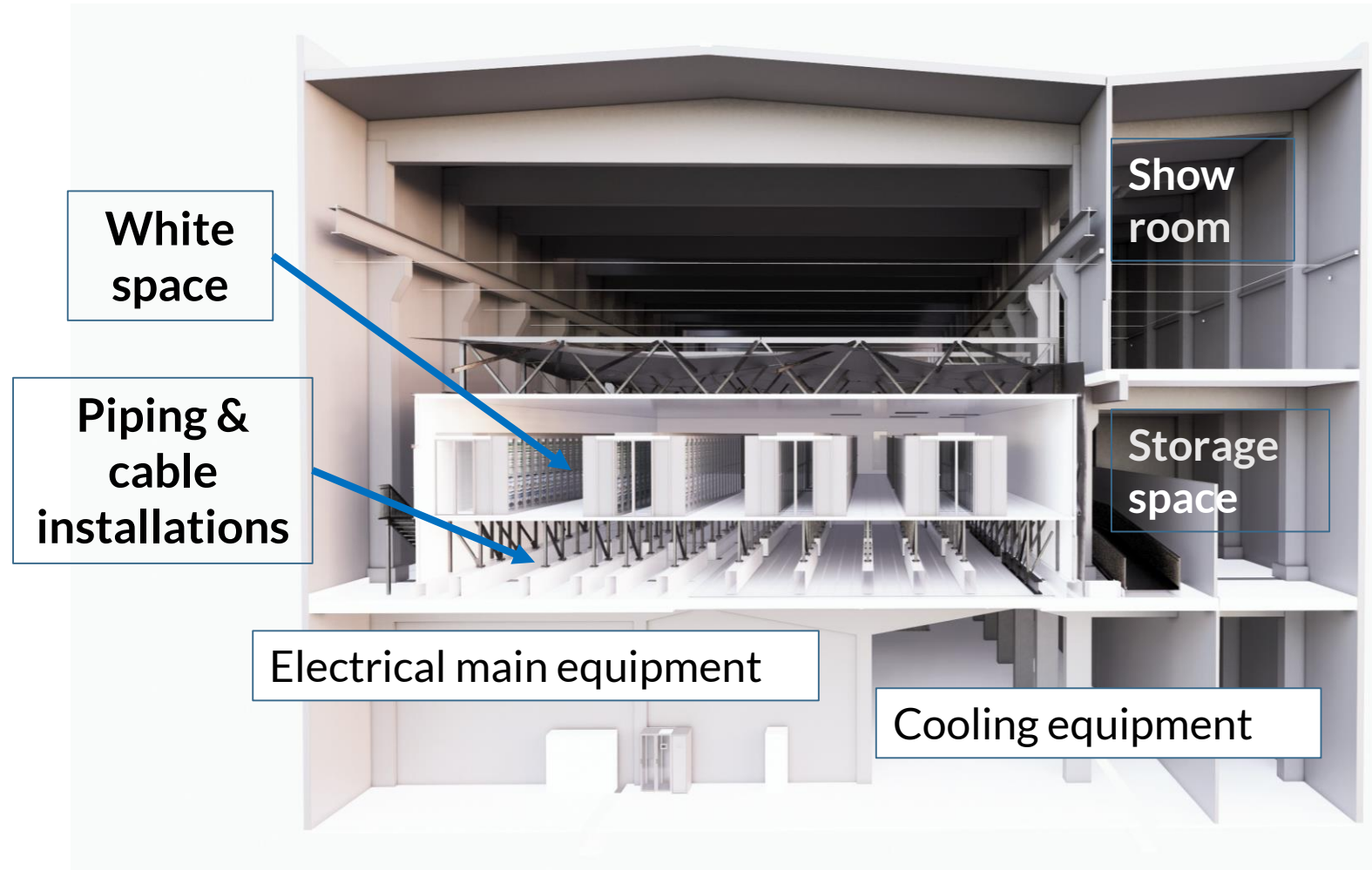
CO₂ Footprint: -12 400 tonnes

Project Summary

- Key objectives in reasonable capital expenses and low total cost of ownership (TCO)

- Big challenge: the final technical requirements of the HPC was available only at the midpoint of the building phase.

- To reach the lowest TCO heat recovery was selected as a primary cooling solution
    - Dry air cooling will act as a backup

- High capacity green power is provided with six independent feeds to on-site substation.
    - Surplus of green energy production in the region, including three nearby hydro power plants and wind farms.
    - One outage during the last 39 years

- LUMI uses 100% certificated hydro power (with a close to zero carbon usage effectiveness) in all its data center production and office environments.
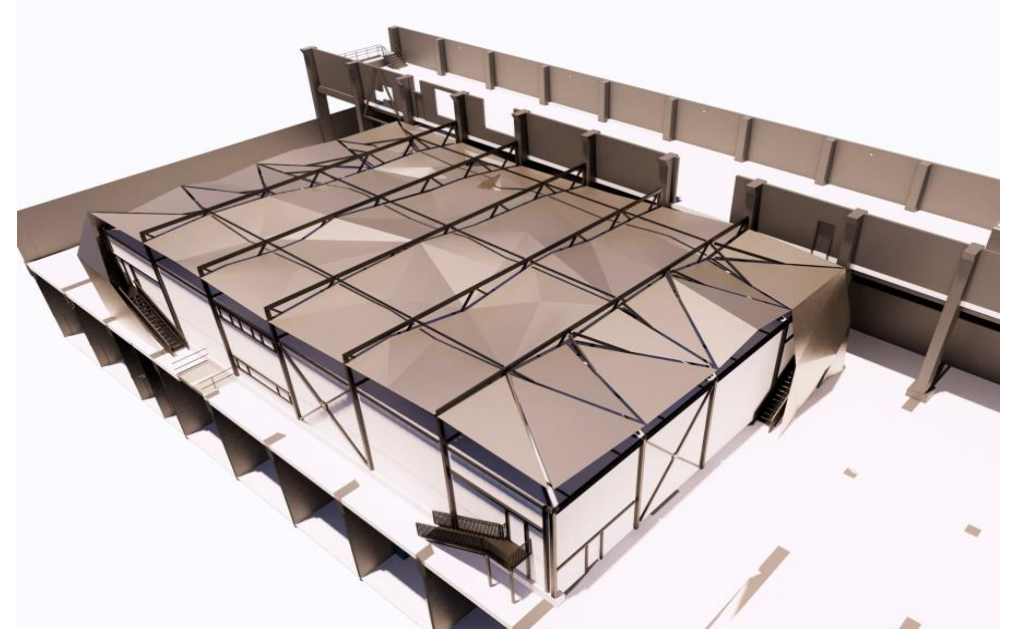
Before LUMI Tour

- Three floor arrangement:
  - Ground floor for the main equipment
  - 1st floor for the piping and cable distribution
  - 2nd floor for the DC- equipment only

- Unique shape of the DC
  - LUMI means SNOW
  - Demonstrates snow

- Whitespace visit in 2 groups
  - Selfies, etc. in front of the cabins
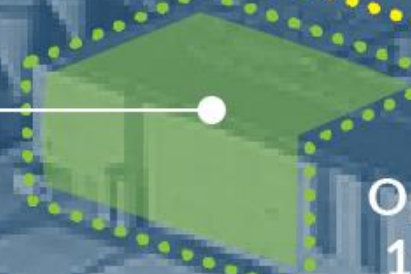 - **No photos on open cabinets or hardware components!**

White space

Piping & cable installations

Show room

Storage space

Electrical main equipment

Cooling equipment

Starting point for LUMI project

LUMI and Future Scalability

LUMI
10 MW

Reservation
50-100 MW
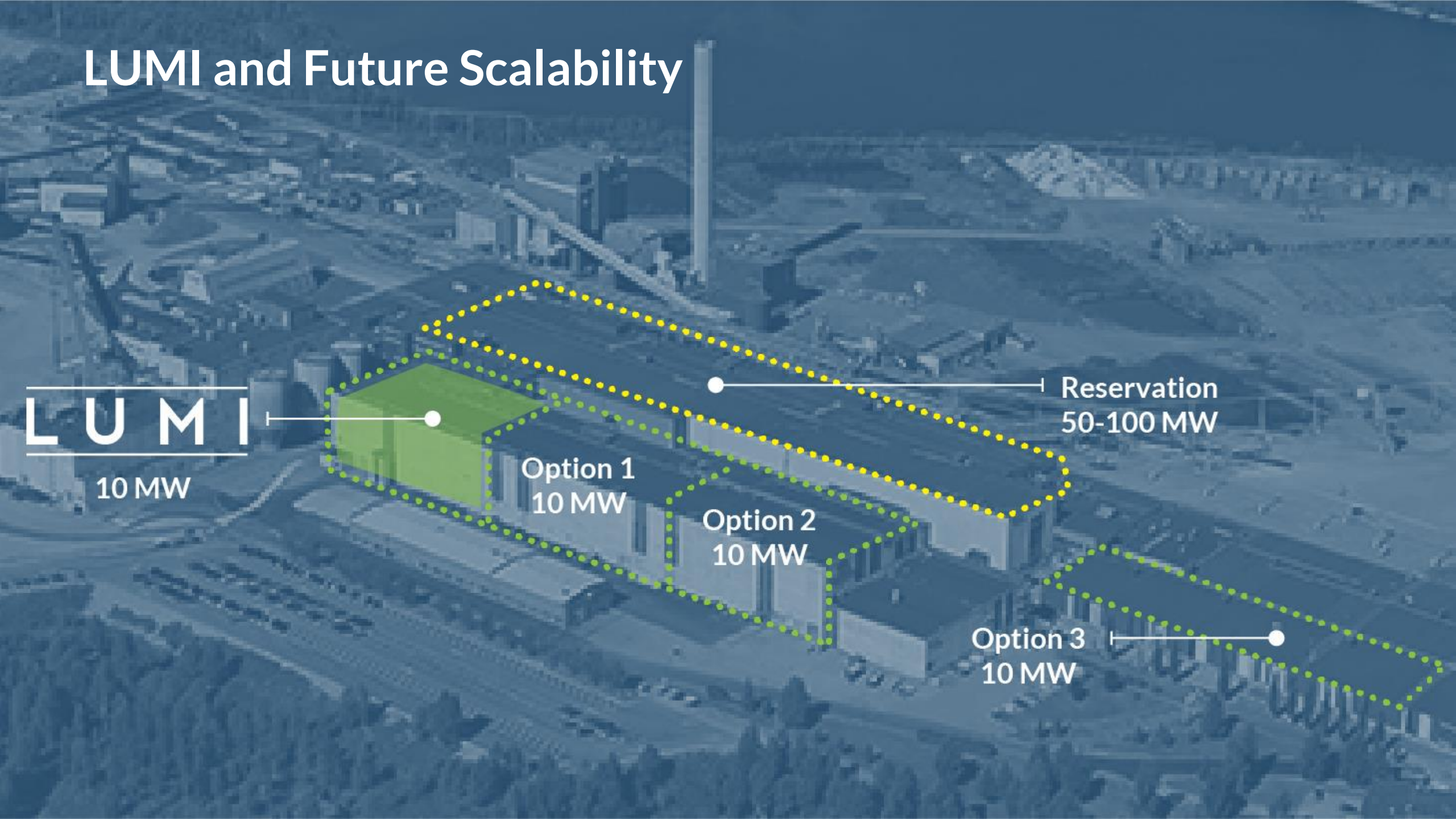
Option 1
10 MW

Option 2
10 MW

Option 3
10 MW

Award winning LUMI data center in Kajaani

The LUMI data center in Kajaani is highly scalable for large hardware installations and extensions or other potential infrastructure, making it ideal for a sustainable and expansive data center ecosystem.

Kajaani and LUMI EuroHPC videos

L U M I

Kajaani:

Kajaani data center sustainability
https://www.youtube.com/watch?v=GUCVB0Z4B0s

Kajaani Renforsin Ranta Business park
https://www.youtube.com/watch?v=IMC6zXQM4Uo&t=2s

LUMI:

Making of LUMI part-1
https://www.youtube.com/watch?v=covoiGPdAwY

Making of LUMI part-2
https://www.youtube.com/watch?v=N0z0_6skUG8

Making of LUMI part-3 & installation
https://www.youtube.com/watch?v=pWxBS_vcofA

LUMI 1st phase system arrival
https://www.youtube.com/watch?v=g1IaWuOZ26A&t=24s

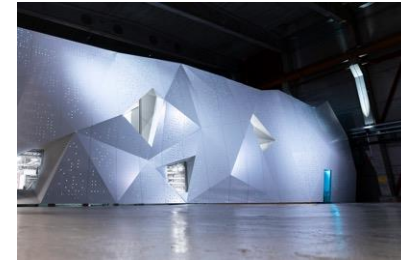LUMI data center
https://www.youtube.com/watch?v=YJ63BqpHqpw

LUMI world-class supercomputer
https://www.youtube.com/watch?v=gZrw58_Cu4g&t=39s

Contact Information

Kajaani Data Center Program executed by CSC - IT Center for Science Ltd. with the support of Kainuu Regional Council and City of Kajaani.

For more detailed information contact:

Jukka-Pekka Partanen

Director
tel. +358 40 544 3501
jukka-pekka.partanen@csc.fi

Mikko Kerttula

Project manager
tel. +358 50 381 2766
mikko.kerttula@csc.fi

Veli-Antti Leinonen

Specialist
tel. +358 44 740 1010
veli-antti.leinonen@csc.fi

CSC – IT Center for Science Ltd.

Follow us: www.csc.fi   **LinkedIn:** https://www.linkedin.com/company/csc---it-center-for-science/

www.aikaecosystem.com   **YouTube:** https://www.youtube.com/c/cscfi

www.lumi-supercomputer.eu   #KajaaniDClocation #lumieurohpc #CSC