JOINT INSTITUTE
FOR NUCLEAR RESEARCH

NICA MPD

FUNDAMENTAL ISSUES OF EXPERIMENTAL FACILITIES AUTOMATION

Baldin Nikita,
Dubna, April 2023

SALUTATION

I am Nikita Baldin

I have the **education** of an accelerator technology automation engineer Moscow Engineering Physical Institute (MEPhI).

More than 10 years I worked for large **system integrators** of full-scale DCS in the power plant industry in Russia.

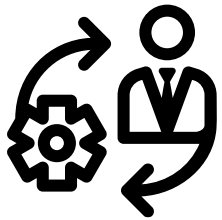
project in science that I did was automation of cryogenic liquefaction plants at the **NICA project in home institute JINR**, Dubna, Russia.

project in science that I did was DCS (detector control system) of ITS (inner tracker system) at **ALICE experiment In CERN** Geneve, Switzerland.

Automation - common terminology

DCS
Distributed Control System

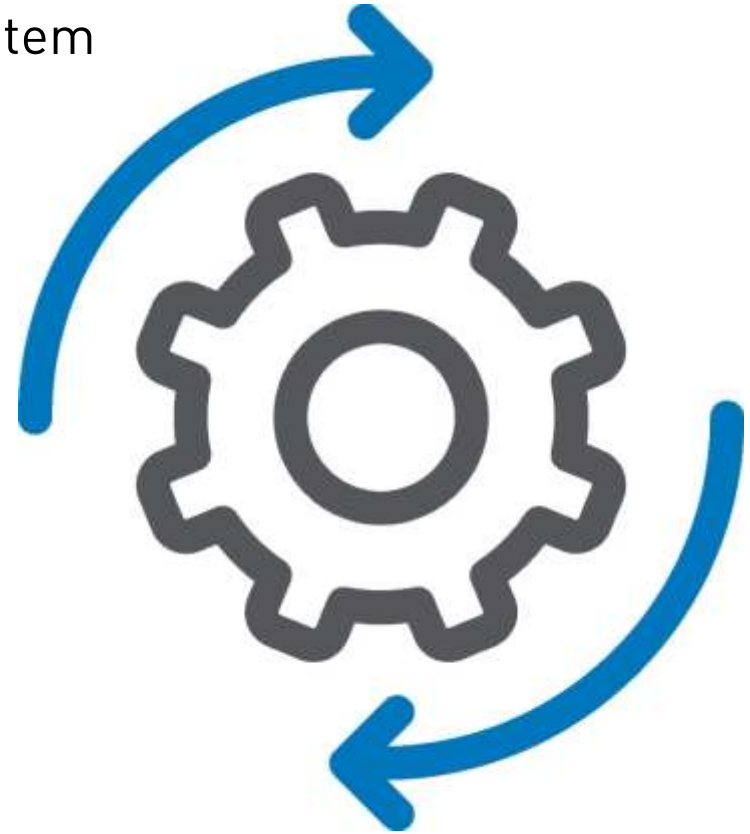
РСУ
Распределенная Система Управления



АСУ ТП
Автоматизированная Система Управления Технологическими Процессами

САУ
Система автоматического управления

Automation

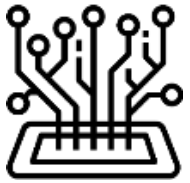


Система мониторинга

Slow Control

FSM
Finite State Machine

DCS
Detector Control System



AUTOMATION - centralization of data & control

A MAJOR MULTI-LEVEL DCS PROJECT ON SCADA WINCC OA AT CERN ON LHC

5
CONTROL ROOMS

over **680**
SUBSYSTEMS

over **45 mil.**
PARAMETERS

over **1400**
DEVELOPERS

GOALS AND OBJECTIVES

1. Provide stable units operation

2. Ensure safety equipment

Experimental data

Education activity

3. Achieving highest output quality

4. Providing an optimal operational mode

CERN STYLE DECOMPOSITION

Detector Control System

- Status equipment
- Parameters technology process
- Equipment modes

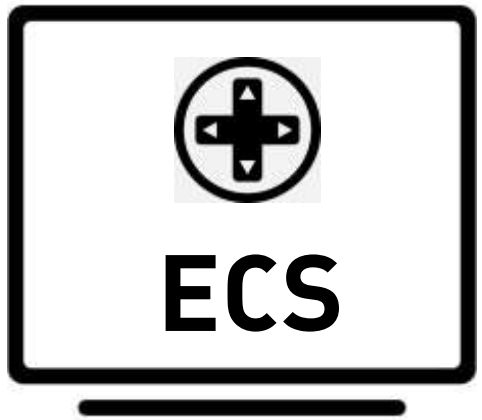
Detector Safety System

- Interlocks
- Setpoints
- Process protection
- Locks and blocks

Data Acquisition System

- RAW data science
- Quality control
- Correct data

Experiment Control System

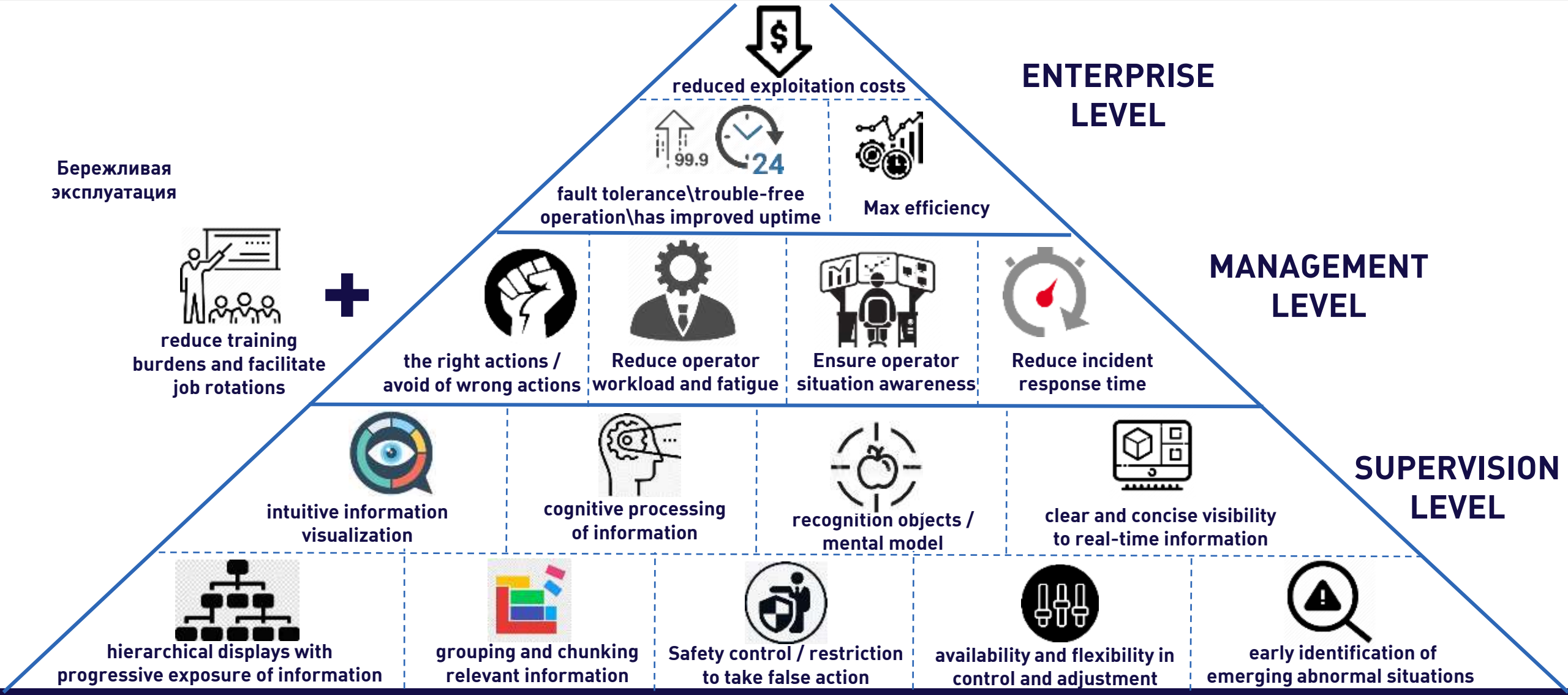


- Run start/stop
- Run coordination
- Run processing

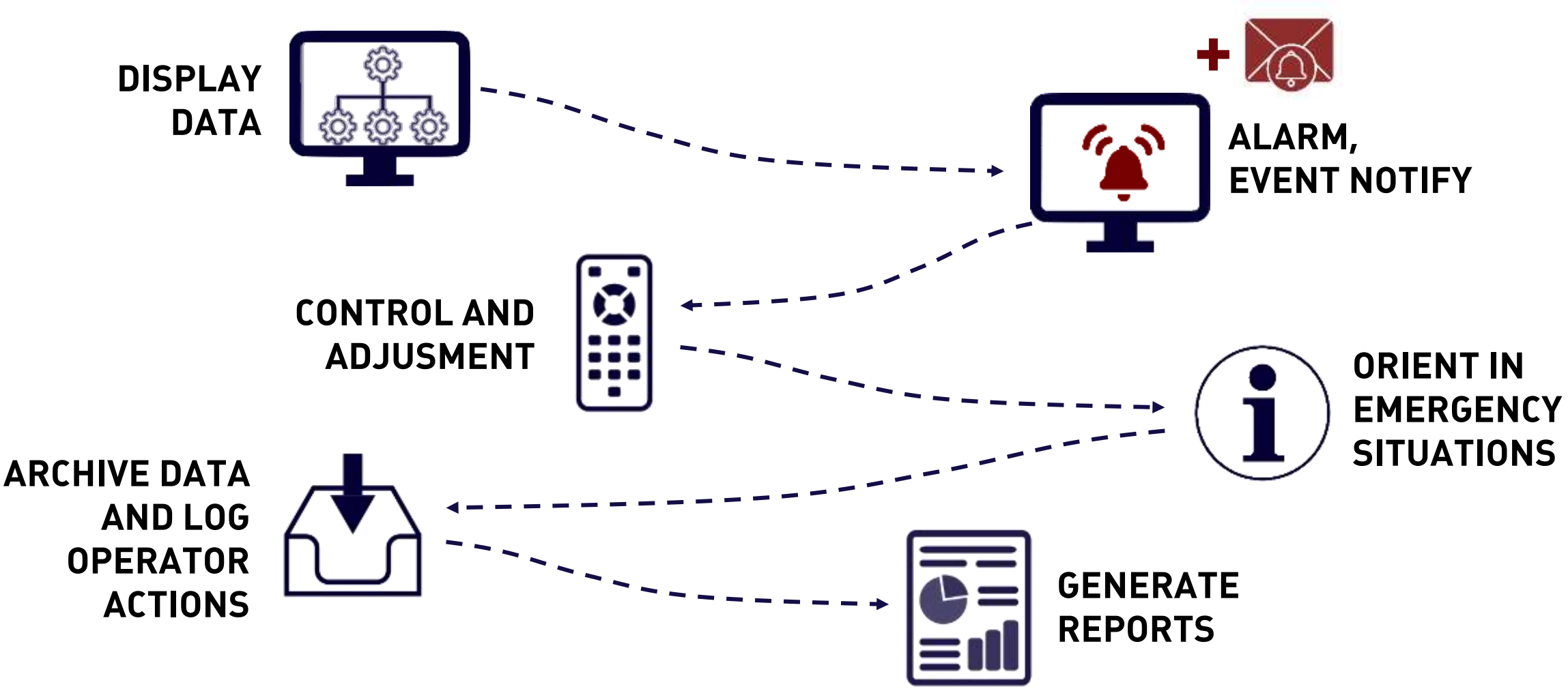
Hierarchy of automated systems

Enterprise Level	detailed planning, inventory management, sales, finance, purchasing
Management Level	monitoring the status and allocation of resources, process quality, performance analysis
Supervision Level	process control and management, production dispatching
Control Level	primary signal processing and logic of algorithms for automatic control of equipment
Field Level	technological equipment, facility, sensors, actuators

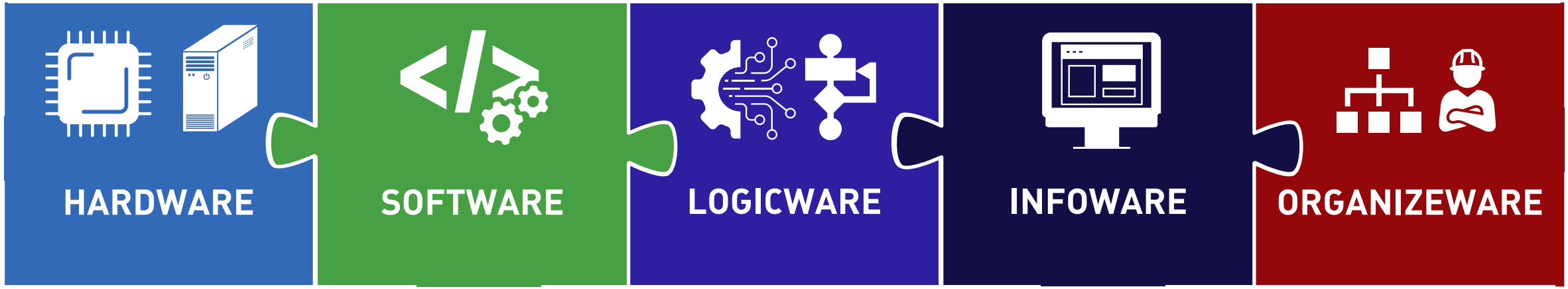
The main goals and objectives by levels



SURFACE FUCTIONALITY



CONSTITUTION OF AUTOMATED SYSTEMS



- Front-end electronics
- i/o modules
- PLC
- Servers
- ARM

- Operation systems
- Protocols
- SCADA
- Developing studio

- Firmware
- Logical components
- Algorithms
- Procedures
- Technological functions

- User interface
- MIMICS
- Graphical panels
- Graphics, trends
- Alarm table

- Organization structure
- Personnel tasks
- Duties
- Rights
- Responsibilities
- Instructions
- User manual

FUNDAMENTAL SERVEY

1.

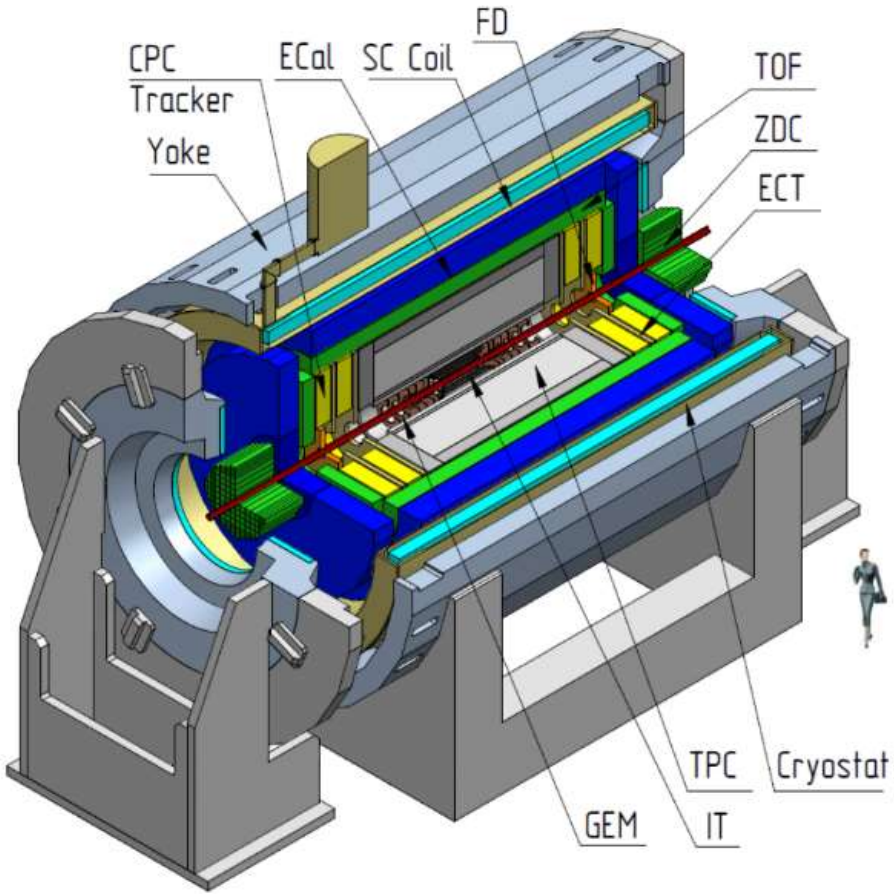
Equipment

2.

Automatable functions

Automation object: MPD experiment facility

Multi-Purpose Detector



First stage Subdetectors:

- TPC, TOF, Ecal, FFD, FHCAL

Second stage Subdetectors:

- ITS, GEM, CPC

Infrastructure subsystems:

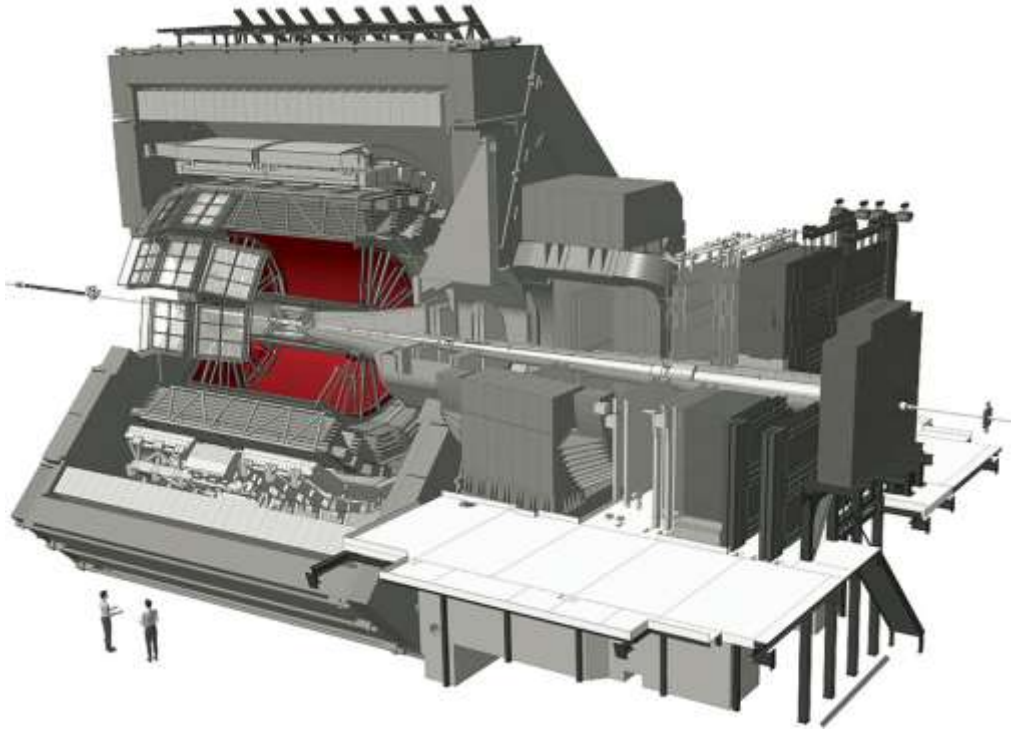
- Magnets, B-field, radiation, access control, ventilation, etc.

External services:

- Electricity, cryogenic, cooling, gas etc.

Automation scale of ALICE at CERN

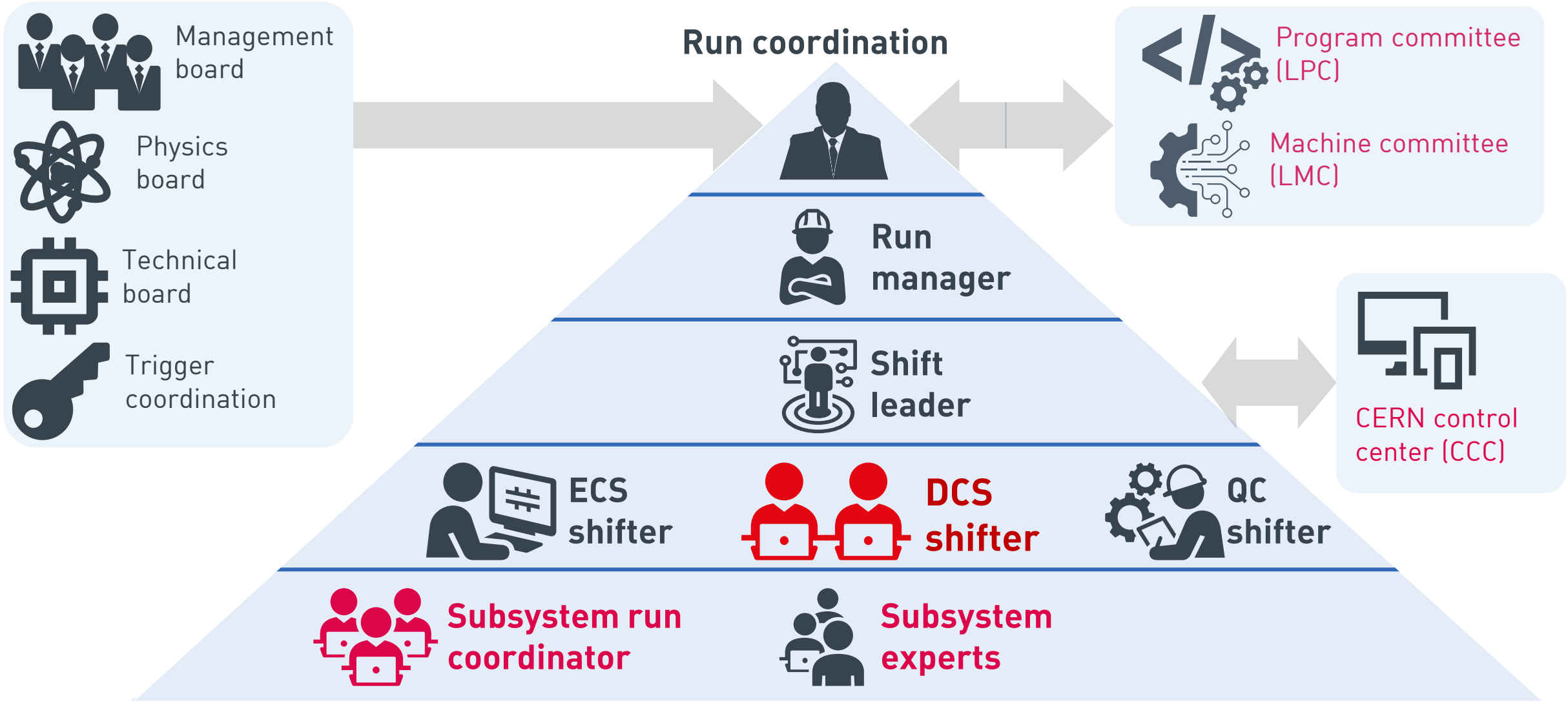
ALICE at CERN



Quantitative indicators:

- 1 control room
- 100 servers (WinCC OA)
  *12 TPC servers
- 270 crates
  *more 60 cabinets
- 1.200 network-attached devices
- 3.000.000 parameters
  *ATLAS 12.000.000

ALICE run coordination



COMPARISON OF ORGANIZATIONAL STRUCTURE

FIELD LEVEL

PLC LEVEL

SERVER LEVEL

STYLE 1 (CLASSICAL/COMMERCIAL)

IF ALARM – FOLLOW THE TECHNOLOGY INSTRUCTION

OPERATOR 0-24 HOURS

OPERATIONAL REPAIR STAFF 0-24 HOURS

SERVICE STAFF

SUPERVISION LEVEL

IF ALARM – CALL EXPERT

SHIFTER 0-24 HOURS

EXPERT 1

EXPERT 2

EXPERT N

STYLE 2 (SCIENCE)

SERVICE ENGINEERS

INSTRUMENT
MECHANIC
HARDWARE
SOFTWARE
COMMUNICATIONS
ACCESS CONTROL
PLC
SCADA
DATABASE
etc.

SUPPORT

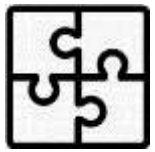
SUMMARY

Goals and objectives of automated systems

- Experimental data, stable beam, etc.
- Operability, safety, quality, optimality

Types of automated systems

- DCS, DSS
- DAQ, ECS

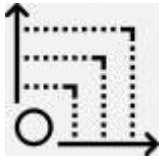


Components of automated systems

- Hardware, software
- Logicware, infoware, organization

Functionality of automated systems

- Providing data, Control & adjustment, automatized functions
- Alarm, orient in emergency situations, archive, reports



Scale of automated systems

- 20 ARM, 100 servers, 100 cabinets
- 1000 network attached devices, Millions DPEs

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Thank you !!!

WinCC OA choice of CERN

CERN's choice in the LHC project: WinCC Open Architecture SIEMENS

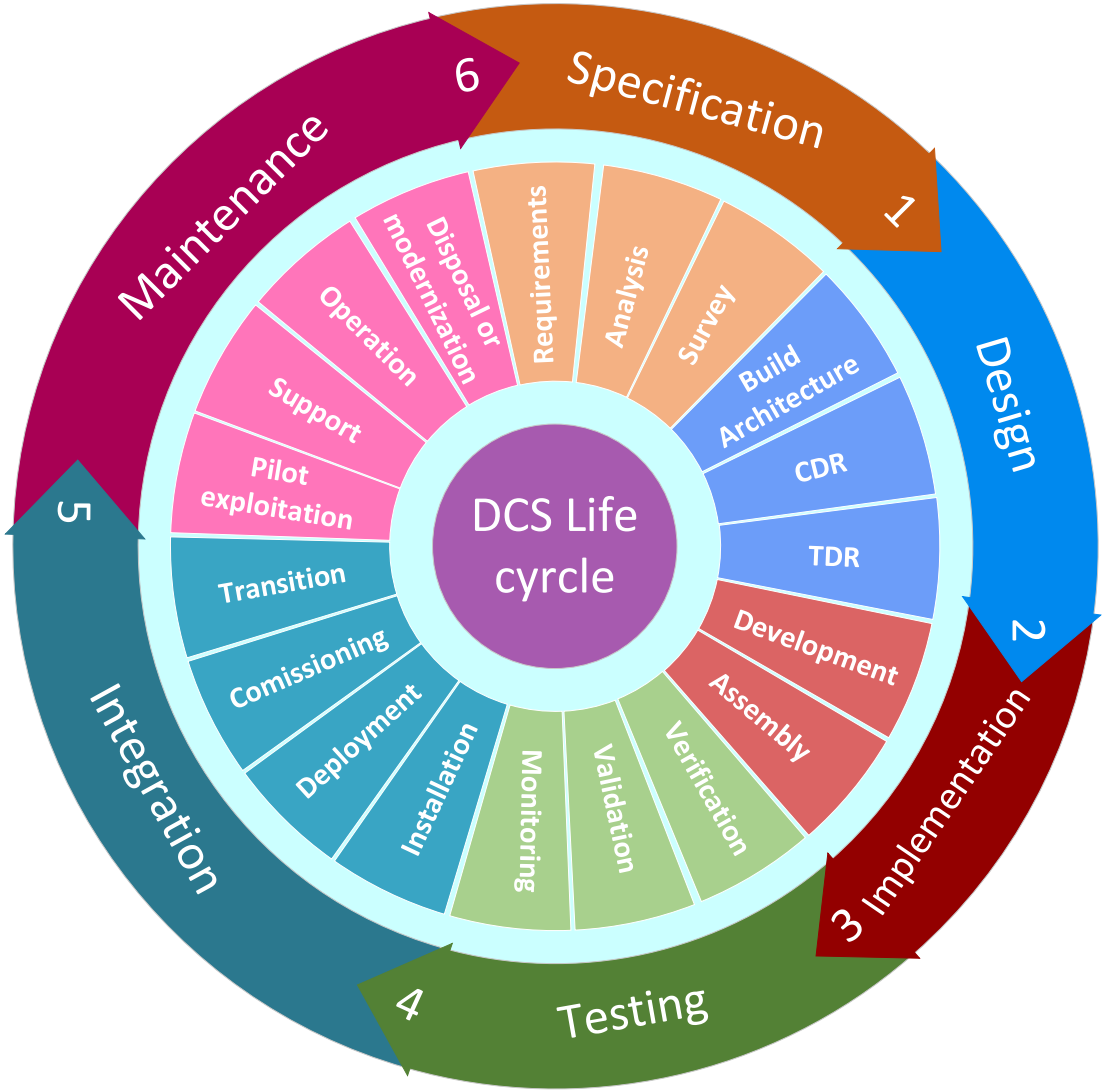
CERN pays a hefty licensing fee every year

CERN management considers switching to TANGO

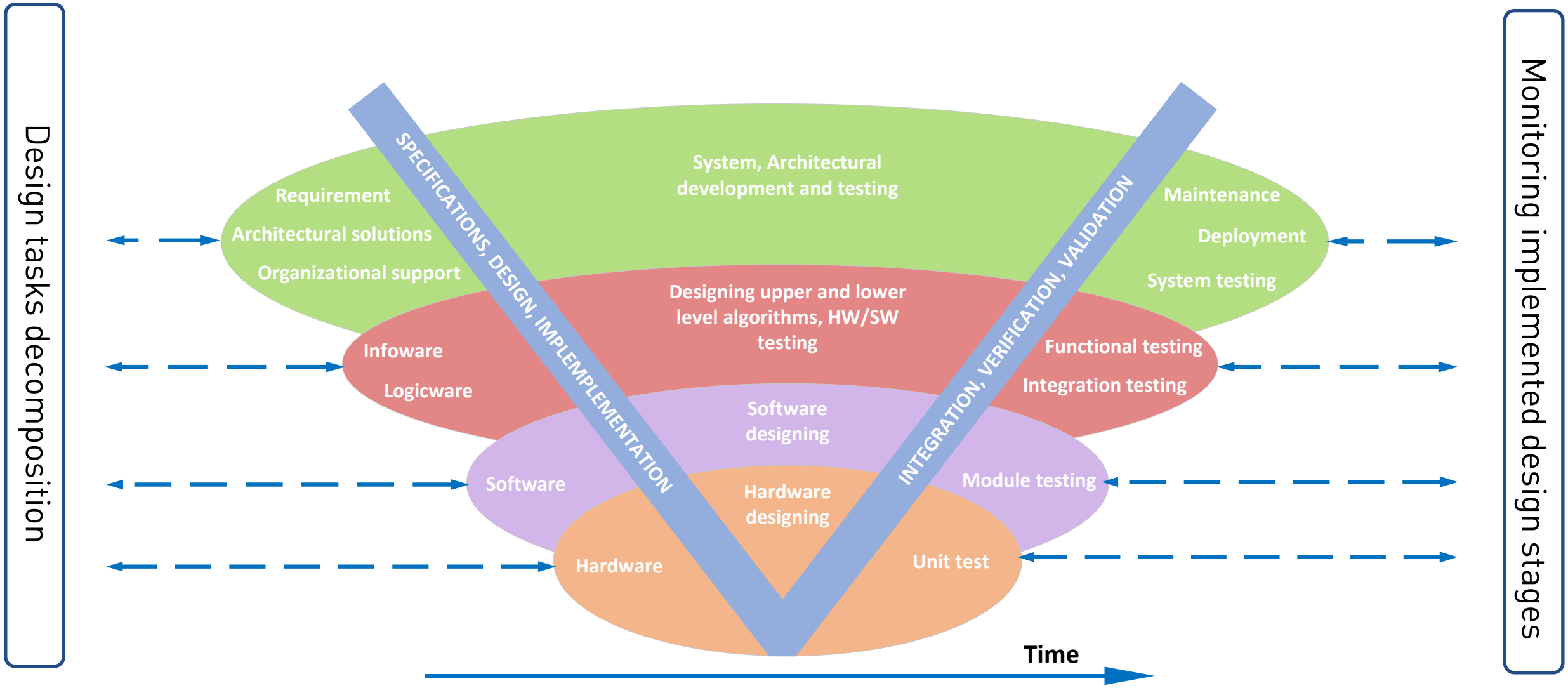
It would take too much resources (manpower, timescale)

*longer that lifetime of LHC

LIFE CYCLES OF AUTOMATED SYSTEMS



V-model


Design tasks decomposition
Monitoring implemented design stages
SPECIFICATIONS, DESIGN, IMPLEMPLEMENTATION
INTEGRATION, VERIFICATION, VALIDATION
System, Architectural development and testing
Requirement
Architectural solutions
Organizational support
Maintenance
Deployment
System testing
Designing upper and lower level algorithms, HW/SW testing
Infoware
Logicware
Functional testing
Integration testing
Software designing
Software
Module testing
Hardware designing
Hardware
Unit test
Time

First surface planning

Survey of the facility

- Subsystems list
- Objects table
- Signals table

Development of conceptual solutions

- Process design
- Deployment diagram
- Engineering design

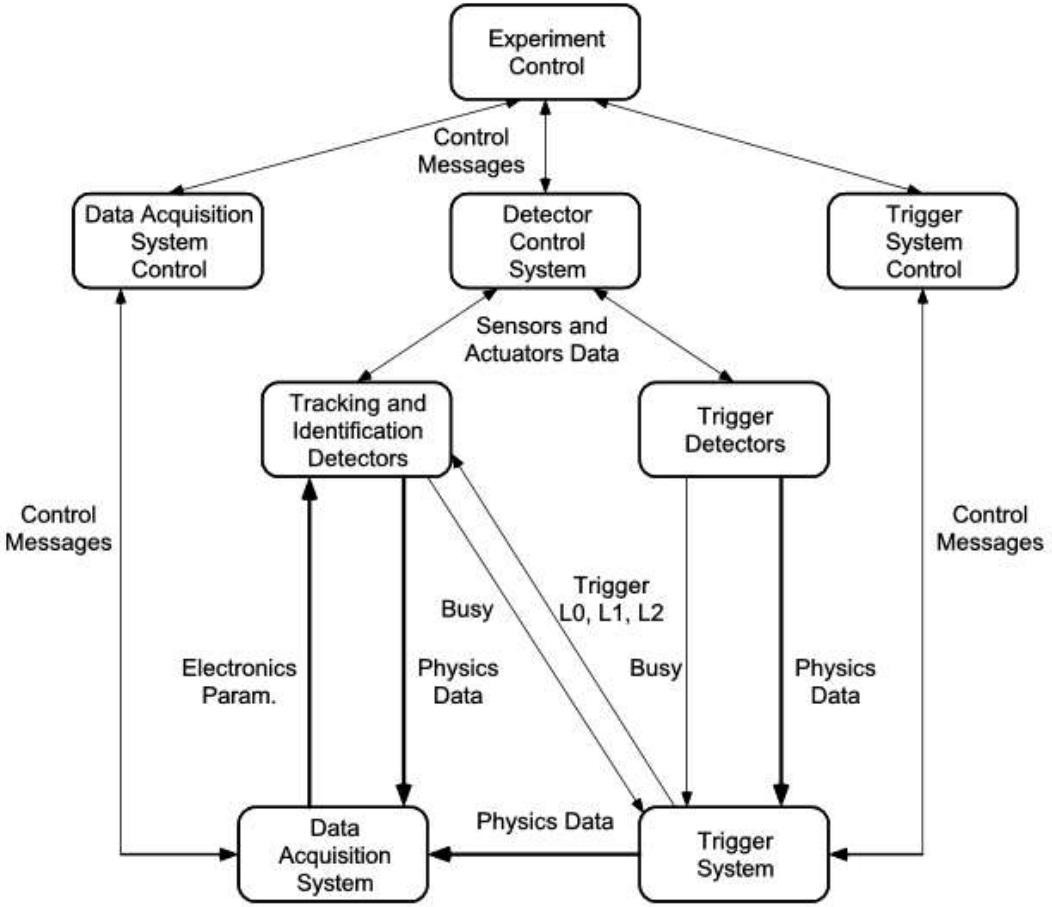
Tasks decomposition

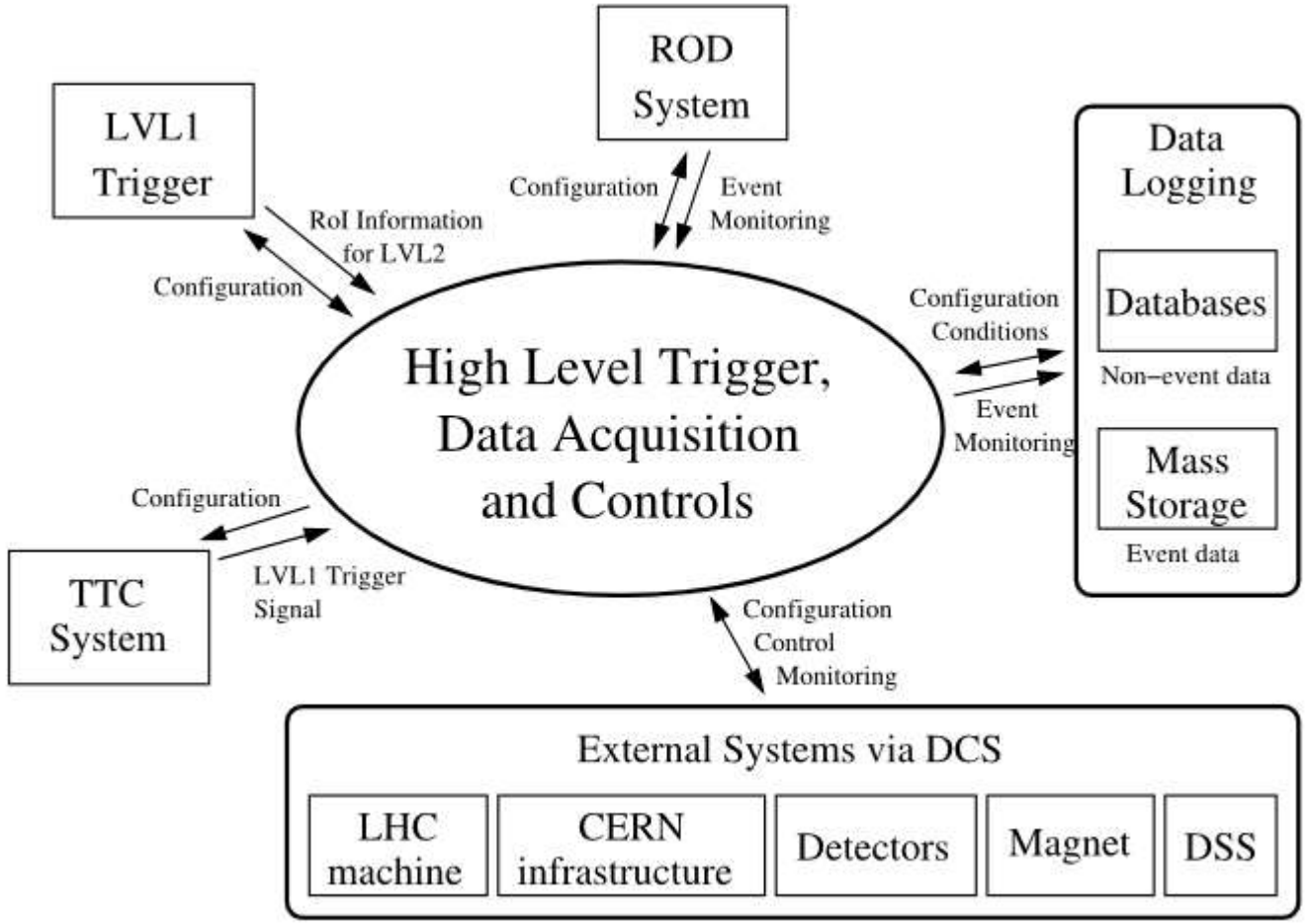
- Subprojects list
- Gantt diagram

Subprojects development

- Technical specifications
- Subprojects portfolio

ПРИМЕР СХЕМ


Experiment Control
Control Messages
Data Acquisition System Control
Detector Control System
Trigger System Control
Sensors and Actuators Data
Tracking and Identification Detectors
Trigger Detectors
Control Messages
Control Messages
Busy
Trigger L0, L1, L2
Electronics Param.
Physics Data
Busy
Physics Data
Physics Data
Data Acquisition System
Trigger System


ROD System
LVL1 Trigger
Configuration
Event Monitoring
RoI Information for LVL2
Configuration
Data Logging
Databases
Non–event data
Mass Storage
Event data
Configuration Conditions
Event Monitoring
High Level Trigger, Data Acquisition and Controls
Configuration
TTC System
LVL1 Trigger Signal
Configuration Control Monitoring
External Systems via DCS
LHC machine
CERN infrastructure
Detectors
Magnet
DSS