gtd Science, Infrastructures & Robotics sir

Presentation

DTT Project – ROMA 30/05

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Science, Infrastructures & Robotics

GTD is a **system and software engineering company** devoted to the design, development and integration of **large, complex** and/or **critical** Operational Systems.

What?

Engineering, Methodology and Norms.

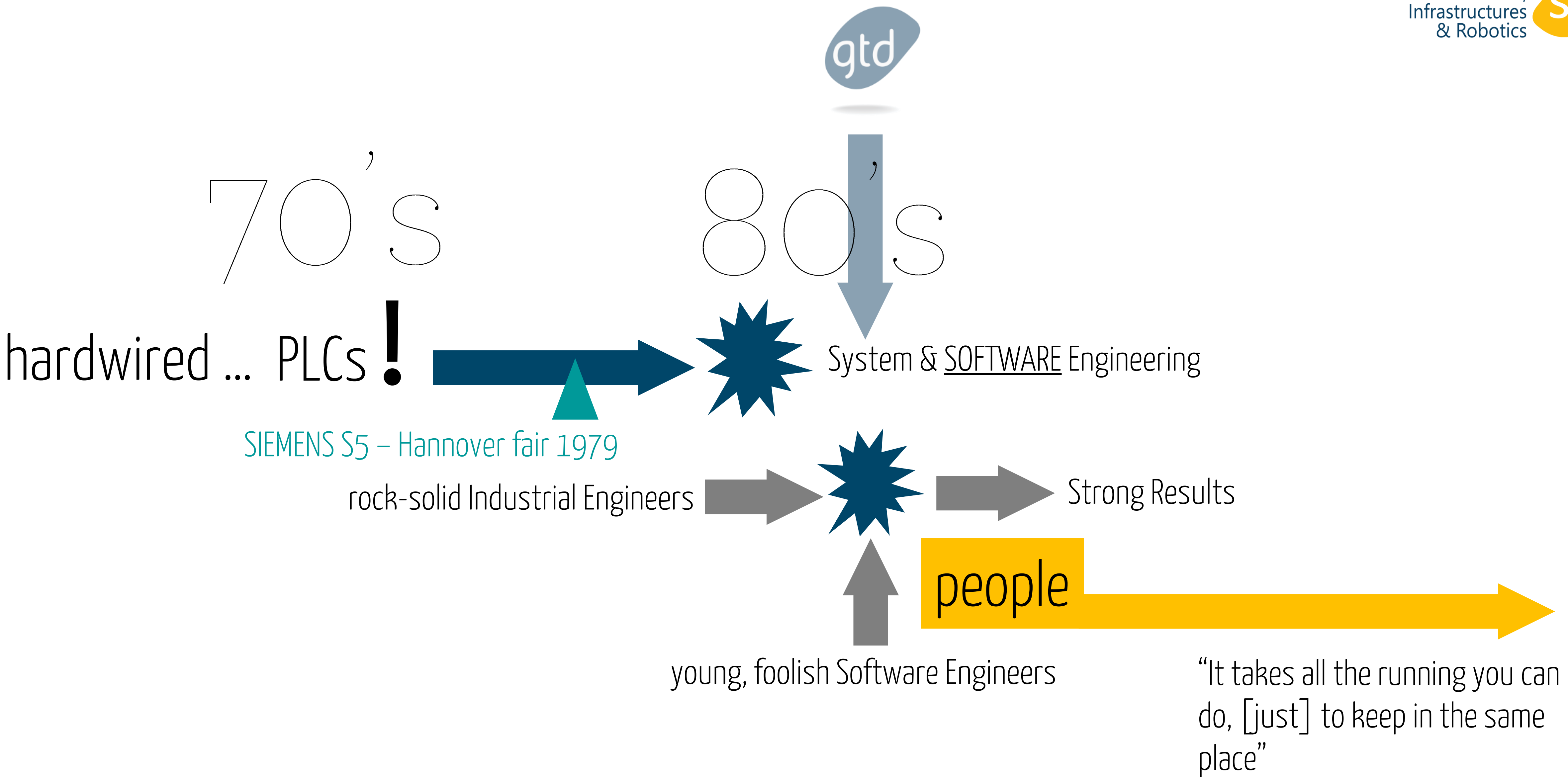
How?

Science, Infrastructures & Robotics

GTD was founded in 1987, in Barcelona.

Work ethics & engineering capabilities.

Science,
Infrastructures
& Robotics



Science, Infrastructures & Robotics

80's

90's

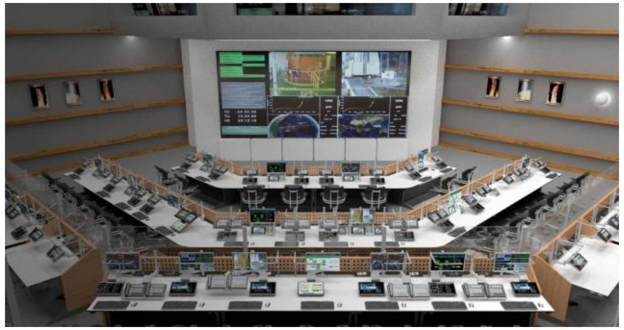
1989

methodology

pragmatism

industrial background

leading role of ESA



Jupiter II Control Room

1977

"the importance of software standards for the proper conduct of complex or critical space software projects"

1984

PSS-05

1995

ISO/IEC 12207

software engineering ECCS-E-40

software product assurance ECSS-Q-80

Science, Infrastructures & Robotics

90's

SPACE → PSS-05

1995 → 1997

methodology

PSS-05

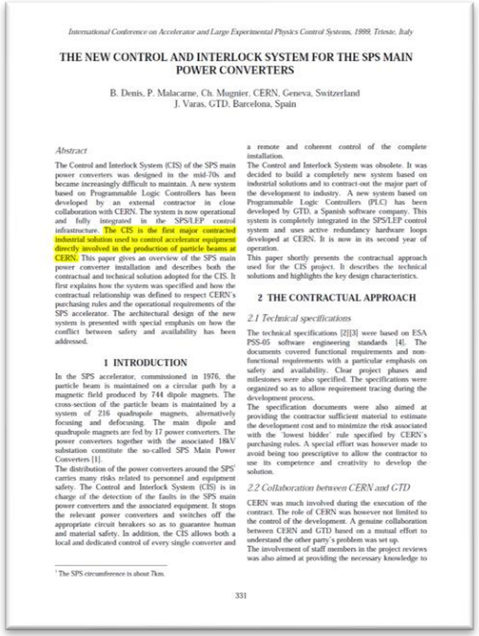
OMT

1997

Control and Interlock System for the SPS main power converters

“the first major contracted industrial solution used to control accelerator equipment directly involved in the production of particle beams at CERN”.

https://accelconf.web.cern.ch/ica99/papers/mc1p28.pdf



International Conference on Accelerator and Large Experimental Physics Control Systems, 1999, Trieste, Italy

THE NEW CONTROL AND INTERLOCK SYSTEM FOR THE SPS MAIN POWER CONVERTERS

B. Denis, P. Malacarne, Ch. Mugnier, CERN, Geneva, Switzerland
J. Varas, GTD, Barcelona, Spain

Abstract

The Control and Interlock System (CIS) of the SPS main power converters was designed in the mid-70s and became increasingly difficult to maintain. A new system based on Programmable Logic Controllers has been developed by an external contractor in close collaboration with CERN. The system is now operational and fully integrated in the SPS/LEP control infrastructure. The CIS is the first major contracted industrial solution used to control accelerator equipment directly involved in the production of particle beams at CERN. This paper gives an overview of the SPS main power converter installation and describes both the contractual and technical solution adopted for the CIS. It first explains how the system was specified and how the contractual relationship was defined to respect CERN's purchasing rules and the operational requirements of the SPS accelerator. The architectural design of the new system is presented with special emphasis on how the conflict between safety and availability has been addressed.

1 INTRODUCTION

In the SPS accelerator, commissioned in 1976, the particle beam is maintained on a circular path by a magnetic field produced by 744 dipole magnets. The cross-section of the particle beam is maintained by a system of 216 quadrupole magnets, alternatively focusing and defocusing. The main dipole and quadrupole magnets are fed by 17 power converters. The power converters together with the associated 18kV substation constitute the so-called SPS Main Power Converters [1].

The distribution of the power converters around the SPS[1] carries many risks related to personnel and equipment safety. The Control and Interlock System (CIS) is in charge of the detection of the faults in the SPS main power converters and the associated equipment. It stops the relevant power converters and switches off the appropriate circuit breakers so as to guarantee human and material safety. In addition, the CIS allows both a local and dedicated control of every single converter and a remote and coherent control of the complete installation.

The Control and Interlock System was obsolete. It was decided to build a completely new system based on industrial solutions and to contract-out the major part of the development to industry. A new system based on Programmable Logic Controllers (PLC) has been developed by GTD, a Spanish software company. This system is completely integrated in the SPS/LEP control system and uses active redundancy hardware loops developed at CERN. It is now in its second year of operation.

This paper shortly presents the contractual approach used for the CIS project. It describes the technical solutions and highlights the key design characteristics.

2 THE CONTRACTUAL APPROACH

2.1 Technical specifications

The technical specifications [2][3] were based on ESA PSS-05 software engineering standards [4]. The documents covered functional requirements and non-functional requirements with a particular emphasis on safety and availability. Clear project phases and milestones were also specified. The specifications were organized so as to allow requirement tracing during the development process.

The specification documents were also aimed at providing the contractor sufficient material to estimate the development cost and to minimize the risk associated with the 'lowest bidder' rule specified by CERN's purchasing rules. A special effort was however made to avoid being too prescriptive to allow the contractor to use its competence and creativity to develop the solution.

2.2 Collaboration between CERN and GTD

CERN was much involved during the execution of the contract. The role of CERN was however not limited to the control of the development. A genuine collaboration between CERN and GTD based on a mutual effort to understand the other party's problem was set up.

The involvement of staff members in the project reviews was also aimed at providing the necessary knowledge to

[1] The SPS circumference is about 7km.

331

“The CIS system has been delivered on time and within budget in March 1998. The technical competence of GTD and the quality of the specification have been key factors explaining the success. We also believe that the quality of the relationship and the true collaboration between CERN and GTD were sine qua non.”

90's

Supervision Layer

Paradigm Change

Emerging Technologies: CORBA-JAVA

“commercial SCADA systems would in general provide significant benefits and that more specifically the new generation of products, which are currently emerging and which are device-oriented, would provide a feasible technical solution for the controls of the LHC detectors.”

1999

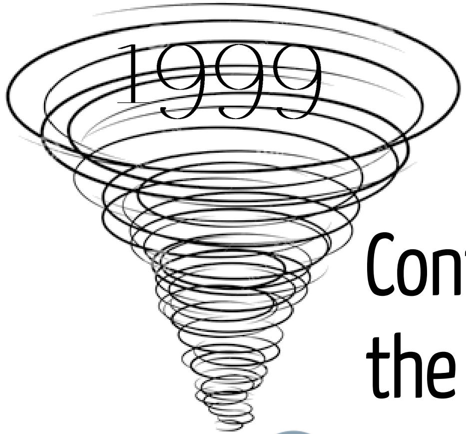
PSS-05

International Conference on Accelerator and Large Experimental Physics Control Systems, 1999, Trieste, Italy

SELECTION AND EVALUATION OF COMMERCIAL SCADA SYSTEMS FOR THE CONTROLS OF THE CERN LHC EXPERIMENTS

A. Daneels, CERN, Geneva, Switzerland
W. Salter, CERN, Geneva, Switzerland

https://accelconf.web.cern.ch/ica99/papers/ta2001.pdf



Control System of the LHC Cryogenics

“However, the selection of a product is not the end of the story. In order to minimise the development effort by the end-users, and to achieve a homogeneous final system, a detailed engineering phase will need to be performed.”

!

ENGINEERING METHODOLOGY
CONTROL FRAMEWORK

2000

Control System of the LHC Cryogenics

UML

PSS-05

UNICOS

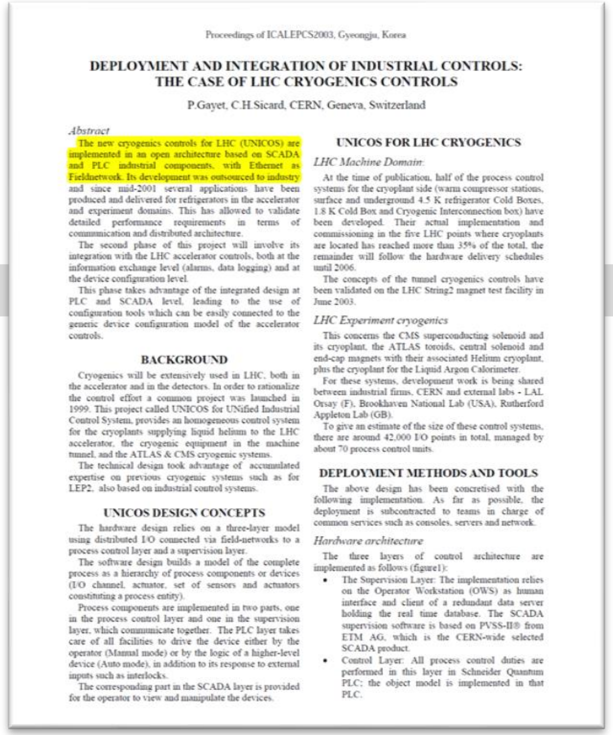
FRAMEWORK

PVSS-II

WinCC OA

Btw … : Design of the new CERN Control Room

2003



Proceedings of ICALEPCS2003, Gyeongju, Korea

DEPLOYMENT AND INTEGRATION OF INDUSTRIAL CONTROLS: THE CASE OF LHC CRYOGENICS CONTROLS

P.Gayet, C.H.Sicard, CERN, Geneva, Switzerland

Abstract

The new cryogenics controls for LHC (UNICOS) are implemented in an open architecture based on SCADA and PLC industrial components, with Ethernet as Fieldnetwork. Its development was outsourced to industry and since mid-2001 several applications have been produced and delivered for refrigerators in the accelerator and experiment domains. This has allowed to validate detailed performance requirements in terms of communication and distributed architecture.

The second phase of this project will involve its integration with the LHC accelerator controls, both at the information exchange level (alarms, data logging) and at the device configuration level.

This phase takes advantage of the integrated design at PLC and SCADA level, leading to the use of configuration tools which can be easily connected to the generic device configuration model of the accelerator controls.

BACKGROUND

Cryogenics will be extensively used in LHC, both in the accelerator and in the detectors. In order to rationalize the control effort a common project was launched in 1999. This project called UNICOS for UNified Industrial Control System, provides an homogeneous control system for the cryoplants supplying liquid helium to the LHC accelerator, the cryogenic equipment in the machine tunnel, and the ATLAS & CMS cryogenic systems.

The technical design took advantage of accumulated expertise on previous cryogenic systems such as for LEP2, also based on industrial control systems.

UNICOS DESIGN CONCEPTS

The hardware design relies on a three-layer model using distributed I/O connected via field-networks to a process control layer and a supervision layer.

The software design builds a model of the complete process as a hierarchy of process components or devices (I/O channel, actuator, set of sensors and actuators constituting a process entity).

Process components are implemented in two parts, one in the process control layer and one in the supervision layer, which communicate together. The PLC layer takes care of all facilities to drive the device either by the operator (Manual mode) or by the logic of a higher-level device (Auto mode), in addition to its response to external inputs such as interlocks.

The corresponding part in the SCADA layer is provided for the operator to view and manipulate the devices.

UNICOS FOR LHC CRYOGENICS

LHC Machine Domain:

At the time of publication, half of the process control systems for the cryoplant side (warm compressor stations, surface and underground 4.5 K refrigerator Cold Boxes, 1.8 K Cold Box and Cryogenic Interconnection box) have been developed. Their actual implementation and commissioning in the five LHC points where cryoplants are located has reached more than 35% of the total, the remainder will follow the hardware delivery schedules until 2006.

The concepts of the tunnel cryogenics controls have been validated on the LHC String2 magnet test facility in June 2003.

LHC Experiment cryogenics

This concerns the CMS superconducting solenoid and its cryoplant, the ATLAS toroids, central solenoid and end-cap magnets with their associated Helium cryoplant, plus the cryoplant for the Liquid Argon Calorimeter.

For these systems, development work is being shared between industrial firms, CERN and external labs - LAL Orsay (F), Brookhaven National Lab (USA), Rutherford Appleton Lab (GB).

To give an estimate of the size of these control systems, there are around 42,000 I/O points in total, managed by about 70 process control units.

DEPLOYMENT METHODS AND TOOLS

The above design has been concretised with the following implementation. As far as possible, the deployment is subcontracted to teams in charge of common services such as consoles, servers and network.

Hardware architecture

The three layers of control architecture are implemented as follows (figure1):

- The Supervision Layer: The implementation relies on the Operator Workstation (OWS) as human interface and client of a redundant data server holding the real time database. The SCADA supervision software is based on PVSS-II® from ETM AG, which is the CERN-wide selected SCADA product.
- Control Layer: All process control duties are performed in this layer in Schneider Quantum PLC: the object model is implemented in that PLC.

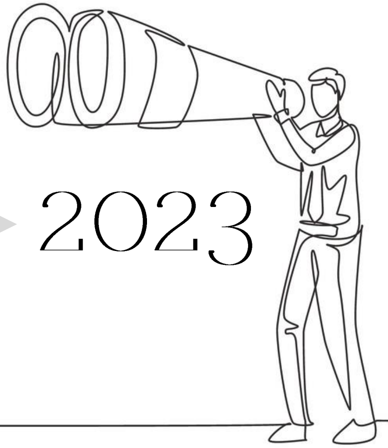
JCOPS UNICOS framework

The new cryogenics controls for LHC (UNICOS) are implemented in an open architecture based on SCADA and PLC industrial components, with Ethernet as Fieldnetwork. Its development was outsourced to industry.

https://cds.cern.ch/record/693164/files/ab-2003-107.pdf

https://accelconf.web.cern.ch/e02/papers/mopdo030.pdf

Science, Infrastructures & Robotics



2023

"the right system right"

methodology

but...

space | BigScience

uncertainty
risk
!

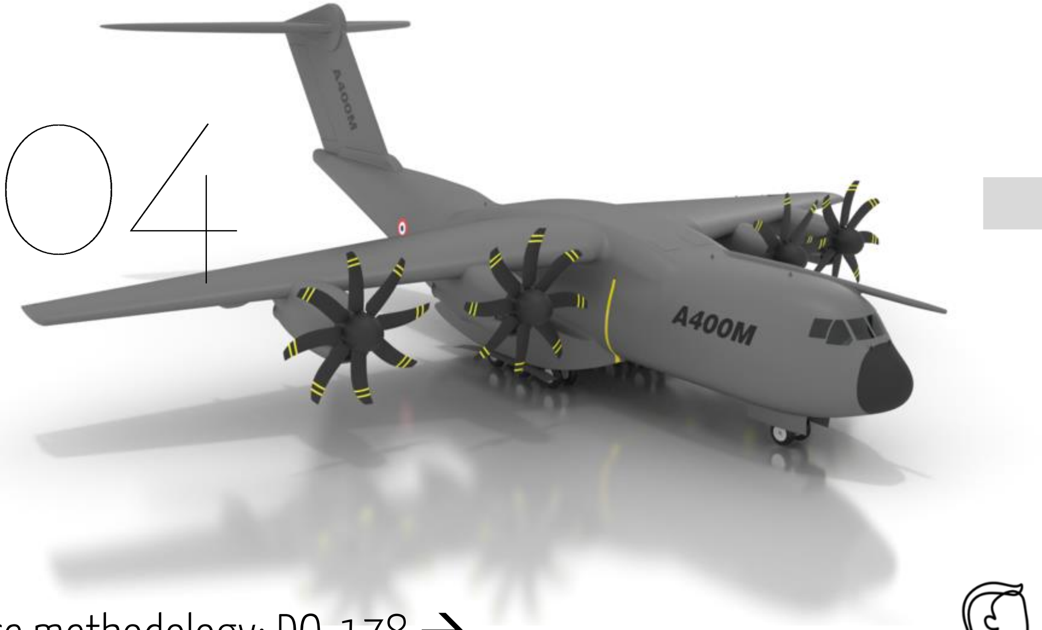
- methodology
- people
- perspective

Middle-long term
Business tempo

Science, Infrastructures & Robotics

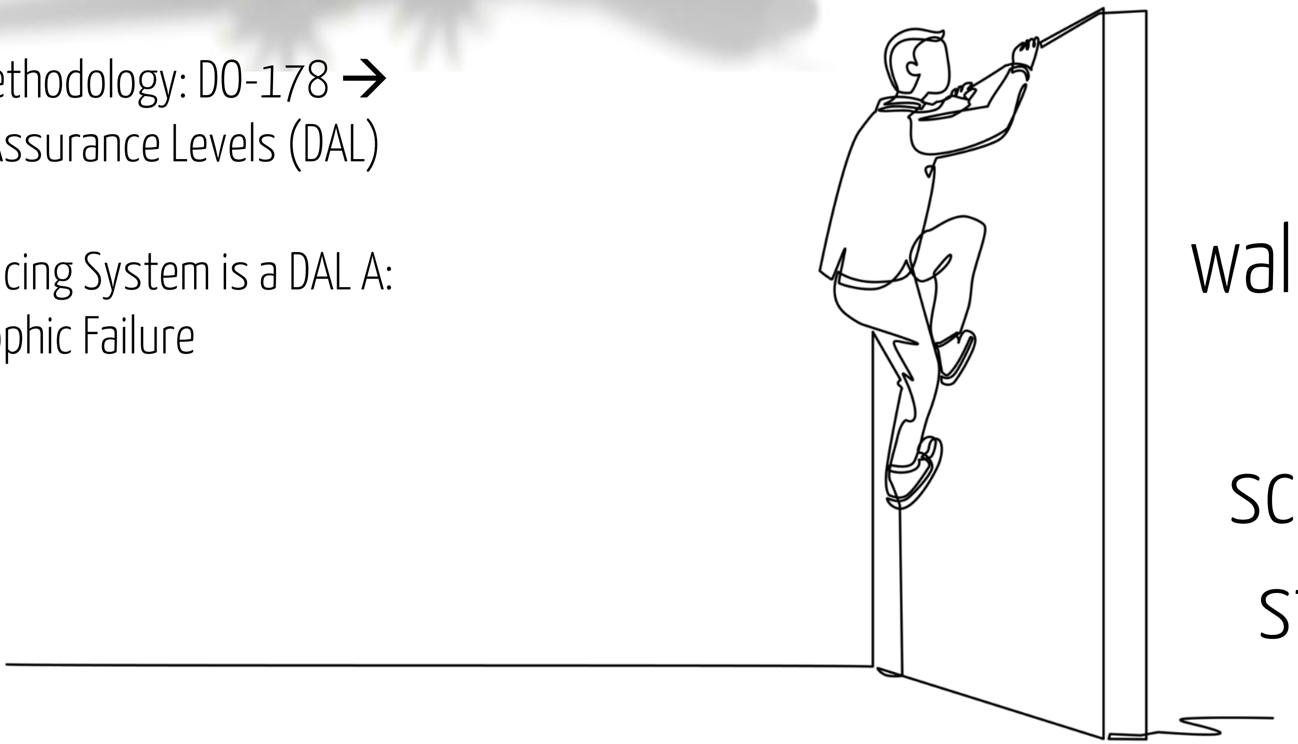
2004

methodology



more methodology: DO-178 →
Design Assurance Levels (DAL)

Wind Deicing System is a DAL A:
Catastrophic Failure



QA:
wall mentality
vs
scaffolding,
structure

Science, Infrastructures & Robotics

gtd sir

2005

2020

ongoing

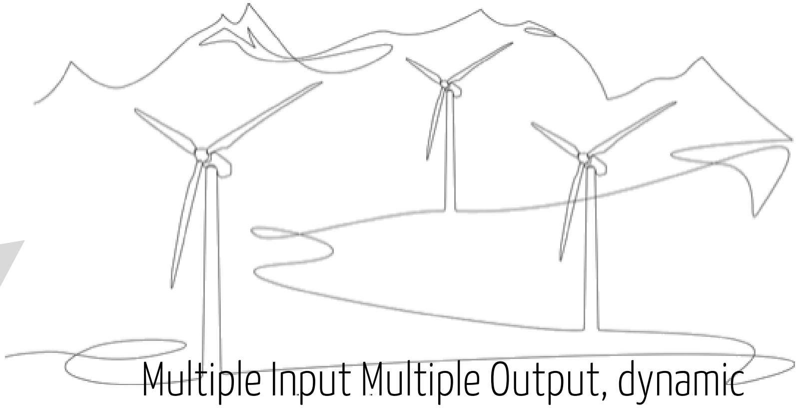
esa

Artificial Intelligence

Operational Environments

Decision Support in the Control Room

acciona energía



Multiple Input Multiple Output, dynamic optimization in real time.

2020 2021 2022 2023

[CEMS1.0]

[1.1]

[1.2]

Analyt

[1.3]

Science, Infrastructures & Robotics

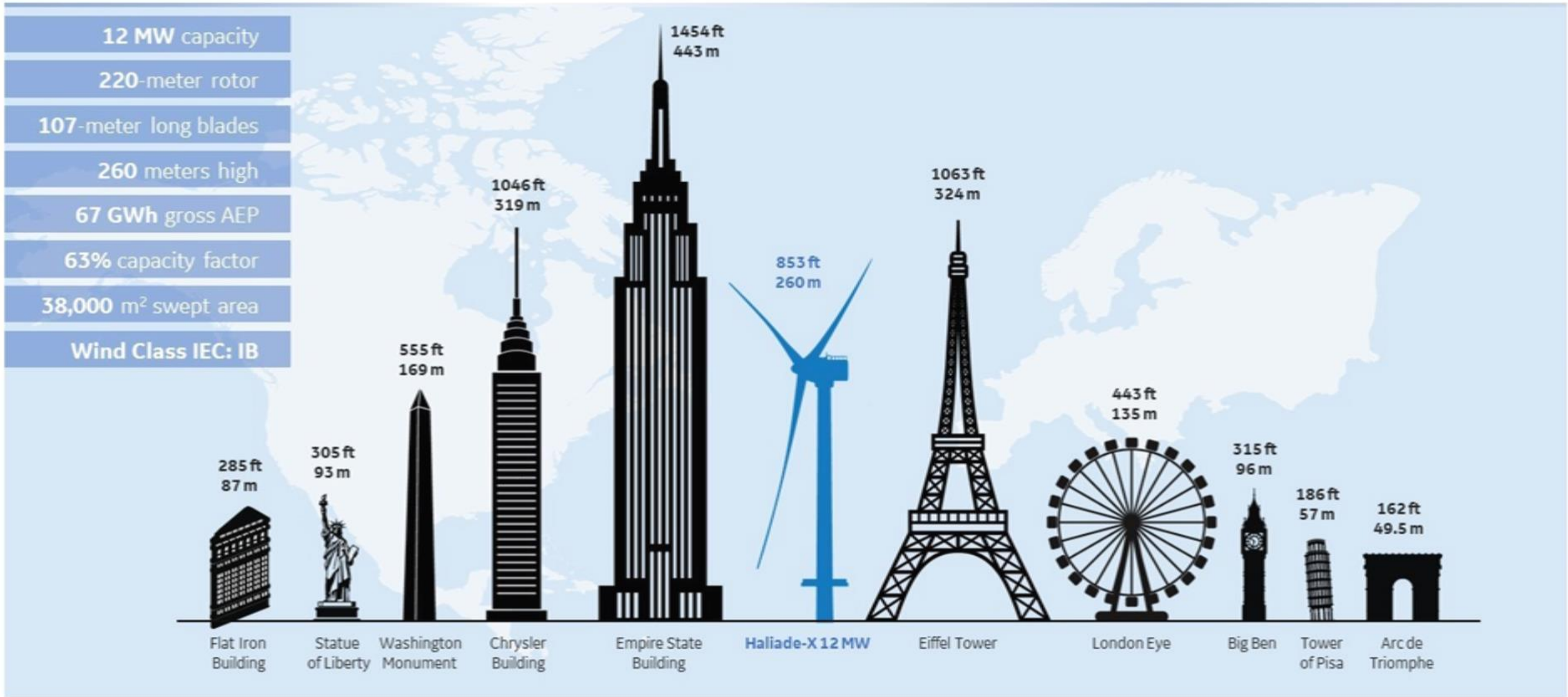
2019

HALIADE-X 12 MW

GE Renewable Energy is developing **Haliade-X 12 MW**, the biggest offshore wind turbine in the world, with **220-meter rotor**, **107-meter blade**, leading capacity factor **(63%)**, and **digital capabilities**, that will help our customers find success in an increasingly competitive environment.

One **Haliade-X 12 MW** can generate **67 GWh annually**, which is **45% more** annual energy production (AEP) than most powerful machines on the market today, and twice as much as the Haliade 150-6MW.

The **Haliade-X 12 MW** turbine will generate enough clean power for up to **16,000** European households per turbine, and up to **1 million** European households in a 750 MW configuration windfarm.



Science,
Infrastructures
& Robotics

2012 1st

FUSION FOR ENERGY

Instrumentation and Control Engineering Support framework contract

gtd

2017 2nd

2021 3rd

"You won because you deserved"

50~60 Task Orders (Projects)

gtd → Science, Infrastructures & Robotics

2019

2012

System & Software Engineering
Industrial Controls
SCADA (WinCC OA)
PSS-05, ECSS-E-40, ECSS-Q-80, IEC12207
DO-178B
IEC61508, 61511, 61513

Science, Infrastructures & Robotics

2012

System & Software Eng.

Frameworks

Control & Sypervision

SCADA (WinCC OA)

PSS-05, ECSS-E-40, ECSS-Q-80, IEC12207

DO-178B

IEC61508, 61511, 61513

Fast Control Systems [µs, ns]

Bespoke Electronics

Interlocks

Remote Handling

CODAC & Core System

Science, Infrastructures & Robotics

80 engineers

Hyperautomation 45

I&C

Simone Scaramozzino

17+8

SCADA Analytics

20

Robotics 16

genrobot

C/C++

Real-Time

Augmented Reality

QT

Edge Computing 14

Marta Baldrís

RealTime

8

Full Stack

6

Project Management 5

Science, Infrastructures & Robotics

Along the last 10 years, GTD SI&R has been involved in the following fusion related systems:

categories	frameworks & projects	System Engineering	Software Engineering	I&C Conventional	Machine Protection	Occupational/ Nuclear Safety	Bespoke Electronics	Slow Control [ms]	Fast Control [ns/μs]	links →
Large systems, complete I&C engineering lifecycle	Cryogenic Distribution System: Torus & Cryostat Cryopumps	■		■	■	■		■		[Torus&Cryostat]
	Electron Cyclotron									
	ECT-Falcon Gyrotron Test Facility	■	■	■	■		■	■	■	[ECT-Falcon]
	Gyrotron Commissioning Components Control System	■	■	■	■		■		■	[GCC]
	EC Plant Control	■	■	■	■				■	[EC Plant]
	Upper Launcher Control System		■	■	■				■	[Upper Launcher]
Diagnostics	Magnetics Diagnostics System	■	■	■	■		■		■	[Magnetics]
	Tokamak Systems Monitor – Tokamak Simulator	■	■						■	[TSM]
Safety Critical	Alarm Survey System	■		■	■	■		■		[Alarm Survey]
	HCLL PbLi Loop	■		■	■	■		■		[HCLL PbLi Loop]
	LIPAc Machine Protection System	■	■		■				■	[LIPAc MPS]
	Disruption Mitigation System (DMS) Plant Interlock System		■		■				■	[DMS PIS]
Backbone Frameworks	Remote Handling Framework: GENROBOT	■	■	■	■	■			■	[GENROBOT]
	CODAC and CODAC Core System		■	■					■	[CODAC]
Bespoke Electronics	Generic Fast Plan Controller		■	■			■		■	[FAST PLANT]
	cRIO HotLink Modules		■	■			■		■	[cRIO]
I&C and Engineering Support services (incl. on-site)	Central Safety System (CSS), both Nuclear and Occupational Safety		■			■		■	■	[CENTRAL SAFETY]
	Electrical Network, Steady State and Pulse Power (SSEN & PPEN)		■	■				■		[ELECTRICAL NETWORK]
	Buildings (nuclear and non-nuclear) incl. Compressed Air, Demineralized Water, Nitrogen Systems, Helium Gas Distribution, Breathing Air system, HVAC, Heavy Nuclear Doors	■	■	■		■		■		[BUILDINGS]

key disciplines

The footprint of GTD SI&R in FUSION is highly rooted in our core expertise:

Science, Infrastructures & Robotics

What we do:

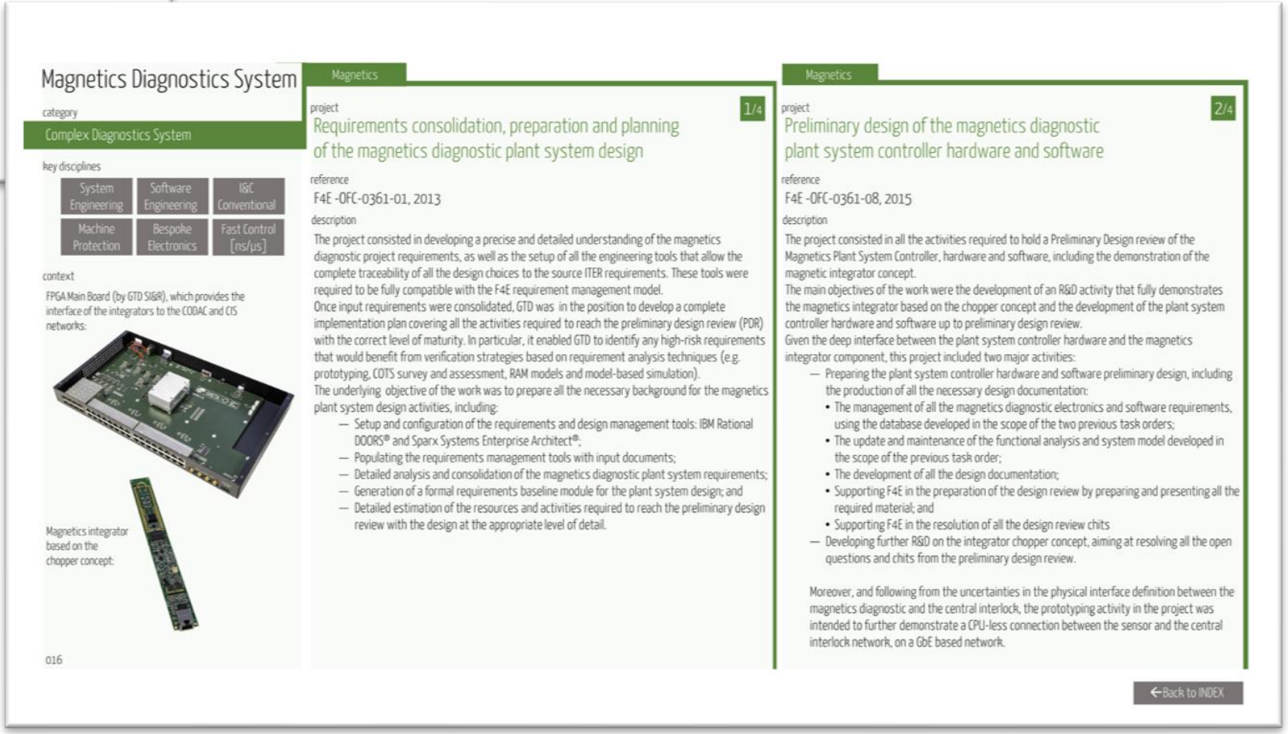
categories …		disciplines …
Large systems, complete I&C engineering lifecycle	✖	System Engineering
Diagnostics		Software Engineering
Safety Critical		I&C Conventional
Backbone Frameworks		Machine Protection
Bespoke Electronics		Occupational/Nuclear Safety
I&C and Engineering Support services (incl. on-site)		Bespoke Electronics
		Slow Control [ms]
		Fast Control [ns/μs]

How we do it:

- Project development
- Technology Development
- I&C Services: Integrations, Engineering Support, On-Site Support (also times&means)

Science, Infrastructures & Robotics

https://nextcloud.gtd.eu/index.php/s/wqe2nTwnBiiWqTf



Magnetics Diagnostics System

category

Complex Diagnostics System

key disciplines

System Engineering	Software Engineering	I&C Conventional
Machine Protection	Bespoke Electronics	Fast Control [ns/µs]

context

FPGA Main Board (by GTD SI&R), which provides the interface of the integrators to the CODAC and CIS networks:

Magnetics integrator based on the chopper concept:

016

Magnetics

project

Requirements consolidation, preparation and planning of the magnetics diagnostic plant system design

1/4

reference

F4E -OFC-0361-01, 2013

description

The project consisted in developing a precise and detailed understanding of the magnetics diagnostic project requirements, as well as the setup of all the engineering tools that allow the complete traceability of all the design choices to the source ITER requirements. These tools were required to be fully compatible with the F4E requirement management model.

Once input requirements were consolidated, GTD was in the position to develop a complete implementation plan covering all the activities required to reach the preliminary design review (PDR) with the correct level of maturity. In particular, it enabled GTD to identify any high-risk requirements that would benefit from verification strategies based on requirement analysis techniques (e.g. prototyping, COTS survey and assessment, RAM models and model-based simulation).

The underlying objective of the work was to prepare all the necessary background for the magnetics plant system design activities, including:

- Setup and configuration of the requirements and design management tools: IBM Rational DOORS® and Sparx Systems Enterprise Architect®;
- Populating the requirements management tools with input documents;
- Detailed analysis and consolidation of the magnetics diagnostic plant system requirements;
- Generation of a formal requirements baseline module for the plant system design; and
- Detailed estimation of the resources and activities required to reach the preliminary design review with the design at the appropriate level of detail.

Magnetics

project

Preliminary design of the magnetics diagnostic plant system controller hardware and software

2/4

reference

F4E -OFC-0361-08, 2015

description

The project consisted in all the activities required to hold a Preliminary Design review of the Magnetics Plant System Controller, hardware and software, including the demonstration of the magnetic integrator concept.

The main objectives of the work were the development of an R&D activity that fully demonstrates the magnetics integrator based on the chopper concept and the development of the plant system controller hardware and software up to preliminary design review.

Given the deep interface between the plant system controller hardware and the magnetics integrator component, this project included two major activities:

- Preparing the plant system controller hardware and software preliminary design, including the production of all the necessary design documentation:
  - The management of all the magnetics diagnostic electronics and software requirements, using the database developed in the scope of the two previous task orders;
  - The update and maintenance of the functional analysis and system model developed in the scope of the previous task order;
  - The development of all the design documentation;
  - Supporting F4E in the preparation of the design review by preparing and presenting all the required material; and
  - Supporting F4E in the resolution of all the design review chits
- Developing further R&D on the integrator chopper concept, aiming at resolving all the open questions and chits from the preliminary design review.

Moreover, and following from the uncertainties in the physical interface definition between the magnetics diagnostic and the central interlock, the prototyping activity in the project was intended to further demonstrate a CPU-less connection between the sensor and the central interlock network, on a GbE based network.

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Presentation

DTT Project – ROMA 30/05



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