EUROPEAN
SPALLATION
SOURCE

The integrated control system at ESS

PRESENTED BY HENRIK CARLING

2020-11

Short introduction

Graduated a long time ago from Lund university/Physics

Worked at CERN with control systems for experiments in mid 80's -> mid 90's

Own software development company for 8 years (15 employees) -> logistics and automation for industry

Management career in mobile telecom during 2000's - embedded software development

Managing automation, control systems and MES in food industry for a couple of years

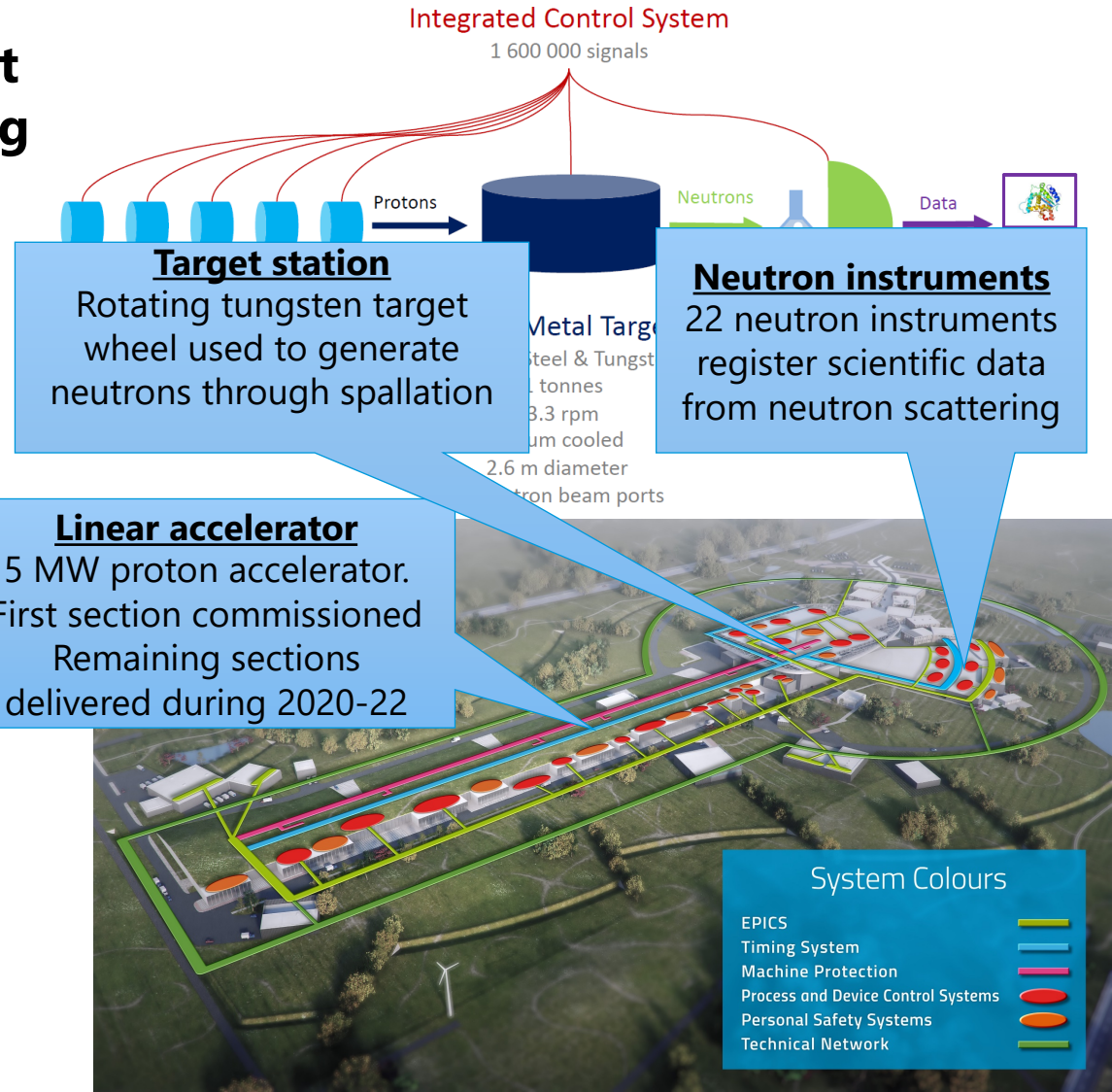
Since 2015 - head of the integrated control systems division at the European spallation source - ESS

The European spallation source

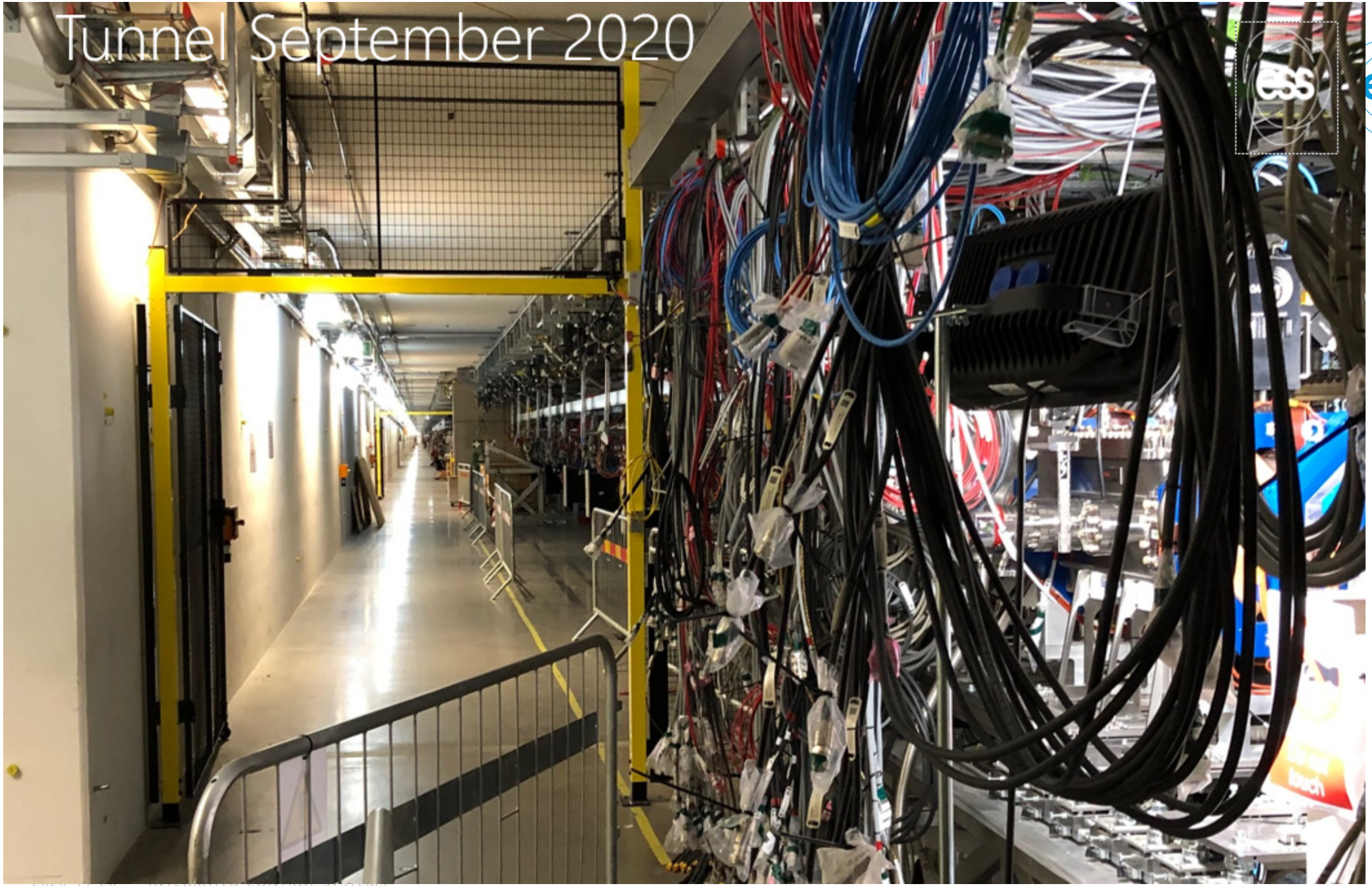
The European Spallation Source is one of the largest science and technology infrastructure projects being built today

The facility design and construction include the most powerful linear proton accelerator ever built, a five-tonne, helium-cooled tungsten target wheel, 22 state-of-the-art neutron instruments, a suite of laboratories and a supercomputing data management and softwa development centre.

In the context of its history and future as a scientific organisation, however, it is more than the sum of its parts. It is a brand new Big Science organisation, built from the ground up.



Tunnel September 2020



MEBT

RFQ

RF gallery now

Elliptical RFDS

Integrated control system

The ESS facility is a large and complex machine with very much and diverse equipment that needs to work in synchronization and with well-known configurations

The Integrated Control System Division (ICS division) is responsible for the control systems within the ESS facility including controls for

- **Accelerator**
- **Target**
- **Neutron Scattering Systems**
- **Conventional Facilities**

In addition, ICS will implement

- **Machine Protection System**
- **Personnel Safety System**

To build a distributed control system of this size is a major undertaking

The ESS integrated control system

The ESS control system complexity is very high

- About 1 600 000 “process values”
- About 100 000 connected “devices”
- Ambitious approach to automation of control system configuration

Facility availability goals are very high

- ICS plays a key role for the availability of the facility
- High performance and availability requirements on equipment used

Some new approaches will be implemented at ESS/ICS

- Full scale deployment of EPICS 7
  - ESS is committed to contributing to the EPICS community
- Full scale deployment of MicroTCA.4
  - ESS is involved in a public procurement for innovation initiative
- Machine learning/Artificial intelligence assisted control system
  - Project started to explore how machine learning technologies can be applied


EPICS
Experimental physics and industrial control system

What is EPICS?

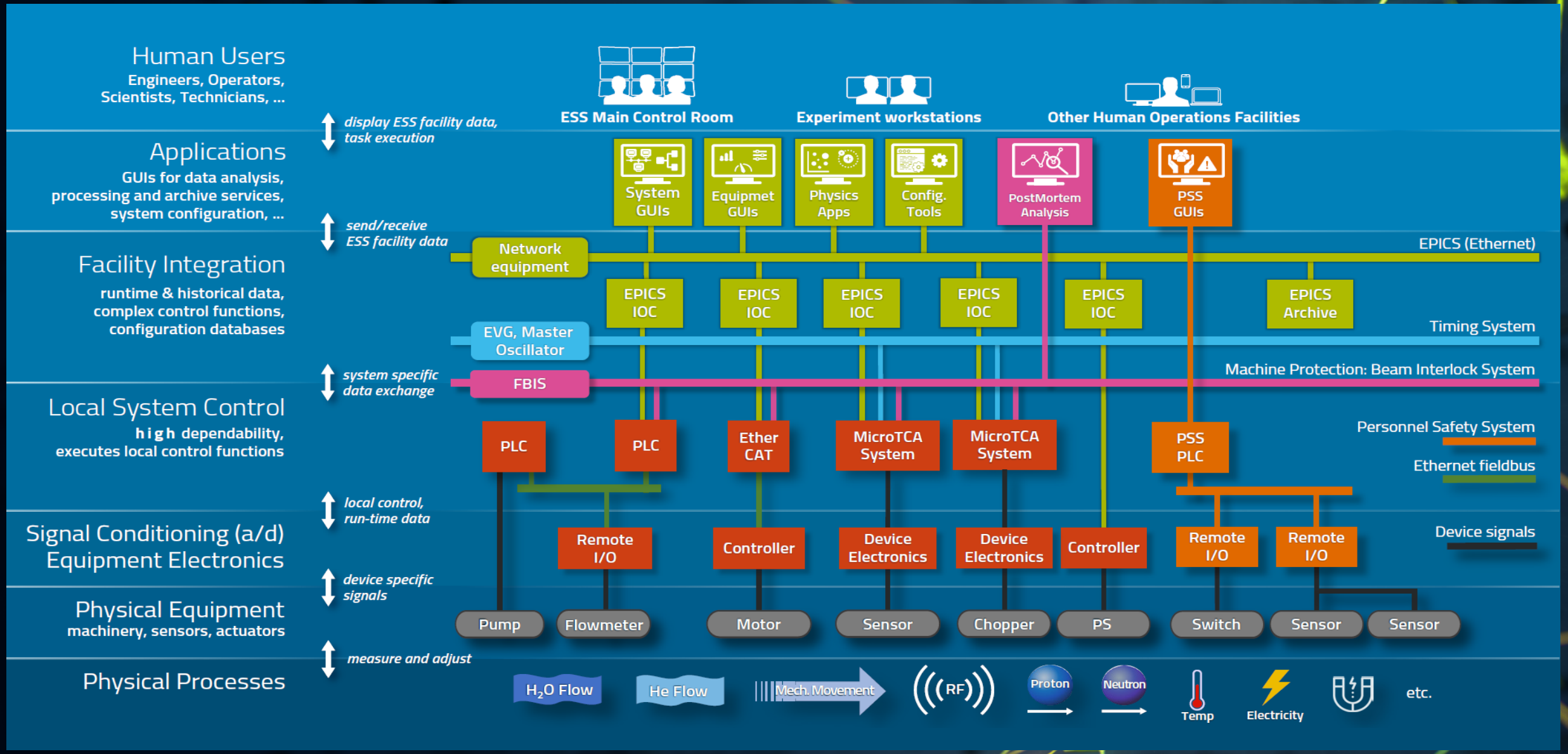
EPICS is a set of software tools and applications which provide a software infrastructure for use in building distributed control systems to operate complex systems such as scientific facilities or complex production industry processes.

Such distributed control systems typically comprise tens to thousands of computing elements, networked together to allow communication between them and to provide control and feedback of the various parts of the device from a central control room, or even remotely over the internet.

What can EPICS do?

- Remote control and monitoring of technical equipment (“universal” compatibility)
- Closed loop control, both slow and fast
- Automatic sequencing of operations
- Handle access security (protecting against user mistakes)
- Equipment operation constraints
- Alarm detection, reporting and logging
- Mode and facility configuration control (save/restore)
- Data acquisition and archiving including image data
- Data conversions and filtering
- Data trending, archiving, retrieval and plotting
- Data analysis - machine learning applications
- Modelling and simulation

Control system hierarchy



Distributed control system

Data centre

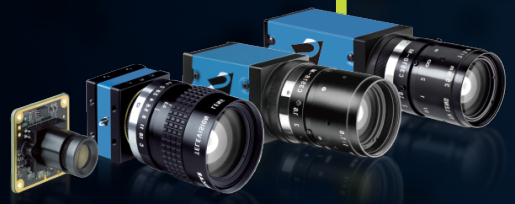
IOC

Control room

IOC:s - input/output controllers
An EPICS control system will contain one or more IOCs
Each IOC has a database telling it what to do
The database contains “Records” with:

- A unique name
- A behaviour defined by its record type
- Controllable properties
- Associated hardware I/O
- Links to other records

IOC



Vision systems

PLC

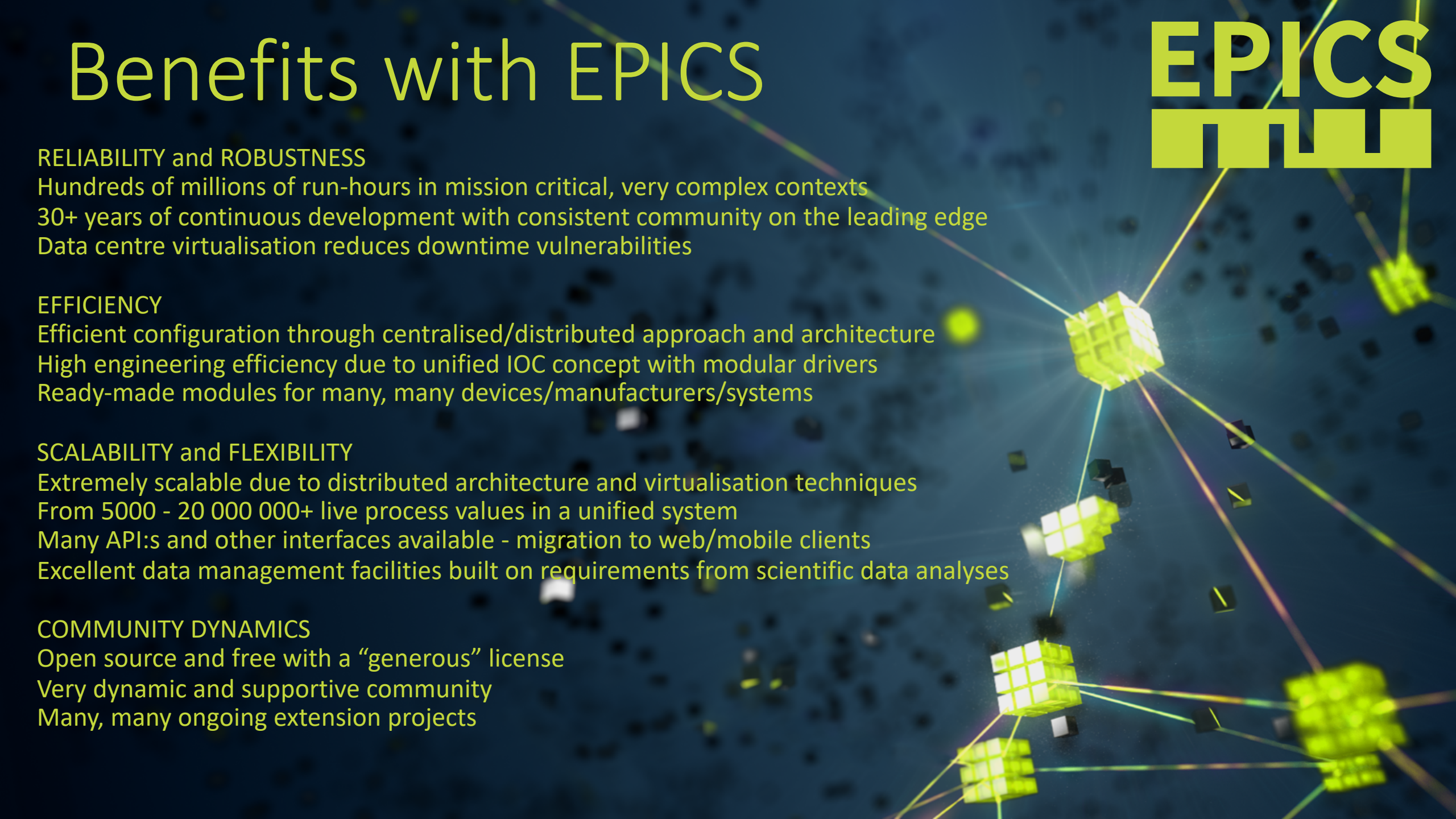
High speed DAQ

High-end PLC

PLC

Sensors

Benefits with EPICS



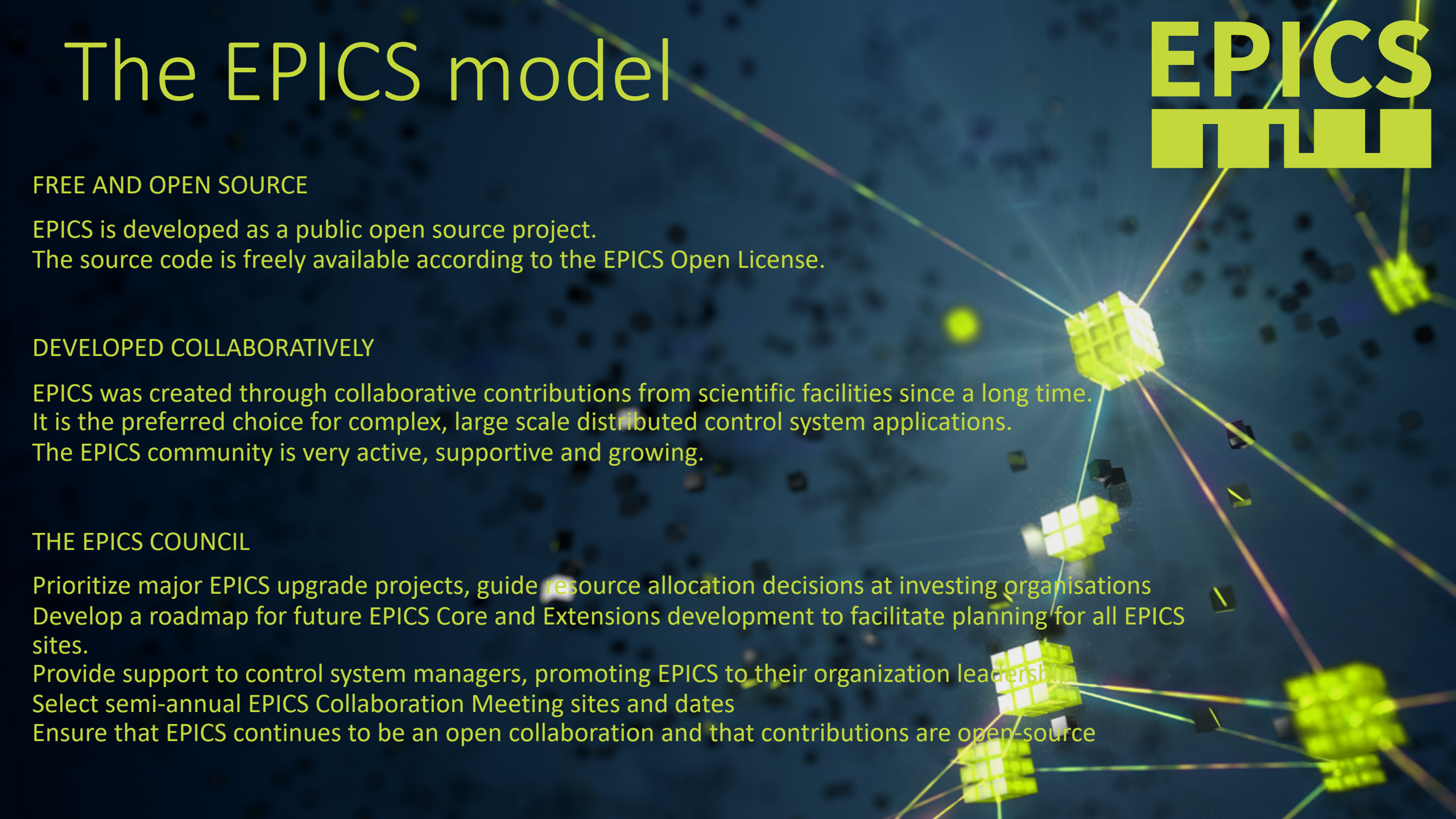
RELIABILITY and ROBUSTNESS
Hundreds of millions of run-hours in mission critical, very complex contexts
30+ years of continuous development with consistent community on the leading edge
Data centre virtualisation reduces downtime vulnerabilities

EFFICIENCY
Efficient configuration through centralised/distributed approach and architecture
High engineering efficiency due to unified IOC concept with modular drivers
Ready-made modules for many, many devices/manufacturers/systems

SCALABILITY and FLEXIBILITY
Extremely scalable due to distributed architecture and virtualisation techniques
From 5000 - 20 000 000+ live process values in a unified system
Many API:s and other interfaces available - migration to web/mobile clients
Excellent data management facilities built on requirements from scientific data analyses

COMMUNITY DYNAMICS
Open source and free with a “generous” license
Very dynamic and supportive community
Many, many ongoing extension projects

The EPICS model



FREE AND OPEN SOURCE

EPICS is developed as a public open source project.
The source code is freely available according to the EPICS Open License.

DEVELOPED COLLABORATIVELY

EPICS was created through collaborative contributions from scientific facilities since a long time.
It is the preferred choice for complex, large scale distributed control system applications.
The EPICS community is very active, supportive and growing.

THE EPICS COUNCIL

Prioritize major EPICS upgrade projects, guide resource allocation decisions at investing organisations
Develop a roadmap for future EPICS Core and Extensions development to facilitate planning for all EPICS sites.
Provide support to control system managers, promoting EPICS to their organization leadership
Select semi-annual EPICS Collaboration Meeting sites and dates
Ensure that EPICS continues to be an open collaboration and that contributions are open-source

Major opportunities next year(s)

- Supporting and working with Accelerator
  - Personnel safety and machine protection systems for accelerator commissioning
  - RF systems for normal conducting linac
  - Delivery and installation, commissioning of MEBT, RFQ and
  - Cryogenic distribution systems controls
  - Beam instrumentation systems

Competence
Embedded systems
EPICS
Process control

Hardware
FMC equipment
EtherCAT equipment
Infrastructure

- Supporting and working with Target, NSS and CF
  - Continue working with process control systems and overall target systems
  - Continue working with technology development for instruments while supporting integration efforts

Competence
PLC/Process control
Hardware
EtherCAT equipment

- ICS internal
  - Rollout of central timing system
  - Control system infrastructure - expanding to network services
  - Continue adapting and enhancing controls configuration management software
  - Continue adapting and enhancing software infrastructure (EPICS, CSS, Alarm, Logbook …)

Competence
Software development
EPICS

Planned procurements 2021

Equipment

WBS Name	Activity ID	Activity Name	Start	Cost 2021
MPS equipment	A20213670	MPS Siemens equipment for Target and NSS	2021-01-07	300 000
NSS equipment	A20214420	NSS integration HW 2020	2020-11-02	122 638
PSS equipment	A20218310	Equipment process control (processkontroll framework)	2021-01-07	423 999
PSS equipment	A20218330	Field devices and equipment (Siemens)	2021-01-07	180 002
PSS equipment	A20218450	Containments	2021-01-07	135 000
Control system networks equipment	A20219230	Cabling system for E buildings	2020-10-01	49 344
Control system networks equipment	A20219240	Cabling system for D buildings	2021-06-01	89 438
NSS equipment	A20228120	NSS integration HW 2021	2021-01-07	486 809
Control system networks equipment	A20228190	Inter-building fibres site wide	2020-08-17	75 140
MPS equipment	A20229790	MPS equipment To be replanned during 2020-02	2021-01-07	634 987

Framework agreements

- Our current framework agreement for procuring software development services expires in Q3 2021 and we are currently preparing for creating a new framework agreement

- Competence spectrum is quite wide
  - Java, database, web interface
  - C/C++ developers, network, real-time
  - EPICS development

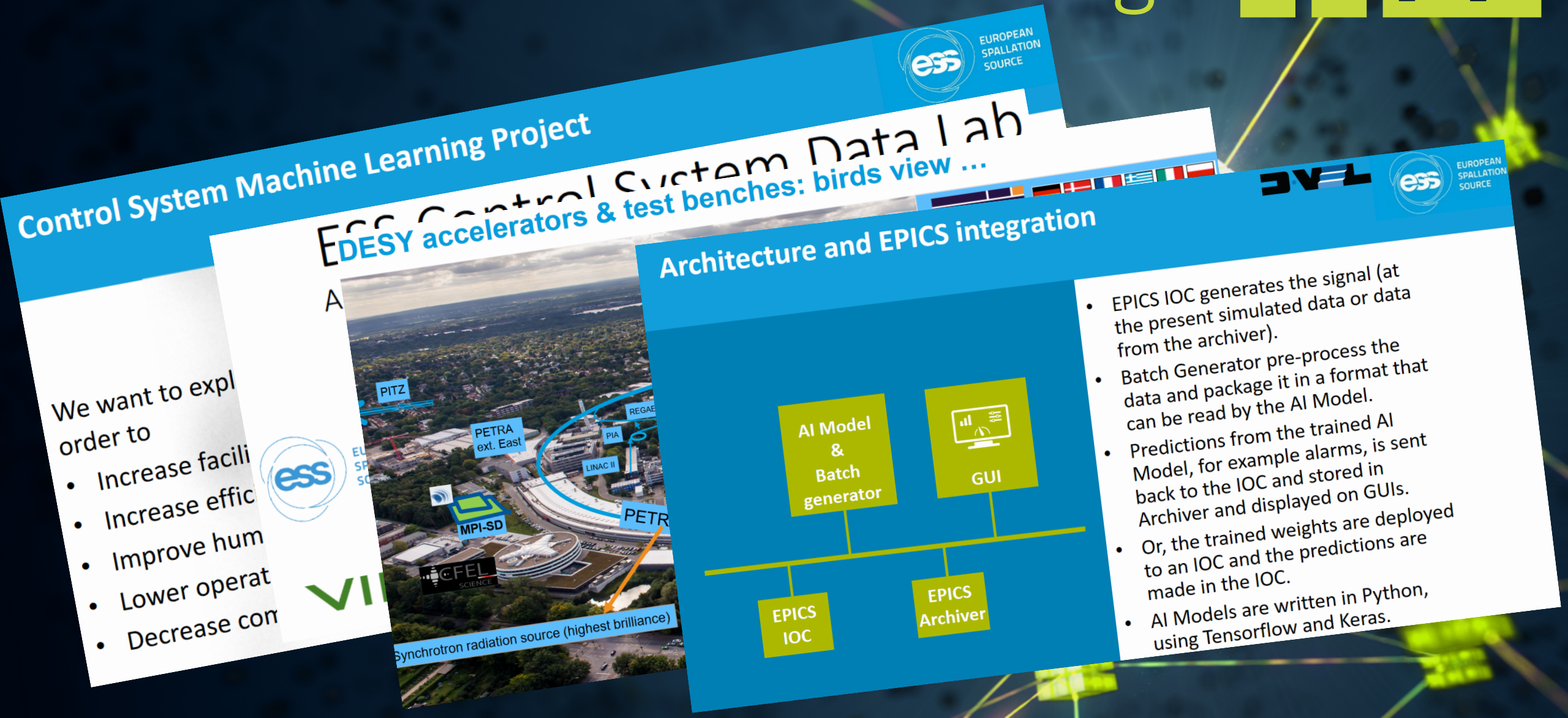
- Our estimate is 1 - 2 M€ per year 2021 - 2025, in total 6.8 M€
- Tip: contact your ESS industrial liaison officer

Software services framework	
Lot 1 (Software design and development)	**Country**
OTIF AB	Sweden
Helmes AS	Estonia
Sigma IT Consulting Sweden AB/ Sigma Connectivity AB	Sweden
Cosylab, Control System Laboratory d.d.	Slovenia
Tessella Ltd	United Kingdom
HiQ Skåne AB	Sweden
Evopro Innovation Ltd	Hungary
Proekspert AS	Estonia
Alten Sverige AB	Sweden
Human IT consulting/ Lexicon	Sweden
Lot 2 (Software development environment and test)	**Country**
Sigma IT Consulting Sweden AB/Sigma Connectivity AB	Sweden
Alten Sverige AB	Sweden
EC Konsult AB/Contribe AB	Sweden
Cosylab, CONTROL SYSTEM LABORATORY d.d.	Slovenia
Softhouse Consulting Sverige AB	Sweden
Combitech AB	Sweden
Tessella Ltd	United Kingdom
OÜ Elvior	Estonia
SCISYS UK Ltd.	United Kingdom
Lot 3 (Control system software development)	**Country**
Evopro Innovation LTD	Hungary
Tessella Ltd	United Kingdom
VITROCISET S.p.A.	Italy
Observatory Sciences Ltd	United Kingdom
Cosylab CONTROL SYSTEM LABORATORY d.d.	Slovenia
Lot 4 (Software project management services)	**Country**
OTIF AB	Sweden
Sigma IT Consulting Sweden AB	Sweden
HiQ Skåne AB	Sweden
Tessella Ltd.	United Kingdom
Cosylab, CONTROL SYSTEM LABORATORY d.d.	Slovenia

Focus areas


ESS driving technology - MicroTCA
ESS is investing significantly in MicroTCA technology
ESS will be around for many years to come
MicroTCA is a hardware platform generating a lot of interest
µTCA
Status and plans for IFC MicroTCA platform
Special focus
ESS standard high-performance controls platform
ESS driving technology - EPICS 7
Experimental Physics and Industrial Control
EPICS is a set of software tools and application
building distributed control systems to operat
Experiments and major Telescopes.
Such distributed control systems typically co
computers, networked together to allow co
to provide control and feedback of the vario
control room
Flexible and scalable
EPICS is used at many science facilities aro
computers that directly or indirectly contr
workstations and servers in the control r
the systems, and perform data logging, a
EPICS development
EPICS is developed through a collabora
the EPICS family of software. The deve
consists of major contributors to the E
infrastructure for use in
ESS driving technology - Machine learning
A project is ongoing to explore if modern AI/Machine learning technologies can be used to augment the ESS control system
– Decrease commissioning time and effort
– Increased facility availability (95% goal)
– Increased efficiency of operation
– Improved human/machine interaction
– Lowered operational and maintenance costs
Control system machine learning project
Machine learning project is starting on Q1 2019
Project deliverables

EPICS and machine learning




EPICS
Thank you
henrik.carling@ess.eu
www.epics-controls.org