JOINT INSTITUTE
FOR NUCLEAR RESEARCH

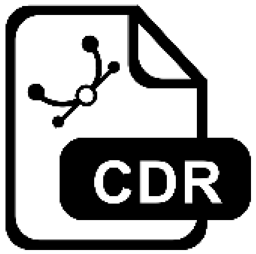
NICA MPD

The issue of functional division of automated systems in experimental facilities

Baldin Nikita,
Dubna, April 2024

AUTOMATION – MAIN IDEA

CURRENT SITUATION AROUND MPD



Current design solutions in automation field

- CDR Conceptual design report MPD
- Shaped DAQ и DCS
- TDR technical design report only for DAQ

Current reporting on the status of works in automation field

- Unreported timebound and percentage about automated subsystems
- DAQ report mostly about hardware solutions
- Couldn't find the latest DCS report

Current understanding the scope of tasks in automation field

- What are the key expectations and functional requirements for automated systems?
- What architectural principles and structure components are envisaged for them?
- What manpower are necessary to to deploy and maintain automated systems?

POTENTIAL EXPECTATIONS

Enterprise expectations

- Max efficiency
- Reduce exploitation costs
- Trouble-free operation
- Improve uptime

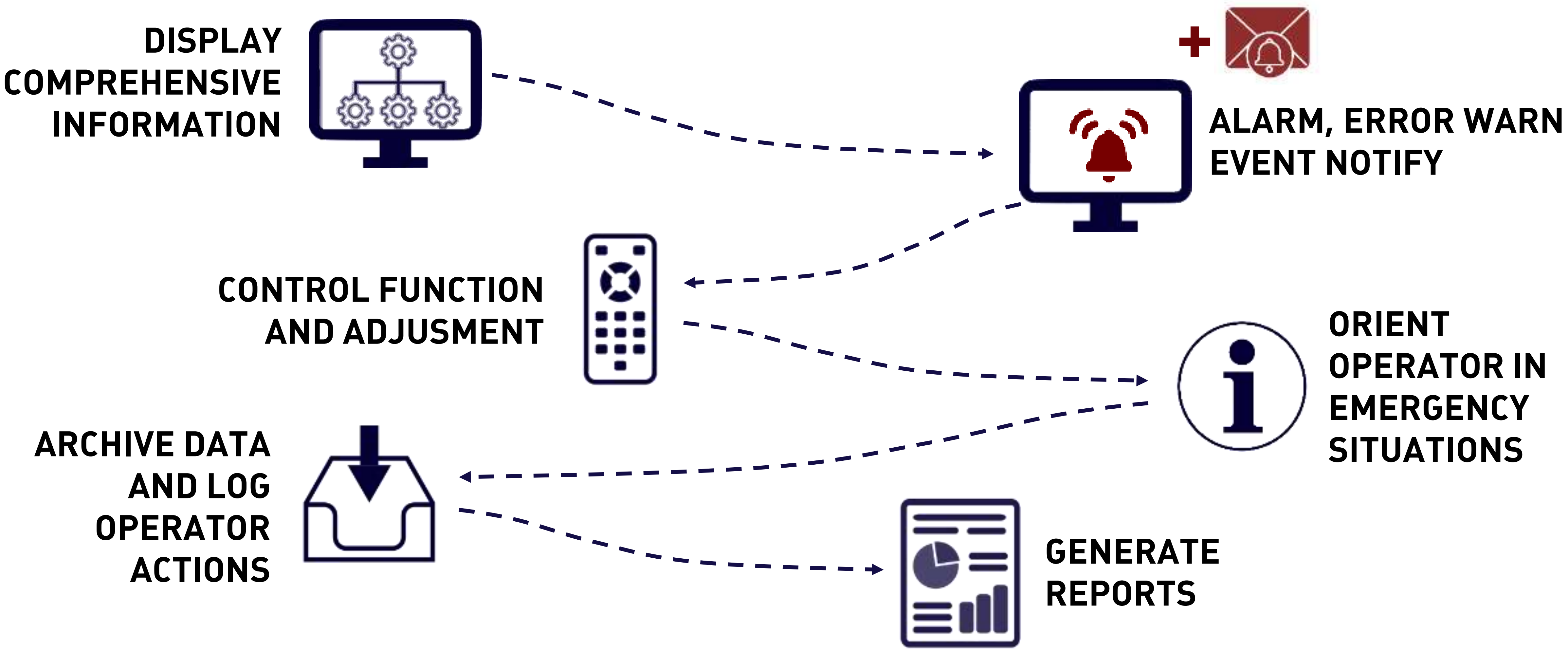
Management expectations

- Streamlined training & staff flexibility
- Correct shifter's actions, minimal mistakes
- Reduced shifter's workload
- Ensure shifter situation awareness
- Reduce incident response time

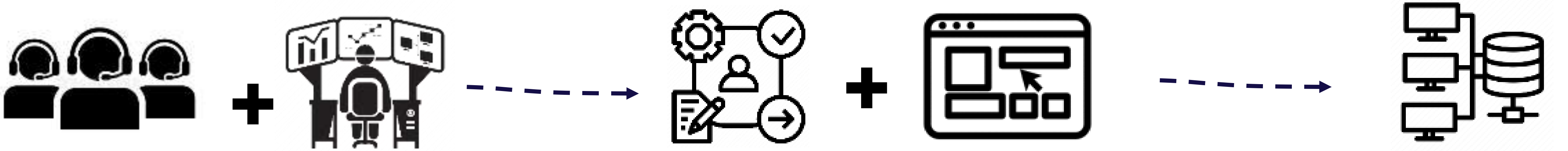
Shifter's expectations

- Intuitive recognizable user interface
- Hierarchical & structured information
- System response & alerts
- Safety control, false action protection
- Flexibility & adjustments possibilities
- Minimum routine

Functionality of Automated Systems

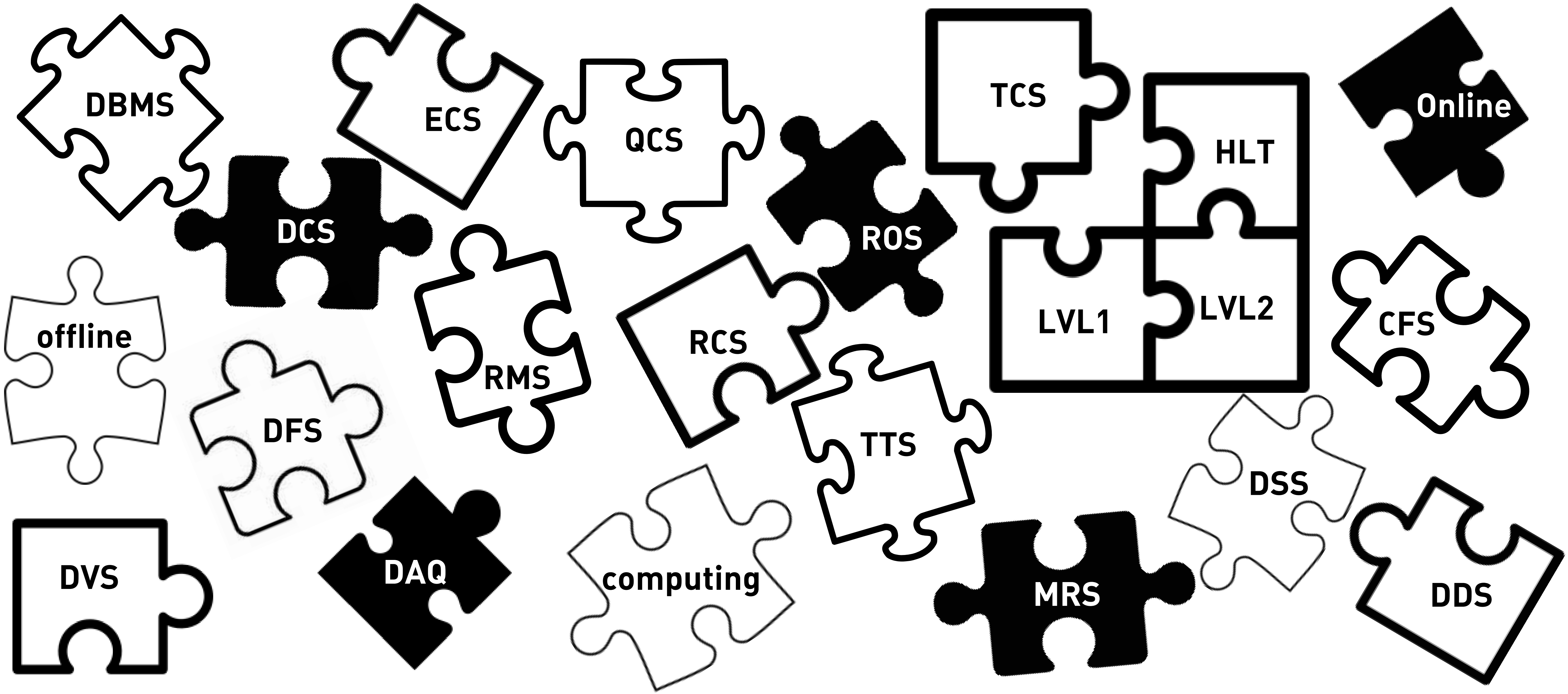


NEED TO DEFINE ARCHITECTURE SOLUTIONS

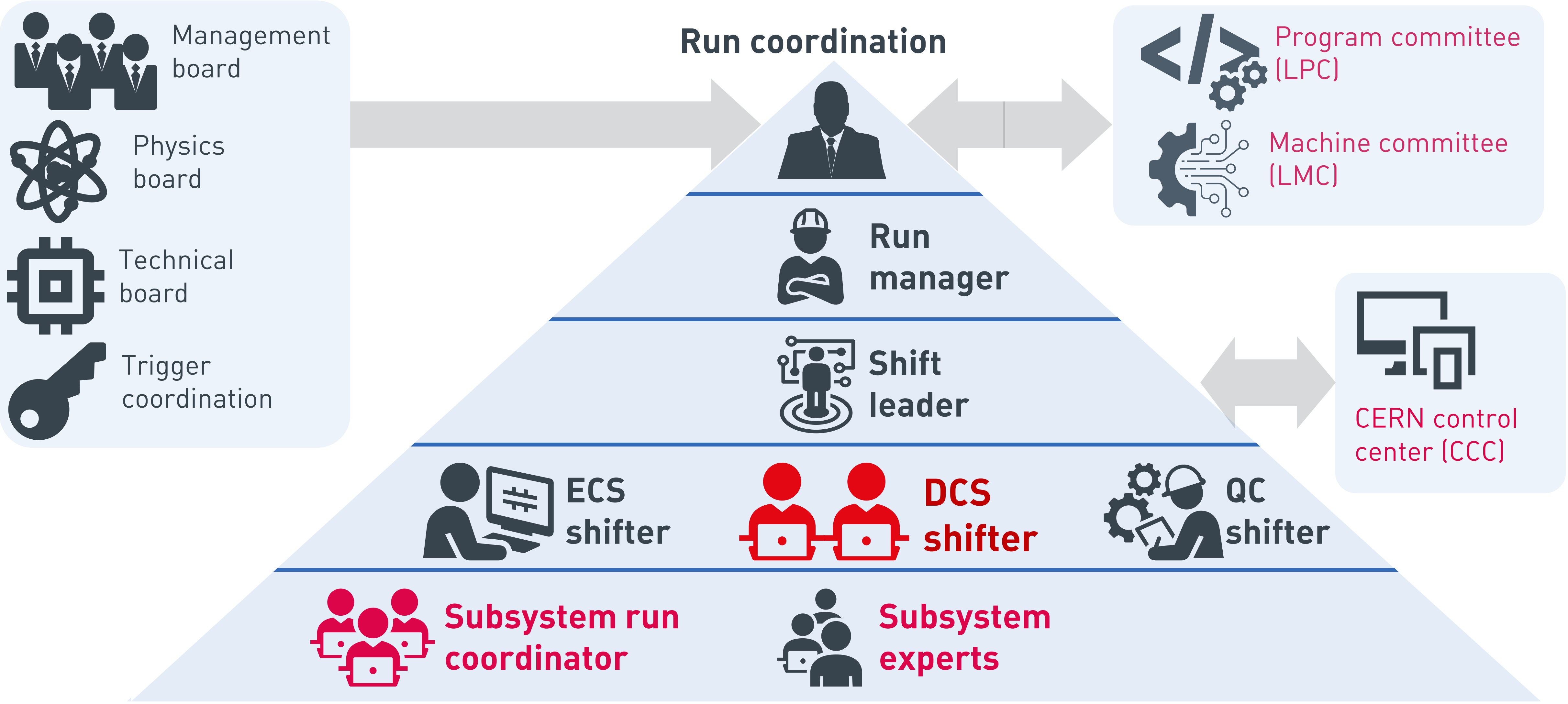


Specified staff team + **Specified shifter work places** → **Functionality division** + **Personalized HMI/GUI** → **Define architecture**

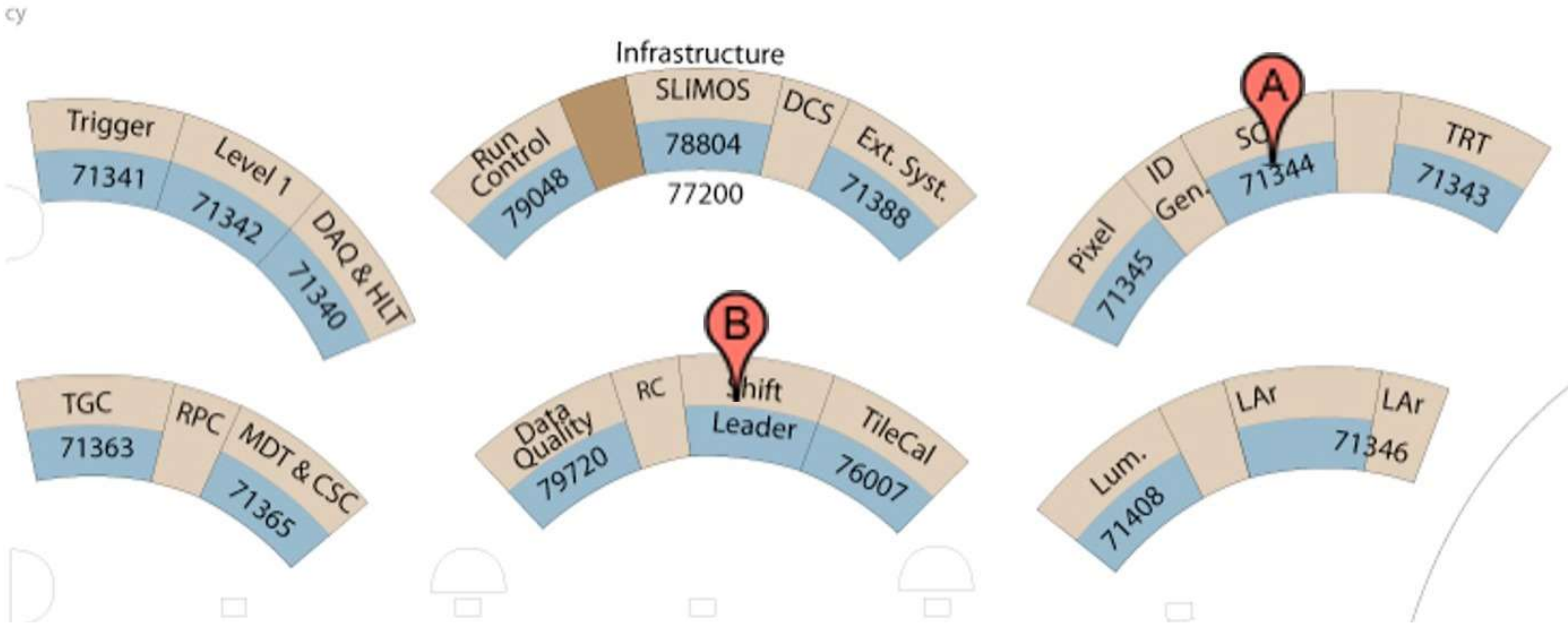
Which division of automated system are needed?



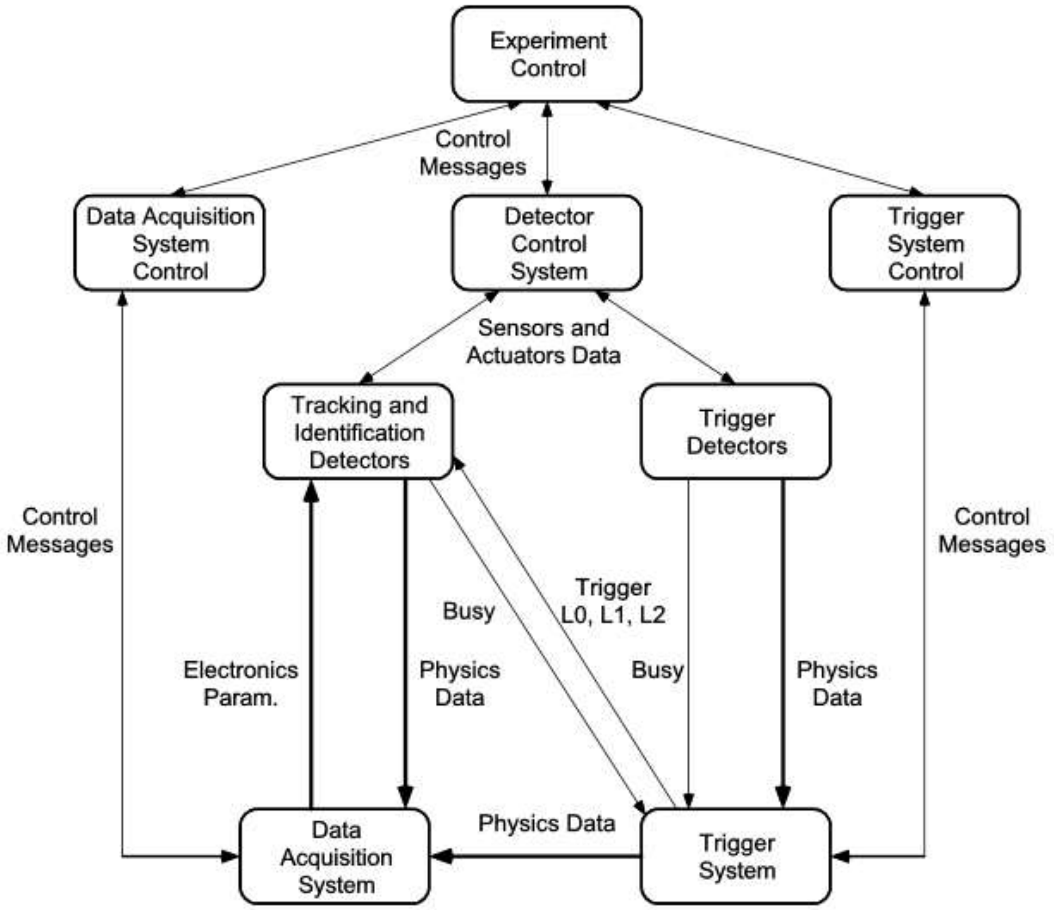
ALICE organization structure

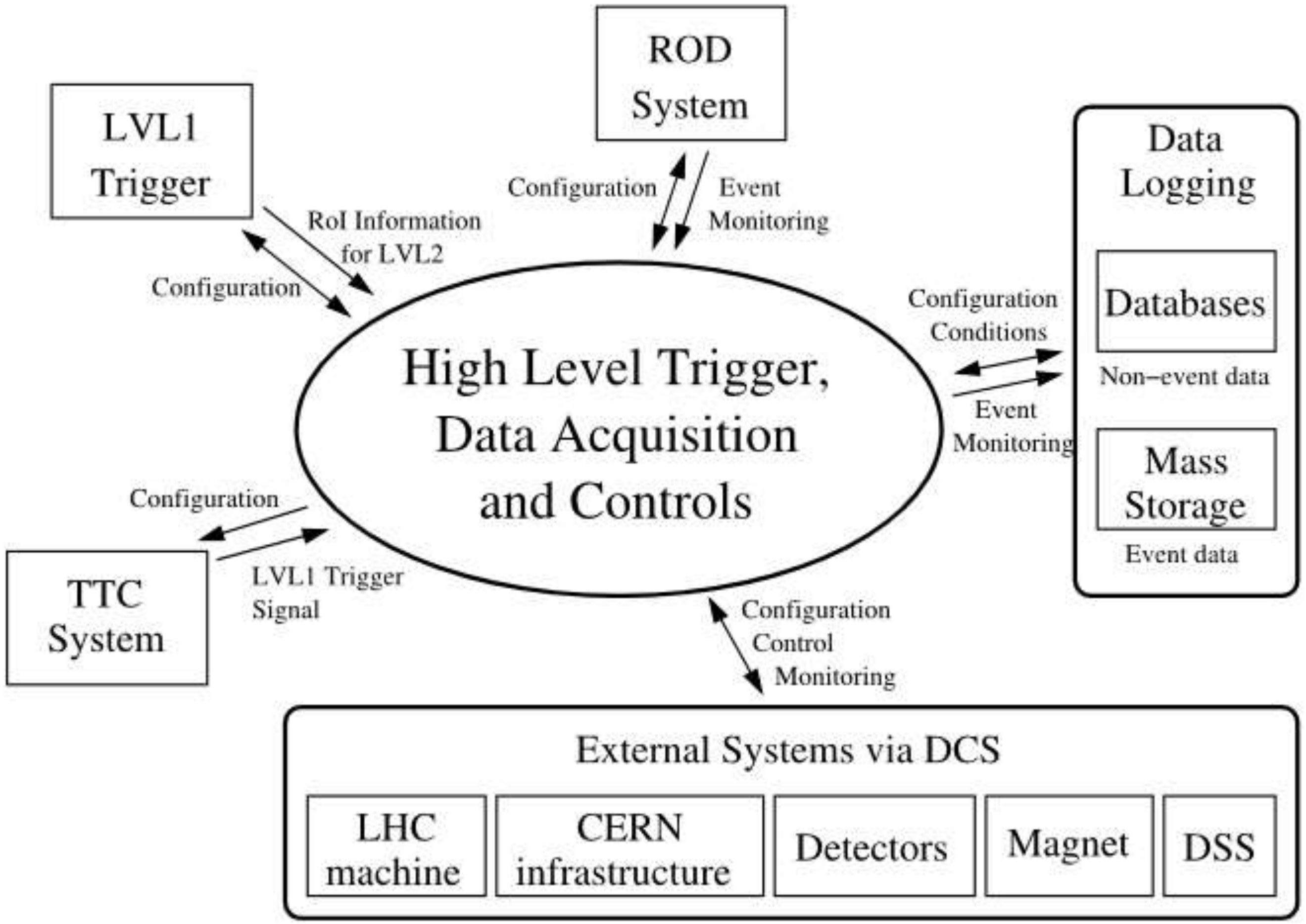


ATLAS CONTROL ROOM work areas



Examples of structured diagrams





GOALS AND OBJECTIVES

1. Provide stable units operation

2. Ensure safety equipment

Experimental data

3. Achieving highest output quality

4. Providing an optimal operational mode

CERN STYLE DECOMPOSITION

Detector Control System

DCS

- Status equipment
- Parameters technology process
- Equipment operation modes

Detector Safety System

DSS

- Interlocks
- Setpoints
- Process protection
- Locks and blocks

Quality Control System

QCS

- RAW data
- Quality control
- Correct data

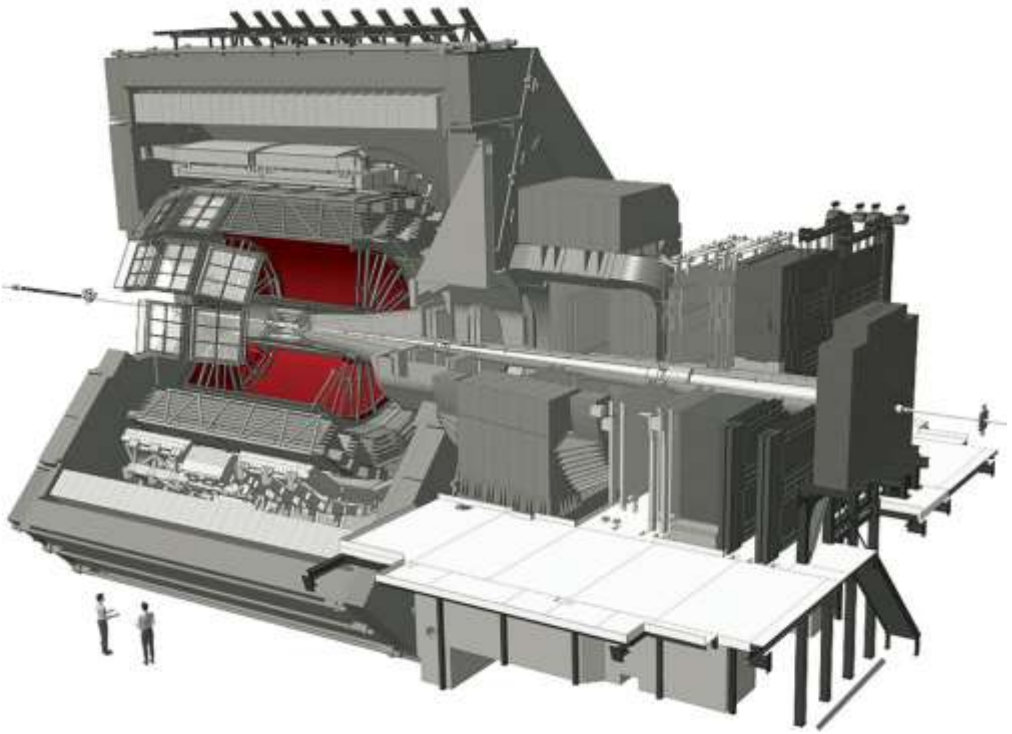
Experiment Control System

ECS

- Run start/stop
- Run coordination
- Run processing

DCS Automation scale of ALICE at CERN

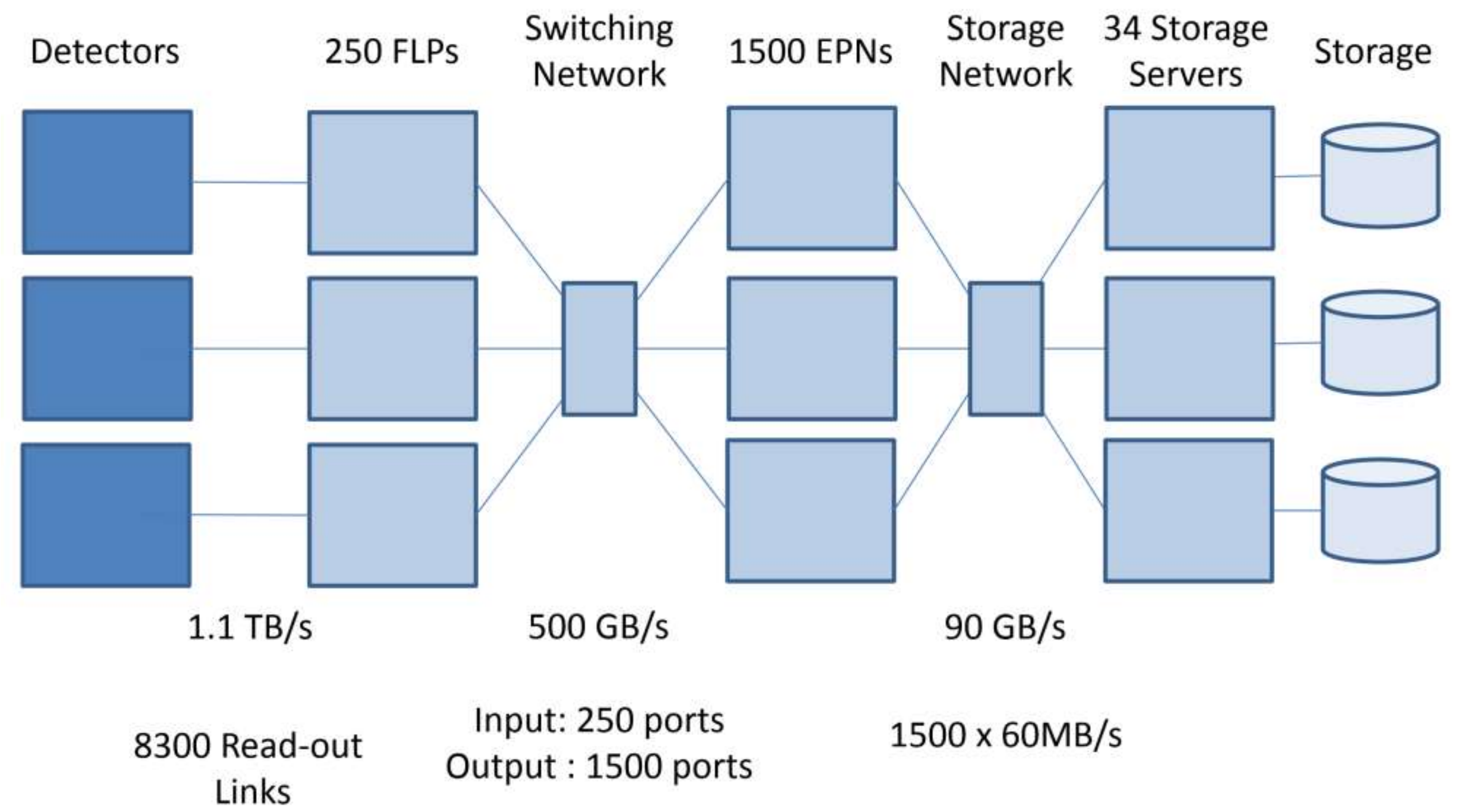
ALICE at CERN



Quantitative metrics:

- 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

Some scale of readout system of ALICE



MPD TPC Subsystem list

MPD subsystems table

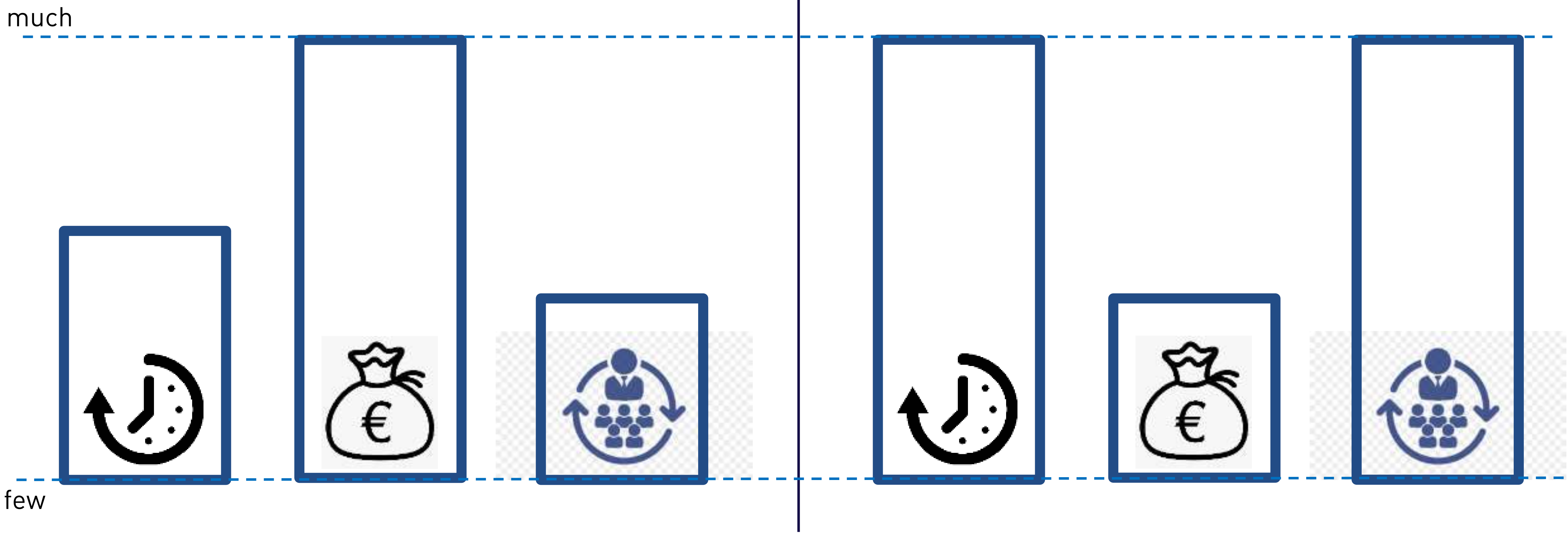
№	system	KKS	subsystem group	subsystem name	full name	amount parameters	кол-во PLC	кол-во серверов		responsible	русское название	комментарий
1	TPC	00TPC01HVP001	power supply	ROC HV PS	Readout Chamber High Voltage power supply subsystem	10000	2	1		Фатеев О.В.		
2	TPC	00TPC01LVP001	power supply	ROC LV PS	Readout Chamber Low Voltage power supply subsystem	10000	2	1		Фатеев О.В.		
3	TPC	00TPC01HVP002	power supply	VHV	Central TPC electrode & field cage	?	?	?		Сердюк В.З.		
4	TPC	00TPC01LVP002	readout	FED	front-end electronic monitoring	30000	6	2		Верещагин С.В.		
5	TPC	00TPC01HVP003	readout	Pulser	Calibration Pulser	?	?	?		Верещагин С.В.	подача тестого сигнала на катодную плоскость	
6	TPC	00TPC01LVP003	power supply	GGG	Gating Grid Generator Power Supply	?	?	?		Мовчан С.А.		
7	TPC	00TPC01HVP004	laser	Laser	Laser and Beam monitoring/control	?	?	?		Лукстиньш Юрис, Аверьянов А.		
8	TPC	00TPC01LVP004	laser	Laser sync	Laser synchronization	?	?	?		Лукстиньш Юрис		
9	TPC	00TPC01HVP005	readout	DVM	Drift Velocity Monitor (Goofie)	?	?	?		Бычков А.	функция лазерной системы	рогочевский, подфункция DA(
10	TPC	00TPC01LVP005	termo	Temperatures	Temperature Monitoring System	500	1	1		Балашов И.А.		
11	TPC	00TPC01HVP006	termo	Cooling	Termostabilisation System monitoring/control	1000	1	1		Балашов И.А.		
12	TPC	00TPC01LVP006	gas	GAS	Gas mixing subsystem	1000	1	1		Сердюк В.З.		
13	TPC	00TPC01HVP007	gas	GGM	gas gain monitor	500	1	1		Фатеев О.В.	контроль газового усиления в ROC камерах, контроль амплитудных спекторов	
14	TPC	00TPC01LVP007	readout	TF	Trigger/synchronization fanout					Верещагин С.В.	размножитель триггерного сигнала и подсистема синхронизации всего оборуд	
15	TPC	00TPC01HVP008	readout	JTAG	JTAG commutator					Потапов Денис	подсистема перепрошивки FPGA	
16	TPC	00TPC01LVP008	power supply	LV FEE	Low Voltage of front-end electronics					Пигяр А.		
17	SCC	00SCC01PSS001	power supply	PSS	power supply of superconductor solenoid					Мухин		
18	SCC	00SCC01VMS001	power supply	VMS	Voltage monitoring system							
19	SCC	00SCC01QPS001	power supply	QPS	quench protection system evacuation current					Мухин	подсистема эвакуации токов	
20	SCC	00SCC01SMS001	-	SMS	suspention monitorion system					Мухин		
21	SCC	00SCC01TMS001	termo	TMS	termo monitorion system					Мухин		
22	SCC	00SCC01MMS001	-	MMS	magnetic megurements					Мухин		
23	SCC	00SCC01VCS001		VCS	vacuum control system							
24	CES	00CES01RFS001	-	RFS	refrigirator							
25	CES	00CES01CDS001	-	CDS	control duarew							
26	CES	00CES01MFS001	-	MFS	nitrogen hitter (MFS) magnet flushing system							
27	CES	00CES01OHS001	-	OHS	outlet hitters							
28	CES	00CES01NTS001	-	NTS	nitrogen tanks							

systems | Subsystems | Units | Devices | Signals/parameters/TAGs | Operating modes | Interlock | Re

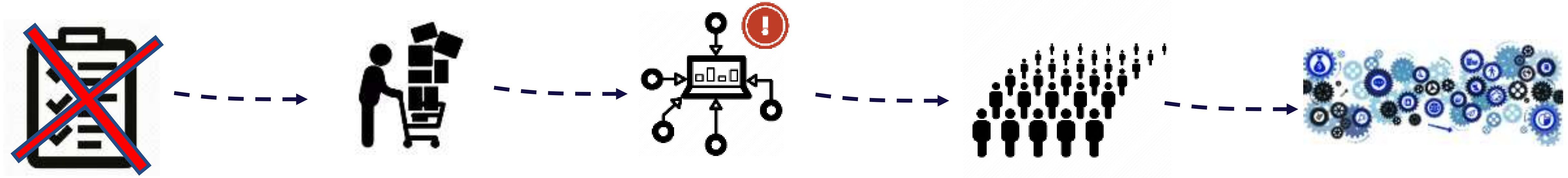
Resource Cost Comparison

Any Commercial SCADA

Open source SCADA TANGO



different ways results



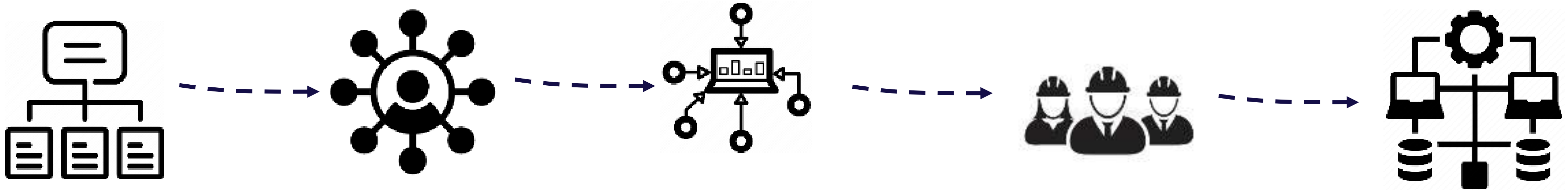
No solutions
No architecture

different local
monitoring subsystem

Integration
problems

Lots of staff

more complex
and expensive system



Structured source
data and architecture

One
supervisory
level

easier
integration

less staff

considered
system

SUMMARY

Functional expectations

- Supervisory – fully controllable, not only “monitoring”:
- Control, adjustments, alarms, historical data, etc.
- Balance between automation and human involvement

Potential architecture

- Vertical Integration: control, management, enterprise, business
- Horizontal Organization: technological units, processes
- Typical main division: DCS, DSS, QCS, ECS

Scale of already existed automated systems (ALICE)

- DCS – more that 100 servers, 1000-ти MIMICS panels
- DAQ – over 8000 fast links, around 2000 servers
- TCS – complex, multilevel: L0, L1, L2, a lot of config DB, algorithms

Call to action

- Establish Clear Functional Devision for MPD's Automated Systems
- Specify Requirements for the Automated Systems of MPD
- Develop design solutions – TDR for each one

JOINT INSTITUTE
FOR NUCLEAR RESEARCH

Thank you !!!

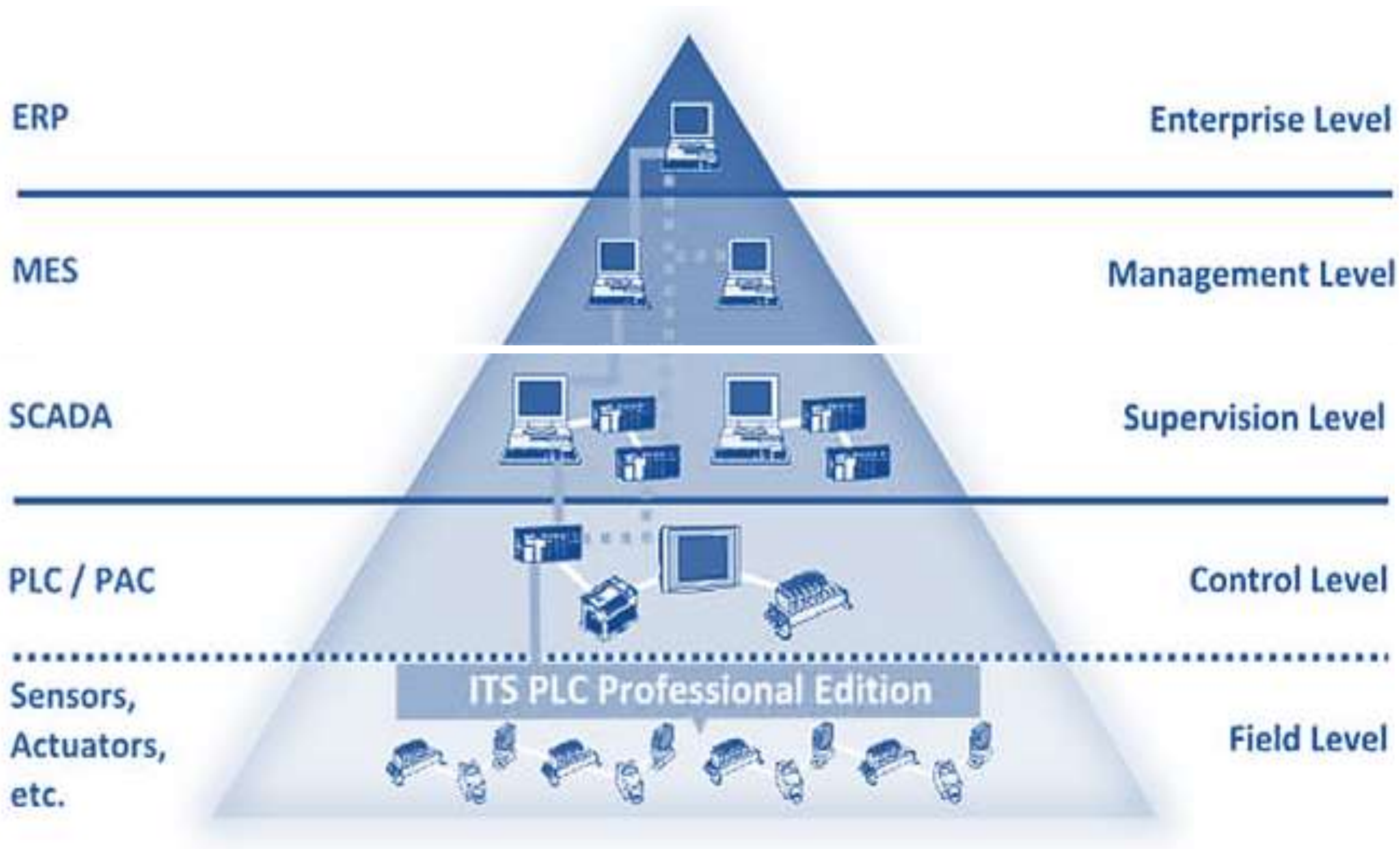
Nikita Baldin

automation lead engineer

nabaldin@jinr.ru

+7(926)5630684

Hierarchy of automated systems



detailed planning, inventory management, sales, finance, purchasing

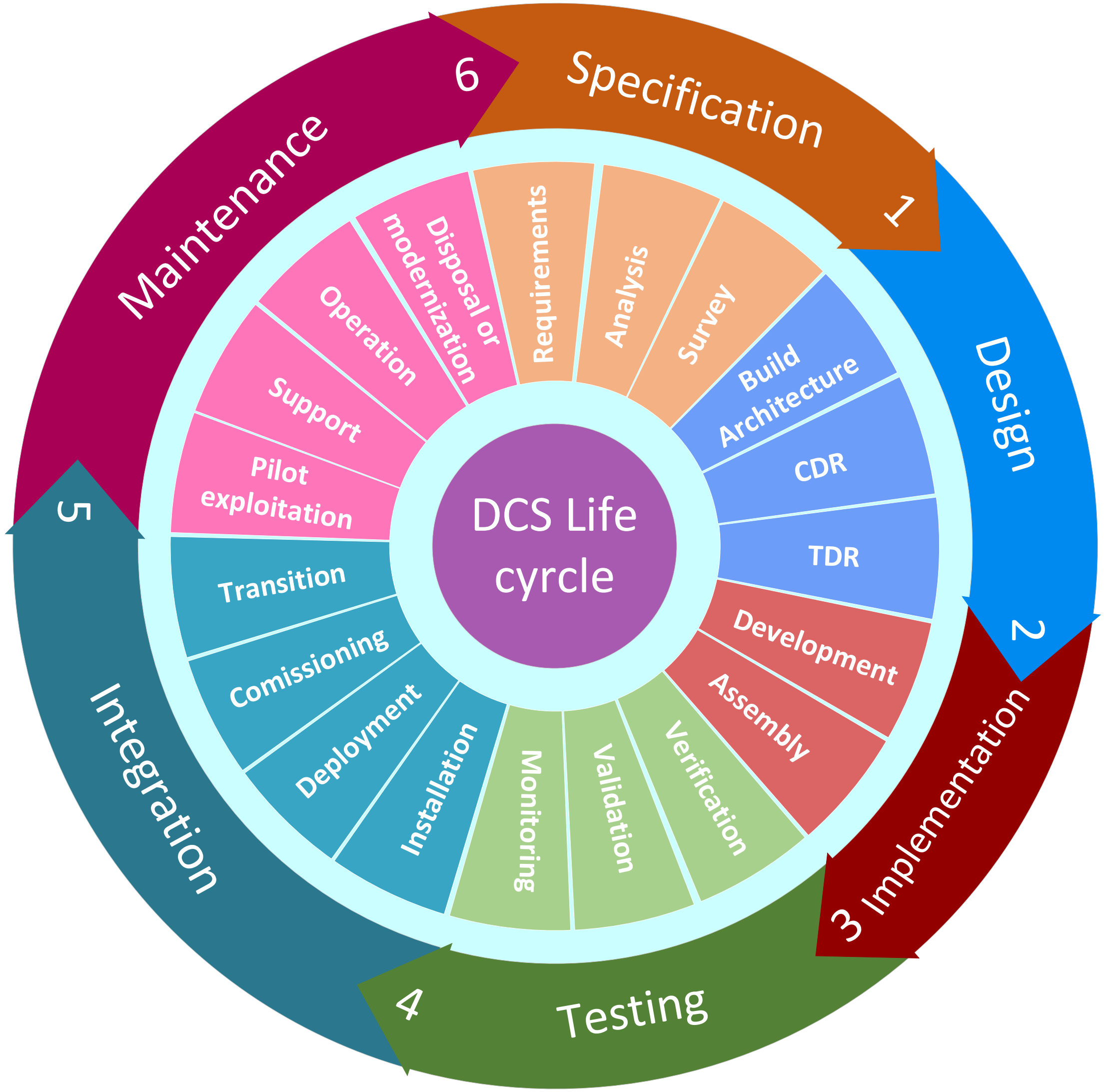
monitoring the status and allocation of resources, process quality, performance analysis

process control and management, production dispatching

primary signal processing and logic of algorithms for automatic control of equipment

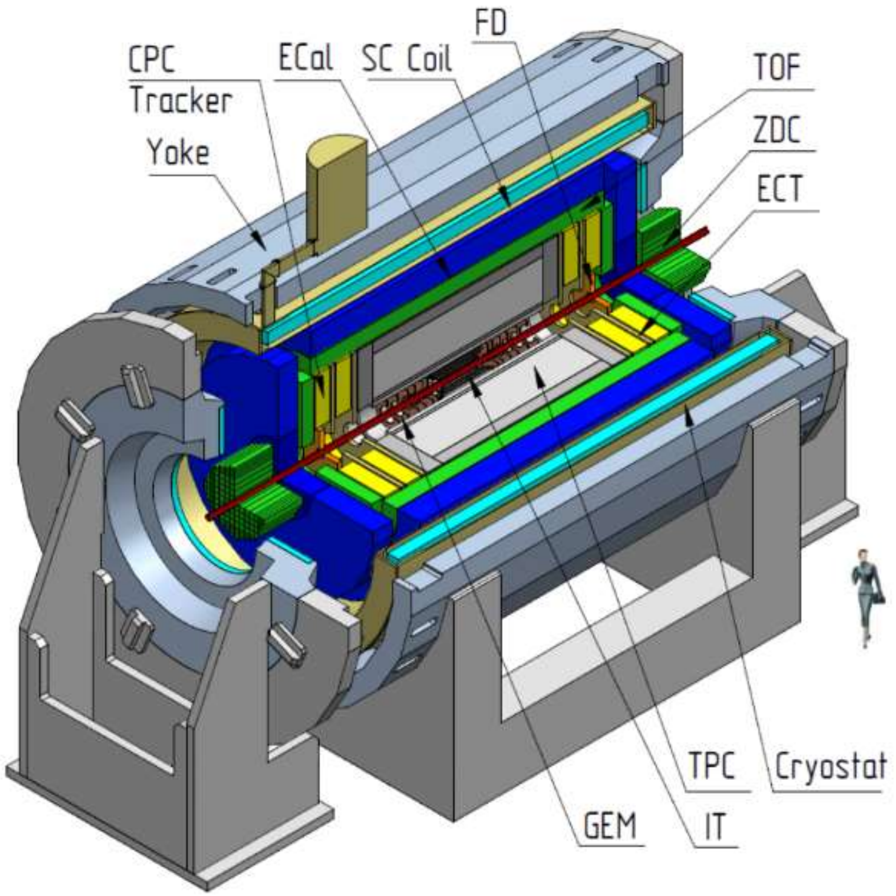
technological equipment, facility, sensors, actuators

LIFE CYCLES OF AUTOMATED SYSTEMS



Automation object: MPD experiment facility

Multi-Purpose Detector



First stage Subdetectors:

- TPC, TOF, Ecal, FFD, FHCAL

Second stage Subdetectors:

- ITS, GEM, CPC

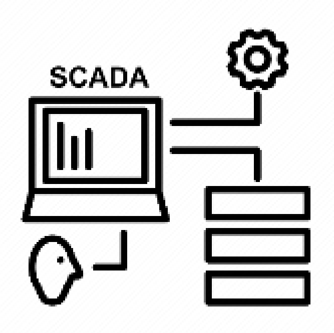
Infrastructure subsystems:

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

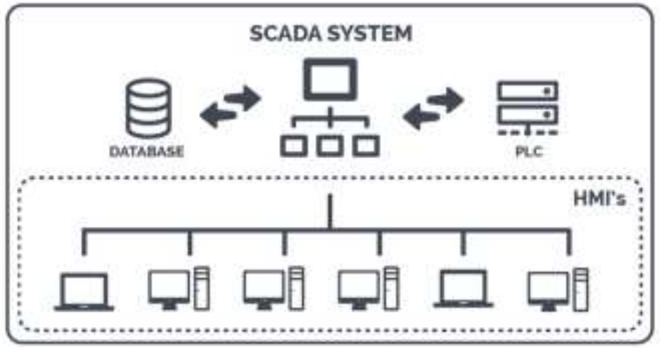
External services:

- Electricity, cryogenic, cooling, gas etc.

SCADA Abbreviation



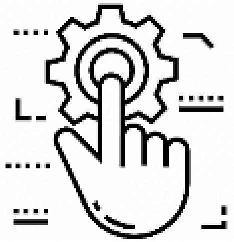
SCADA



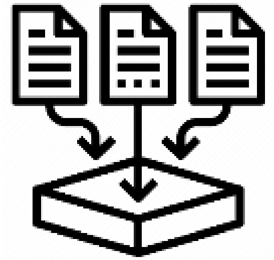
Supervisory, control and **data acquisition**

Supervisory

Control



Data Acquisition

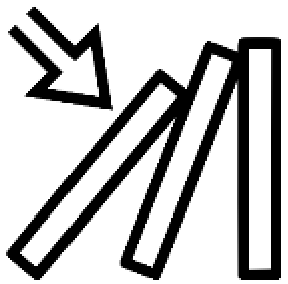


Experimental physics terminology

"Data Acquisition, Control and Trigger"

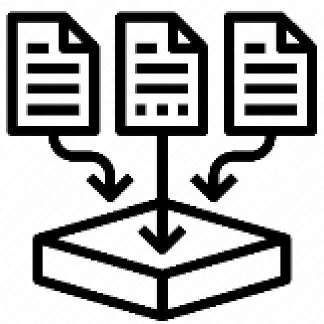
"High-Level Trigger, Data Acquisition and Controls"

Trigger



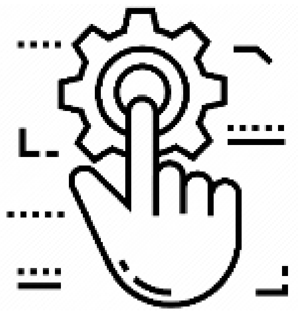
+

Data Acquisition



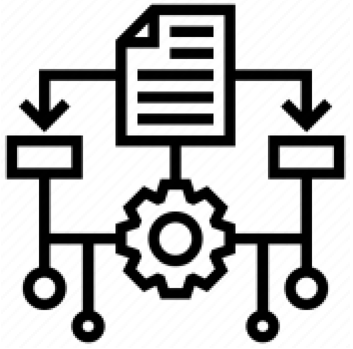
+

Controls



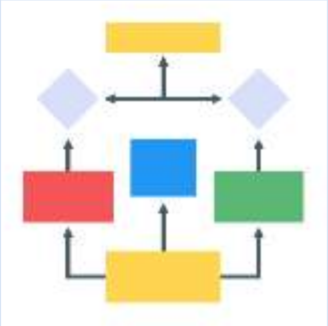
DESIGN APPROACHES

top-down design



- overall concept
- defined structure and architecture
- Improved planning and understanding requirements
- Easy maintenance

bottom-up design



- detailed design of low-level components
- gradual increase
- risk of component integration problems and architecture revision
- Difficulties in managing complexity, harder maintenance & rising costs

“convenient” user interface example

Stave	PLC Monitor?	PU1 Monitored?	PU1 Safe?	PU2 Monitored?	PU2 Safe?	PU1 Int. T	PU1 Halfstave T	PU1 Powered?	PU2 Int. T	PU2 Halfstave T	PU2 Powered?	RU FPGA T
L6_00	YES	NO	TRUE	NO	TRUE	22.35	21.52	ERR	21.24	21.07	ERR	30.51
L6_01	YES	NO	TRUE	NO	TRUE	22.19	22.34	ERR	21.15	21.26	ERR	86.80
L6_02	YES	NO	TRUE	NO	TRUE	18.99	18.92	NO	18.74	18.54	NO	172.23
L6_03	YES	NO	TRUE	NO	TRUE	36.81	-268.56	ERR	36.81	-268.56	ERR	99.03
L6_04	YES	NO	TRUE	NO	TRUE	36.81	-268.56	ERR	36.81	-268.56	ERR	-273.82
L6_05	YES	NO	TRUE	NO	TRUE	36.81	-268.56	ERR	36.81	-268.56	ERR	-273.82
L6_06	YES	NO	TRUE	NO	TRUE	36.81	-268.56	ERR	-33.10	501.70	NO	99.04
L6_07	YES	NO	TRUE	NO	TRUE	36.81	-268.56	ERR	36.81	-268.56	ERR	-273.82
L6_08	YES	NO	TRUE	NO	TRUE	-259.51	175.01	ERR	-259.73	1.16	ERR	-273.82
L6_09	YES	NO	TRUE	NO	TRUE	-259.73	-268.34	ERR	-259.73	1.16	ERR	-273.82
L6_10	YES	NO	TRUE	NO	TRUE	36.81	-268.56	ERR	36.81	-268.56	ERR	-273.82
L6_11	YES	NO	TRUE	NO	TRUE	36.81	-268.56	ERR	36.81	-268.56	ERR	31.41
L6_12	YES	NO	TRUE	NO	TRUE	779.17	-268.56	ERR	18.83	18.22	NO	-273.71
L6_13	YES	NO	TRUE	NO	TRUE	299.11	-247.79	ERR	18.80	18.13	NO	32958422.83
L6_14	YES	NO	TRUE	NO	TRUE	19.28	18.38	NO	18.77	18.47	NO	32958422.83
L6_15	YES	NO	TRUE	NO	TRUE	19.25	18.70	NO	18.74	18.54	NO	32958422.83
L6_16	YES	NO	TRUE	NO	TRUE	19.28	18.60	NO	18.83	18.35	NO	32958422.83
L6_17	YES	NO	TRUE	NO	TRUE	19.28	18.70	NO	18.64	18.19	NO	32958422.83
L6_18	YES	NO	TRUE	NO	TRUE	19.02	19.01	NO	18.52	18.66	NO	32958422.83
L6_19	YES	NO	TRUE	NO	TRUE	19.09	18.38	NO	18.67	18.22	NO	32958422.83
L6_20	YES	NO	TRUE	NO	TRUE	19.06	18.89	NO	18.52	18.28	NO	32958422.83
L6_21	YES	NO	TRUE	NO	TRUE	278.69	106.77	ERR	18.52	18.22	NO	32958422.83
L6_22	YES	NO	TRUE	NO	TRUE	19.12	18.51	NO	18.52	18.89	NO	32958422.83
L6_23	YES	NO	TRUE	NO	TRUE	18.93	18.32	NO	18.45	18.47	NO	32958422.83

DCS qualitative indicators

Qualitative indicators:

Monitoring all subsystems
All in one application

Alarm table & tips
All in one application

Automations algorithms

Control function

Archive & logging