EUROPEAN SPALLATION SOURCE

Controls Integration at ESS and In-kind

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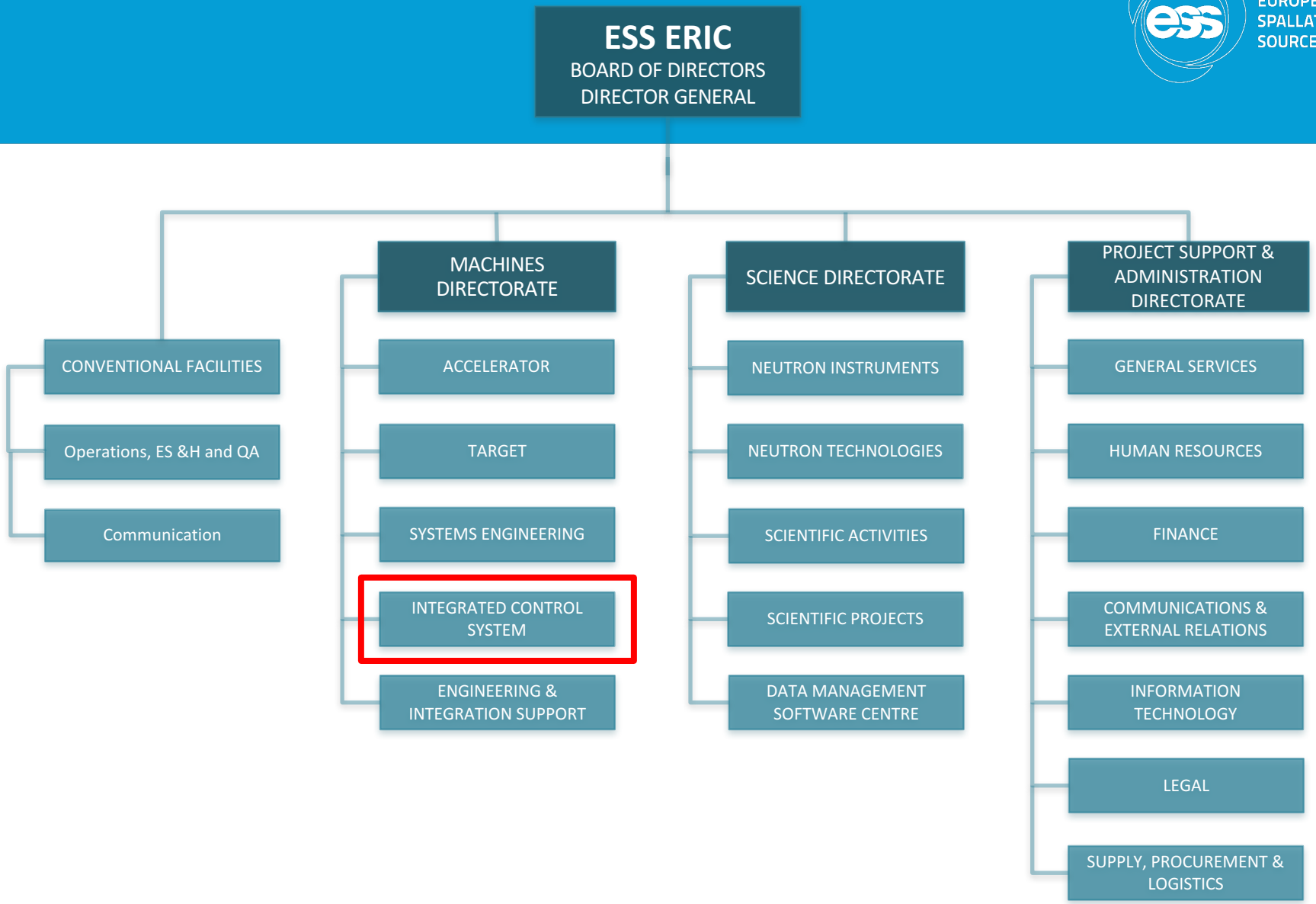
Outline

- Integrated Control System and In-Kind
- Challenges
  - Challenges from technology diversity, distributed design & development
  - Organizational challenges
- Solutions
  - Standardization
  - Distributed design and development management
  - Team Culture
- Conclusions


ESS ERIC
BOARD OF DIRECTORS
DIRECTOR GENERAL
CONVENTIONAL FACILITIES
Operations, ES &H and QA
Communication
MACHINES DIRECTORATE
ACCELERATOR
TARGET
SYSTEMS ENGINEERING
INTEGRATED CONTROL SYSTEM
ENGINEERING & INTEGRATION SUPPORT
SCIENCE DIRECTORATE
NEUTRON INSTRUMENTS
NEUTRON TECHNOLOGIES
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SCIENTIFIC PROJECTS
DATA MANAGEMENT SOFTWARE CENTRE
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GENERAL SERVICES
HUMAN RESOURCES
FINANCE
COMMUNICATIONS & EXTERNAL RELATIONS
INFORMATION TECHNOLOGY
LEGAL
SUPPLY, PROCUREMENT & LOGISTICS

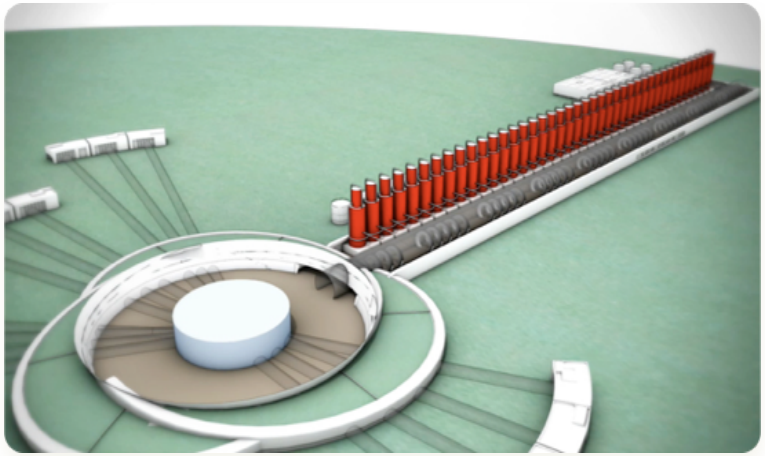
What is ICS about?

- The ESS facility is a large and complex machine with very, very much equipment that needs to work in synchronization - and with well-known configurations
  - Power Supplies
  - Vacuum systems
  - Cryogenic System
  - Water Cooling Systems
  - RF equipment
  - Beam Instrumentation
  - Building Management Systems

- For this purpose almost all equipment at the ESS facility is connected to the **Integrated Control System.**

- The goal is to create an abstraction of the whole machine in Process Variables that allows the operation of the machine as a whole

- An estimated **1.5 million** Process Variables will be needed



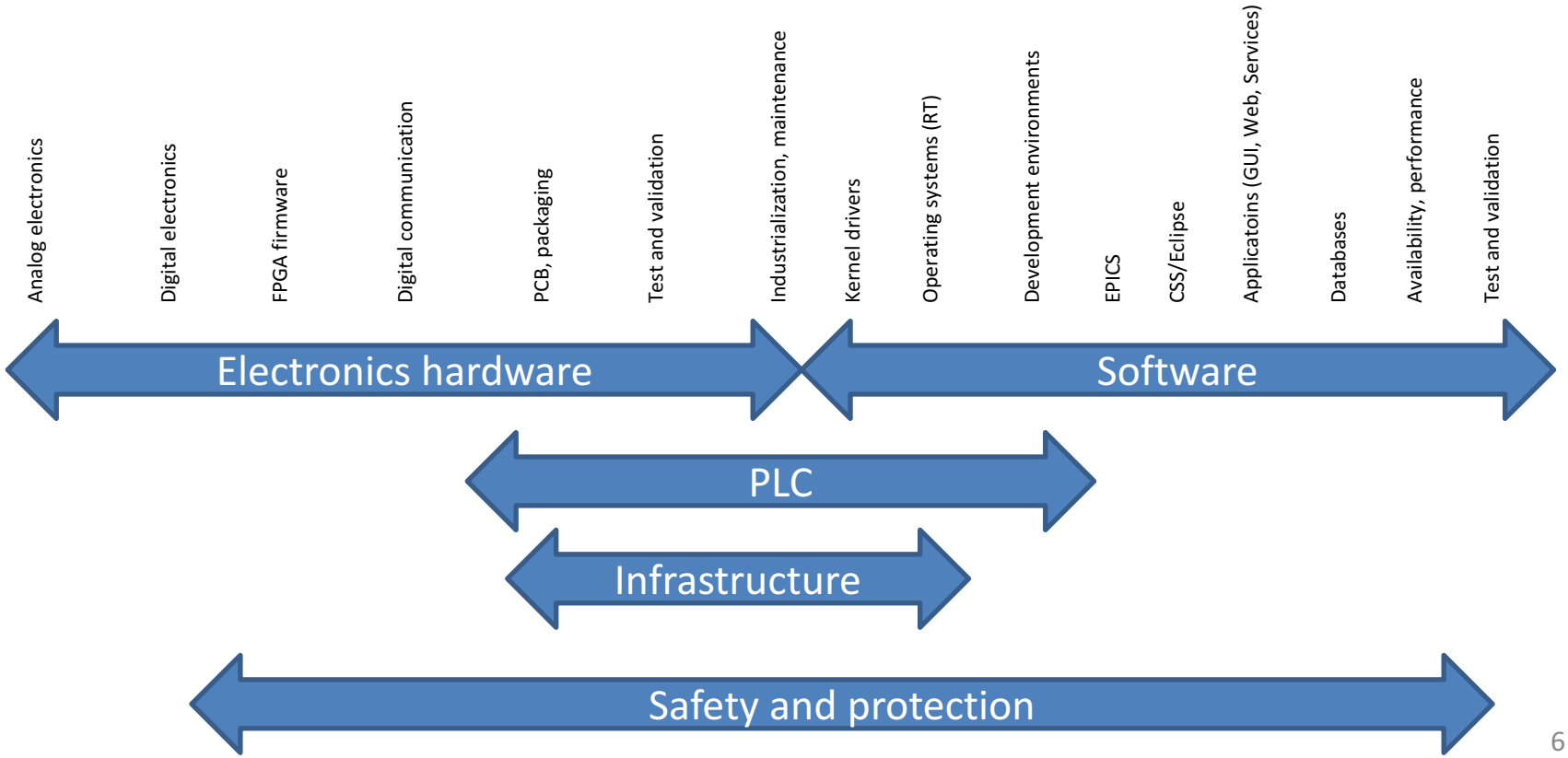
Top Level Requirements

- Provide the following to ESS:
  - Control system framework for monitoring and control of **accelerator**, **target**, **instruments** and **conventional facilities (EPICS)**
  - Timing service for **generating events**, **synchronization** of devices and **time stamping** (in the ns range)
  - Control system services and applications to perform **commissioning** and **operations**
  - **IOC** and **Integration Support** to stakeholders
  - **Machine Protection** and **Personnel Safety** systems
  - Control Room(s)

- Constraining requirements
  - High reliability and availability!

Technology scope for ICS

- The span of technical scope and the competencies needed in ICS is enormous
- The processes and the different stages in the lifecycle have to be adapted to the development of different technologies (e. g. Agile development for Sofware vs. Classical development cycles for hardware).



ICS Organization

2016-11-07

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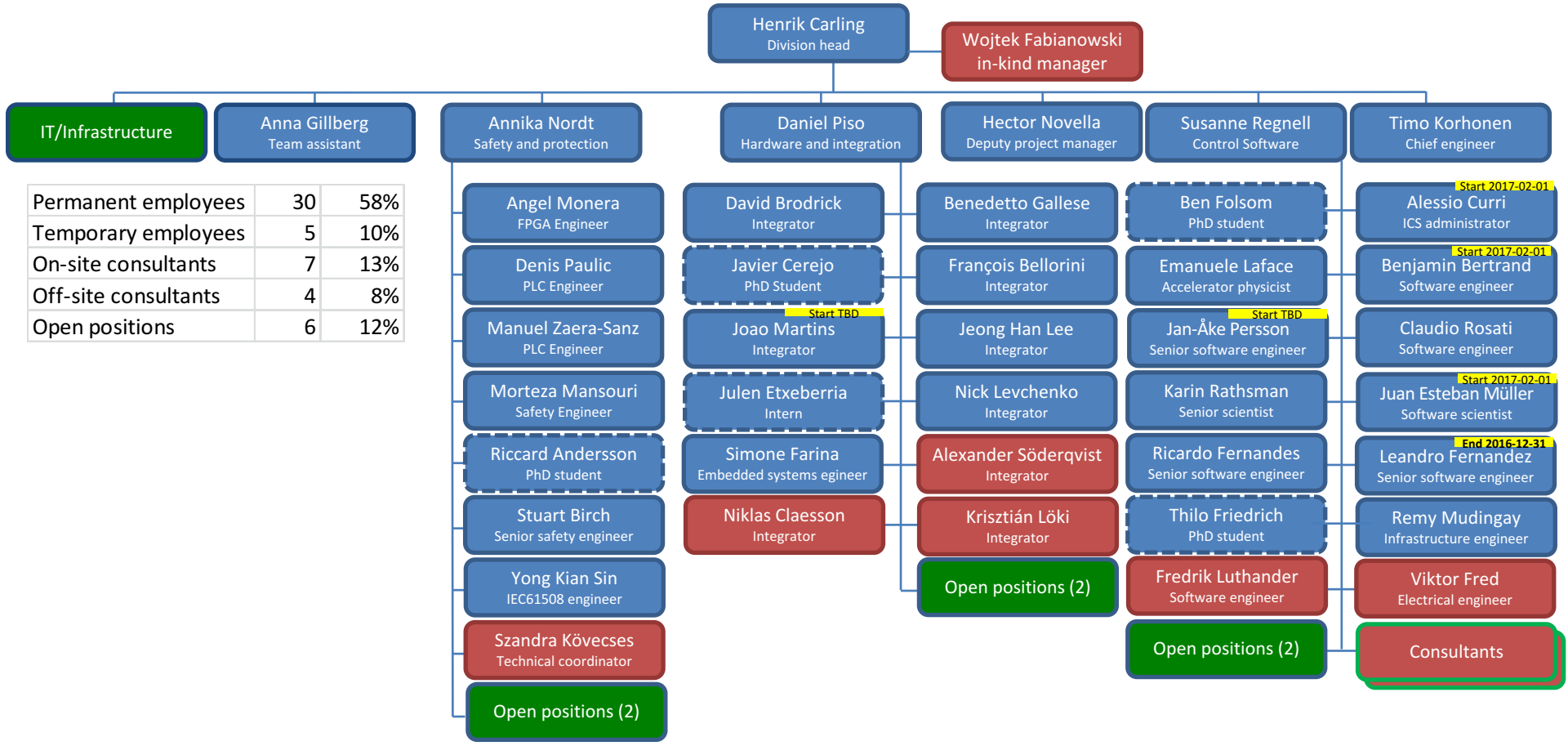


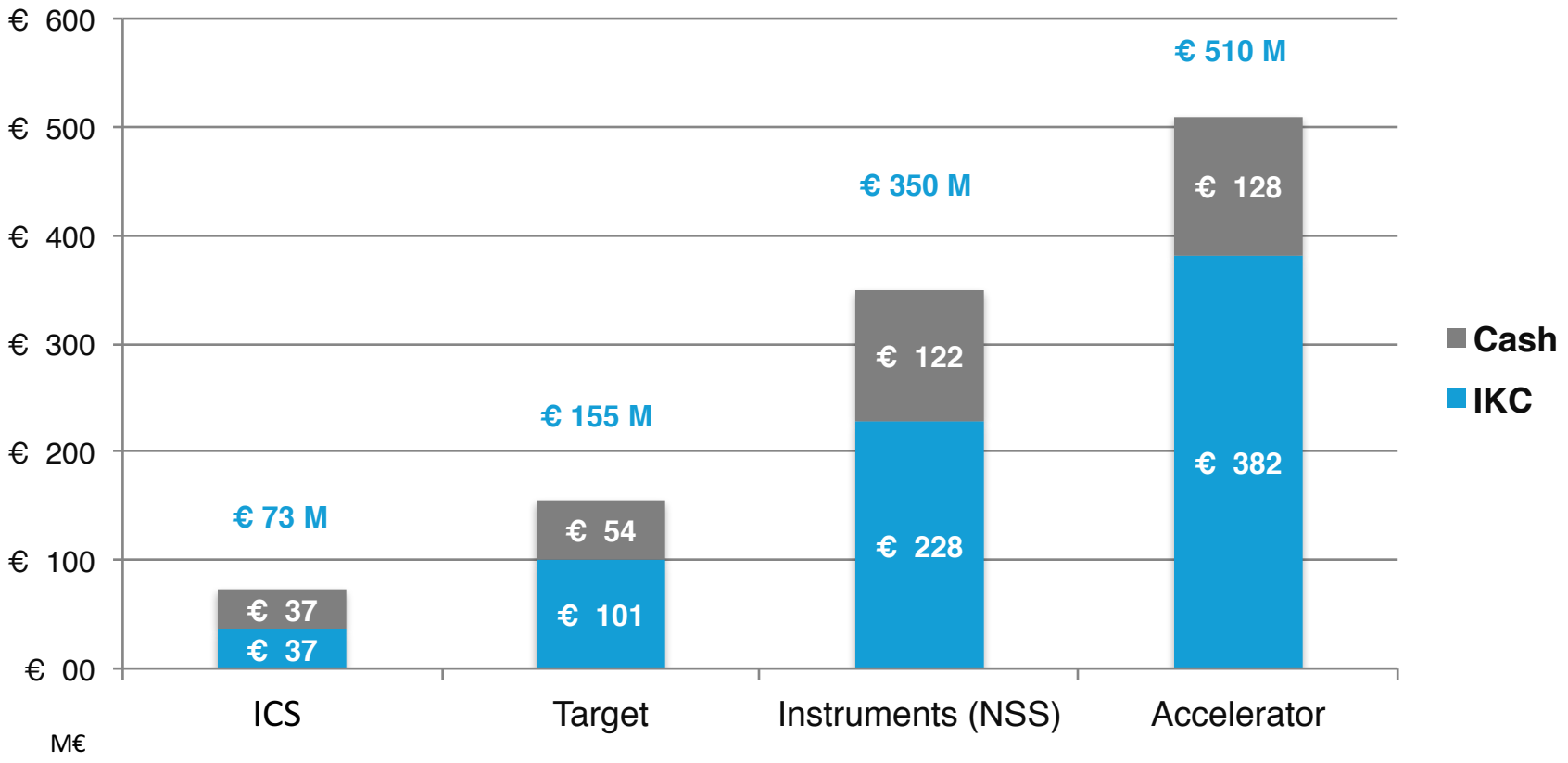
Permanent employees	30	58%
Temporary employees	5	10%
On-site consultants	7	13%
Off-site consultants	4	8%
Open positions	6	12%

Employee | Consultant

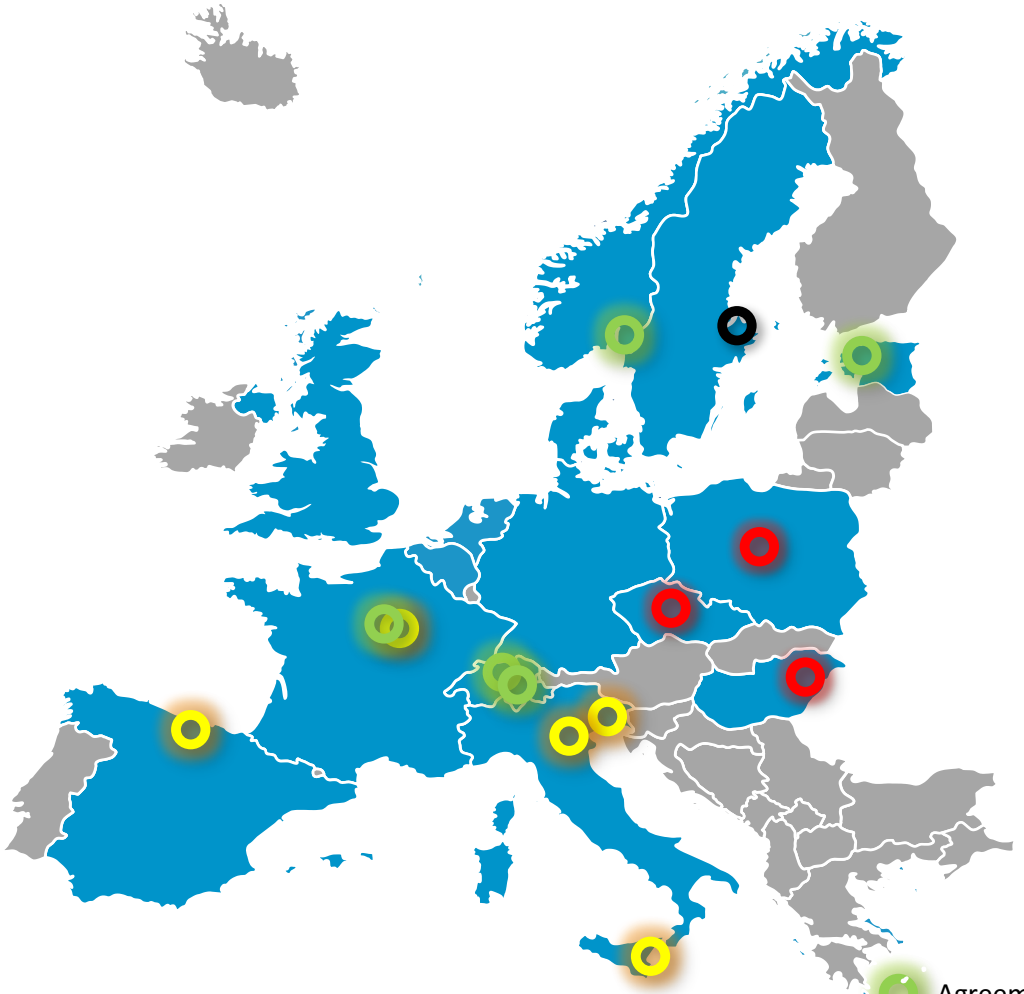
Temporary employee | Consultant off-site | Position under consideration

ESS In-kind Goals

Construction cost: € 1.84 Billion (2013 €)
In-kind: € 747.5 Million



ICS In-kind partners



Partner Institutes
Atomki, Hungary
CEA, France
CNRS/IPNO, France
Elettra, Italy
ESS Bilbao, Spain
IFE, Norway
INFN Catania, Italy
INFN Legnaro, Italy
PSI, Switzerland
Tallinn Technical University, Estonia
ÚJV Řež, Czech Republic
University of Łódź , Poland
Uppsala University, Sweden
ZHAW, Switzerland

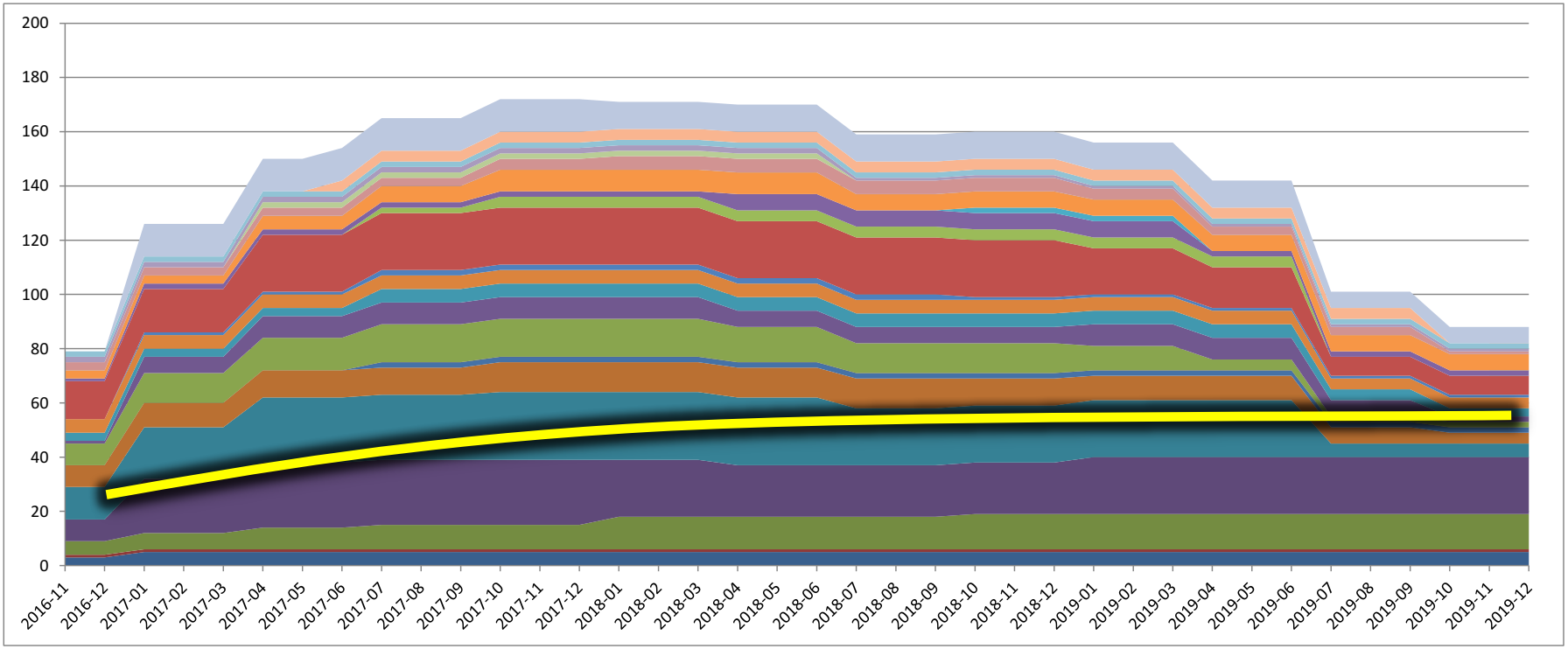
Agreement signed

Early discussions

Agreement waiting for signature

Collaboration agreement

ICS - construction phase value envelope



- The ICS value envelope for the construction phase shows the aggressive project schedule
- A majority of the ICS value is labor based effort (i.e. not equipment)
- The ICS estimated headcount envelope reveals large in-kind/supplier opportunities

Control System Integration

- (ISO/IEC/IEEE 15288) describes integration in a system life cycle process perspective as “to synthesize a set of system elements into a realized system (product or service) that satisfies system requirements, architecture and design”

- The scope of the **Integration Team** is to perform of the development of control systems from requirements engineering, design, implementation, procurement and delivery for installation, verification and support by using the components provided by other teams.

- Goals
  - Achieve a proper abstraction of subsystems/devices as a collection of EPICS PVs, to permit operation and monitoring
  - Remote access to all local control parameters and all data that is potentially relevant/interesting for operation and maintenance.
  - Data in a form that allows correlation across the machine

- Approach
  - The machine is huge – design for uniformity
  - Interface to similar local control is uniform
    - DAQ boards, Power supplies, motion control, imaging, …
  - Provide subsystems/devices data in a standard form
  - Keep the amount of different types of hardware to support as low as possible
  - Use common software components whenever possible
  - Focus on documentation on support to developers and integrators

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Challenges from technology diversity, distributed design & development*

- Technical design, but also project management is often heavily based on assumptions (e.g. attainable performances or lead development times of novel system designs).

- Integration is often performed in a *bottom-up* way, initially within the context of specialty engineering teams, and gradually converging to higher-level systems . Creating SILOS!

- In-kind process distributes the design lifecycle, interface and requirements management over different organizations with different organizations" probably with different conventions/styles/models/ontologies….

- The diversity of systems and technologies requires a coordinated systems engineering approach. This applies to system life cycle management and system-related techncial information management.

* T. Friedrich and D. Piso, "*An Integration Strategy for Controls and Computing Systems at a large Particle Accelerator based Research Facility*". Conference on System of Systems Engineering (2016)

Organizational challenges*

- ESS is a mix of highly specialized individuals with heterogeneous professional backgrounds from often temporary, singular project conditions.
- The organization is young, so the bonds within and between teams is still weak.
- High-end facilities exhibit a strong *prototypical character* that often persists over the lifetime of the facility. The *variety of involved professional backgrounds* hinders or distracts from the utilisation of formal or informal engineering standards typically found in different disciplines
- Establishing the view of an accelerator or an instrument as *one* system does not necessarily come naturally to involved scientists and engineers. It can be caused by ownership concerns and unfamiliarity with *systems thinking*.
- Lack of well stablished process for configuration management (main case PLM).
- The number of interfaces is increased and designs resemble the organization

The control and computing systems domain is particularly exposed to these effects, as it is essentially involved in next to all technical aspects or systems.

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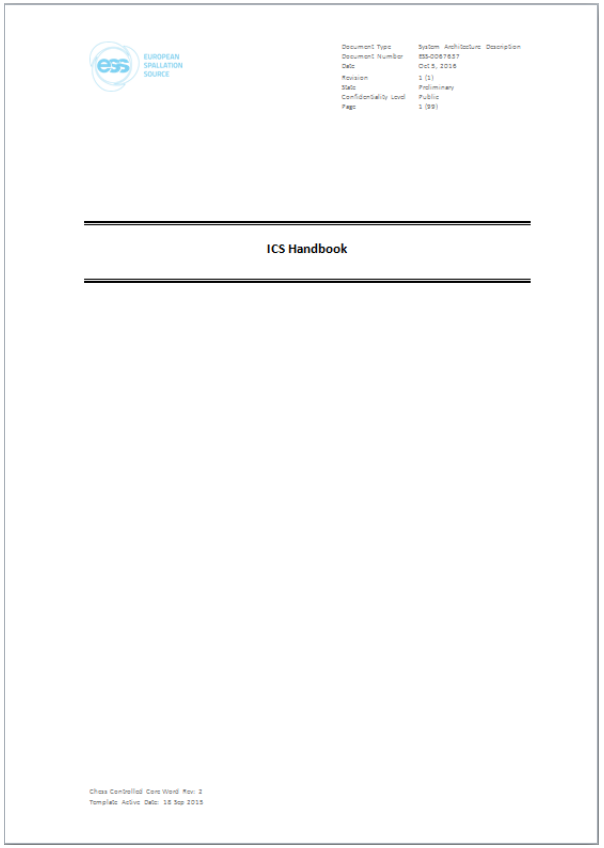
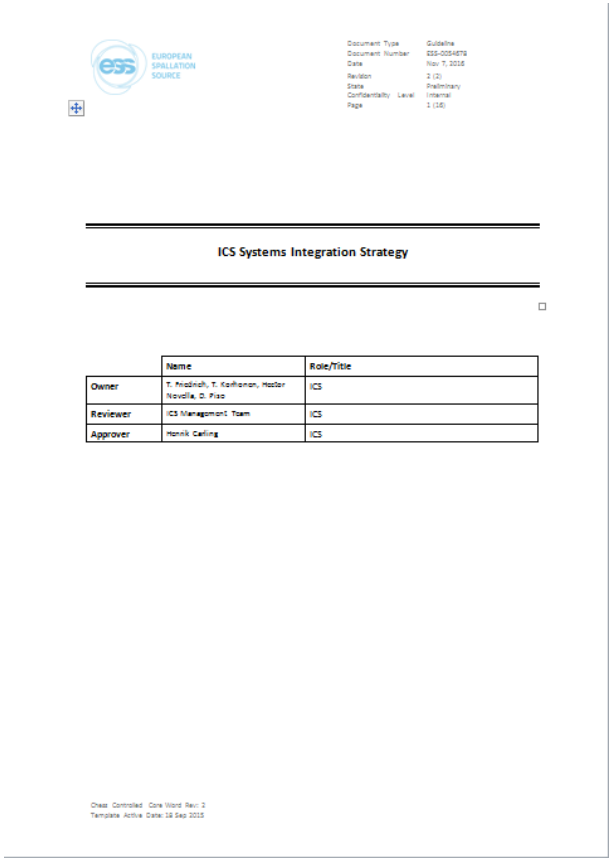
Distributed Life Cycle

- ICS Handbook



ICS Handbook

- ICS Integration strategy



ICS Systems Integration Strategy

	Name	Role/Title
Owner	T. Friedrich, T. Korhonen, Hasan Nowaliq, D. Piso	ICS
Reviewer	ICS Management Team	ICS
Approver	Henrik Carling	ICS

Standardization

- Crucial for controls
- Affects costs and even the shape of the teams on the short term and operation costs in the long term
- It is important to understand standardization as lifecycle management

EPICS

control system studio

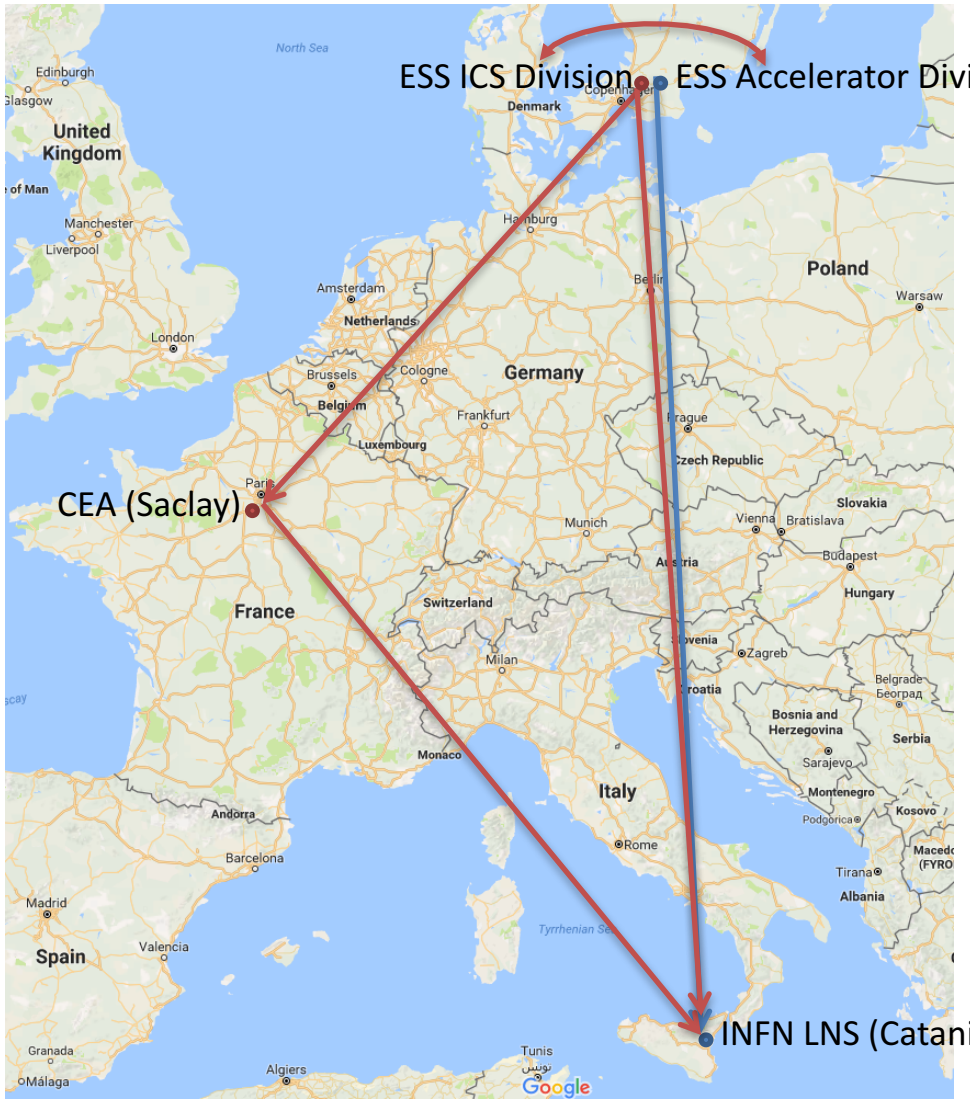
ANSIBLE

VAGRANT

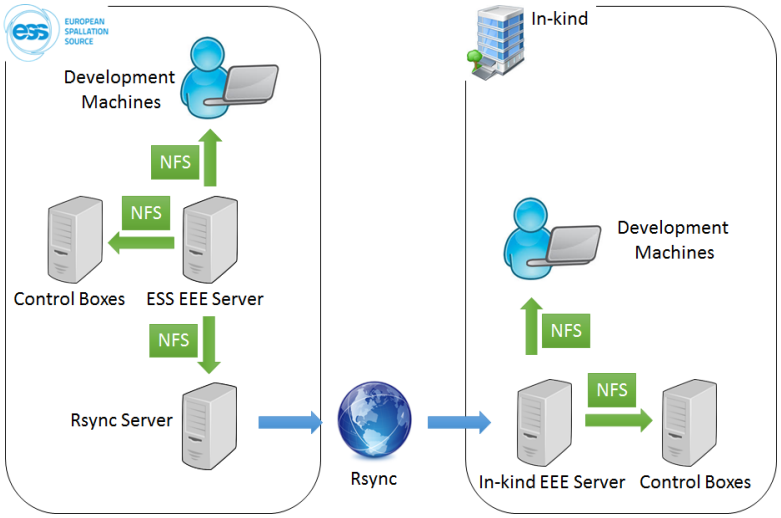
Atlassian

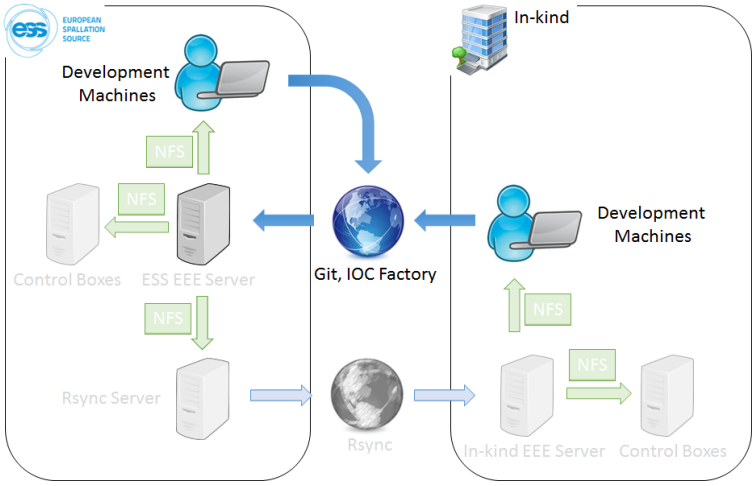
Micro-Research Finland Oy

Distributed development



Distributed development





ESS EPICS Environment

```
[nicklevchenko@localhost modules]$ tree vac_ctrl_leyboldtd20/
vac_ctrl_leyboldtd20/
└── nicklevchenko
    ├── 3.14.12.5
    │   └── lib
    │       ├── centos7-x86_64
    │       │   └── vac_ctrl_leyboldtd20.dep
    │       └── eldk56-e500v2
    │           └── vac_ctrl_leyboldtd20.dep
    ├── 3.15.2
    │   └── lib
    │       ├── centos7-x86_64
    │       │   └── vac_ctrl_leyboldtd20.dep
    │       └── eldk56-e500v2
    │           └── vac_ctrl_leyboldtd20.dep
    ├── 3.15.4
    │   └── lib
    │       ├── centos7-x86_64
    │       │   └── vac_ctrl_leyboldtd20.dep
    │       └── eldk56-e500v2
    │           └── vac_ctrl_leyboldtd20.dep
    ├── db
    │   └── vac-ctrl-leyboldtd20.db
    ├── misc
    │   └── vac-ctrl-leyboldtd20.proto
    └── startup
        └── vac-ctrl-leyboldtd20.cmd
```

HW & I Group Mission Statement, Values and Soft Skills

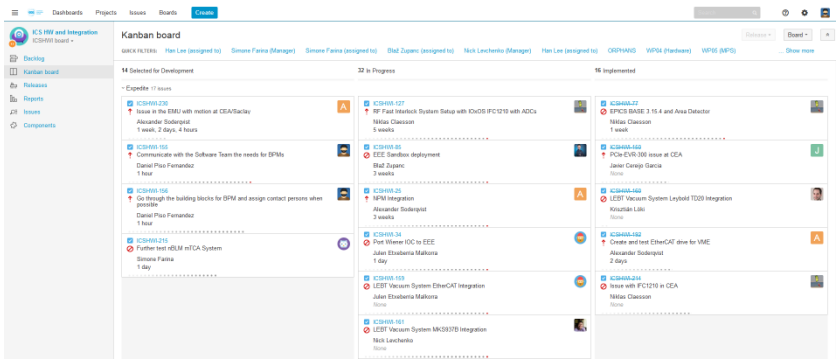
- To develop a reliable, high-performance and cost-efficient control system in collaboration with the rest of ICS, stakeholders and the community. To become a reference group for excellent engineering practices in hardware and systems integration.

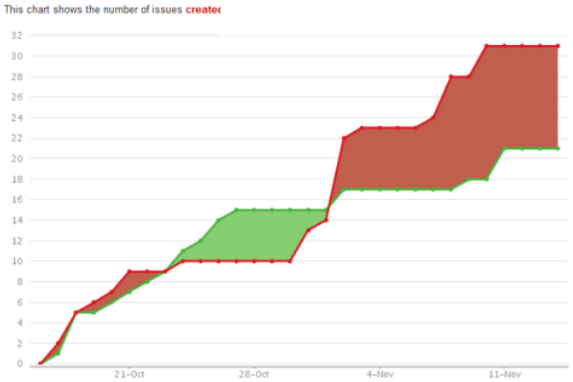
- Openness and honesty
  - Honest and clear
  - Communication is key
  - Try to resolve conflicts quickly and put them behind us
- Helpful attitude and team spirit
  - Help each other
  - No finger pointing - no blaming - no competition
  - Adapt to changes quickly
- Respect mandate and competence
  - Respect other's mandate
  - Respect other's work
  - Respect others competence
- One ICS towards stakeholders
  - Act as one team, and one ICS
  - We stand-in for each other
  - Gather information for the team, do not amplify rumors, act based on facts

- Flexibility
- Team spirit
- Ability to manage conflict and imperfection
- Ability to influence without power

Organizational setup

- The team, as the rest of ICS is organize in a classical matrix structure
- It provides resources to 6 workpackages representing about 40% of the project value
- The matrix allows flexibility in assigning resources and managing prioritization
- At least in theory, everyone is available for any task!
- The long term goal is to set up metrics (KPIs) to measure and improve the efficiency of the team and the processes related to integration





Conclusion

- In-kind activity brings a lot of value and also challenges for the development of the control systems
- Without in-kind ESS could not build an organization and deliver a neutron source at the same time.
- In-kind enables transfer of knowledge and availability of highly specialized skills.
- Controls is a discipline specially affected by the lack of a more coordinated systems engineering approach
- Standardization and good distributed development process and open communication are key for success in controls integration