Approaching the Final Design of the ITER Control System

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ITER Organization

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- ITER recap
- Status of ITER construction
- Control System Architecture and Integration
- Infrastructure
- High Level Applications
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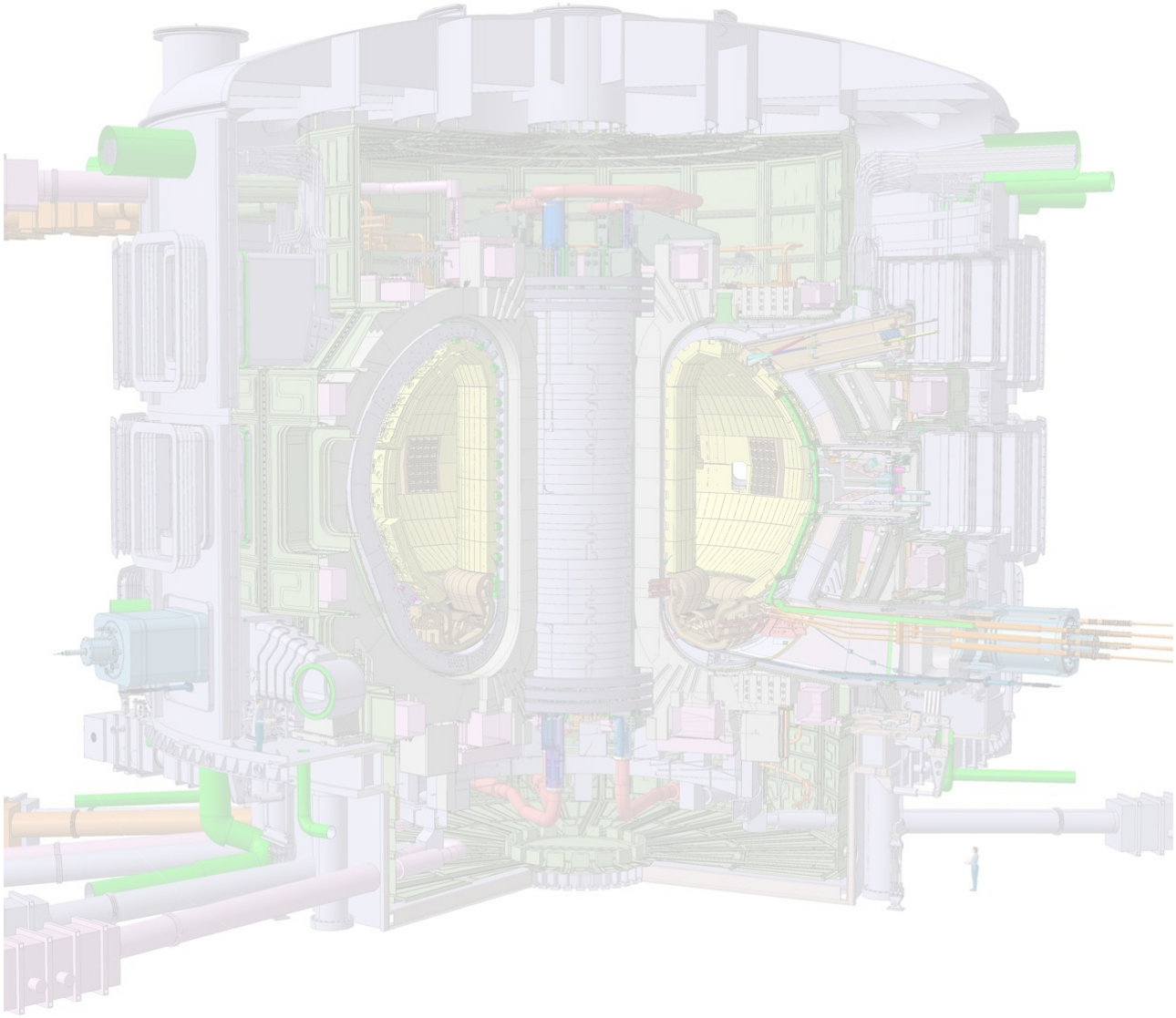
ITER Recap



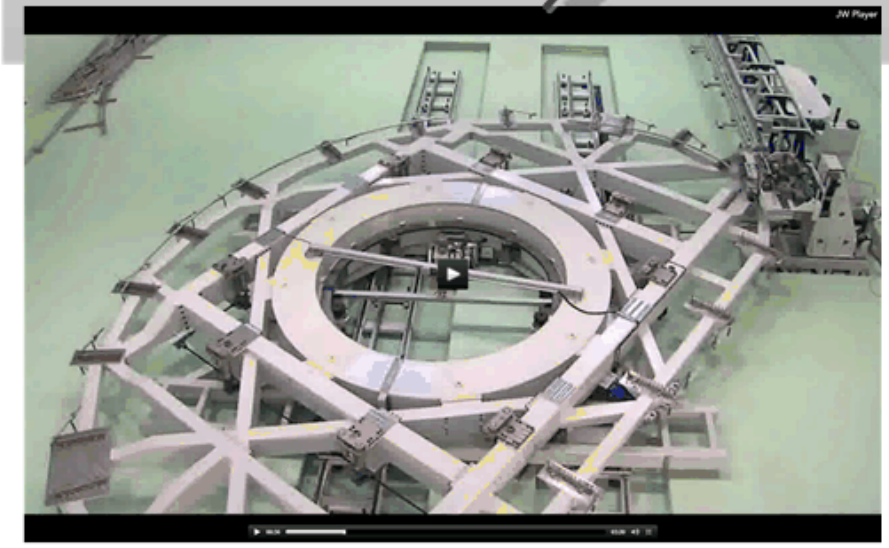
- **The objective of the ITER project is to demonstrate the feasibility of commercial production of fusion energy**
- **ITER is based on magnetic confinement of the plasma using a "Tokamak" as opposed to inertial confinement**
- **ITER is an international project with seven members (China, Europe, India, Japan, Korea, Russia and USA)**
- **ITER is based on IN-KIND procurement arrangements, where the members mainly provide systems/components, not money**
- **ITER is currently in construction phase**
- **Final design reviews of ITER control system start Jan 2014**


ITER construction site, France, Aug 30, 2013

Progress of ITER Construction (examples)

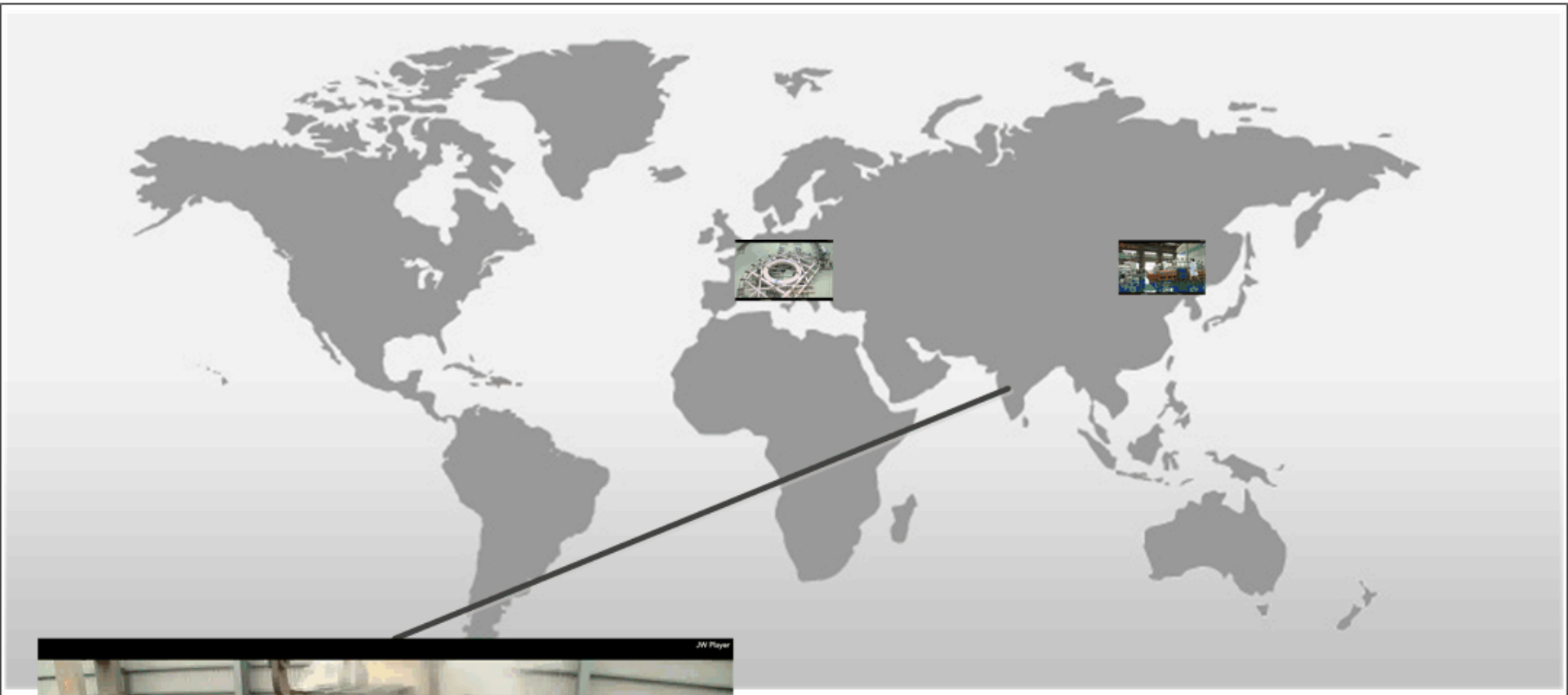
Superconducting feeders and cables

Progress of ITER Construction (examples)



Toroidal Field Coils

Progress of ITER Construction (examples)

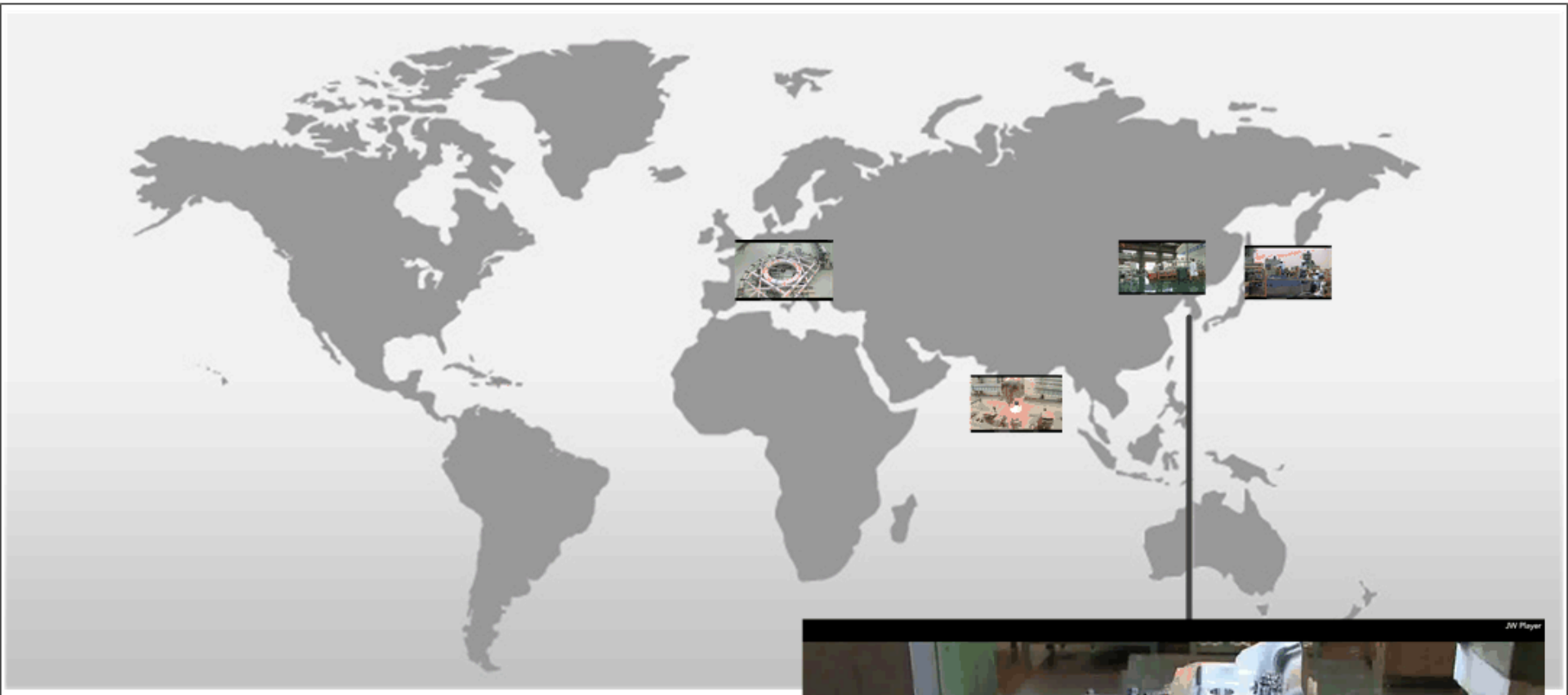


Cryostat

Progress of ITER Construction (examples)

Superconductors

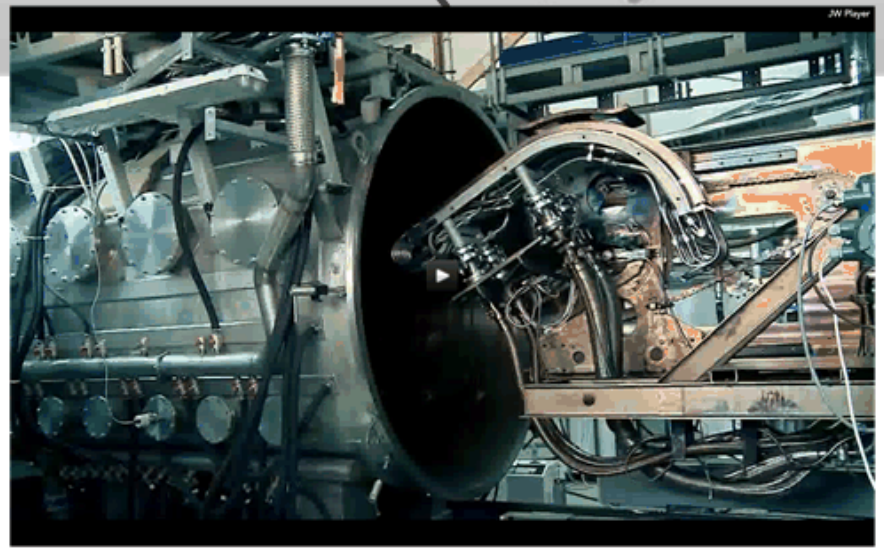
Progress of ITER Construction (examples)



Vacuum Vessel Sectors

Progress of ITER Construction (examples)

Plasma Facing Components



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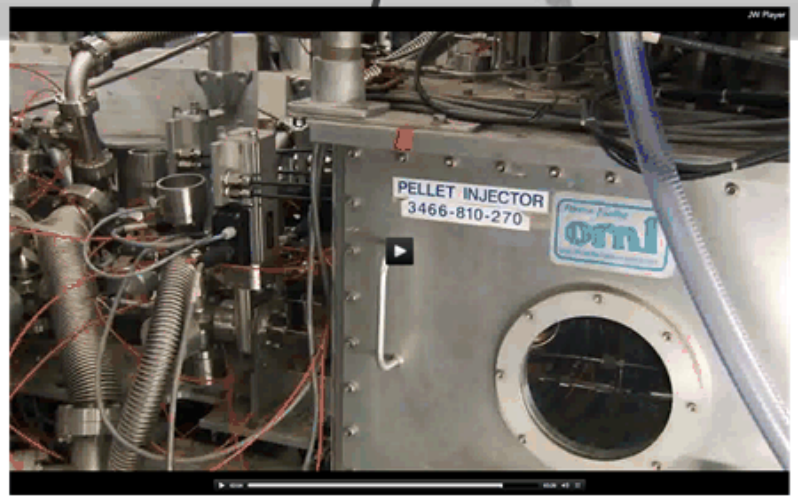

Pellet Injector

Progress of ITER Construction (examples)

- ITER manufacturing in progress around the world
- First components expected at ITER site in 2015

Control System Architecture and Integration

ITER Control System

Mission Statement

Ensure all ITER Plant Systems Instrumentation & Control are designed, implemented and integrated such that ITER can be operated as a fully **integrated** and automated system.

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- Successful integration = higher reliability
- Minimize required operators
- Minimize required maintenance crew
- Minimize operator human errors
- Single control room with standard equipment

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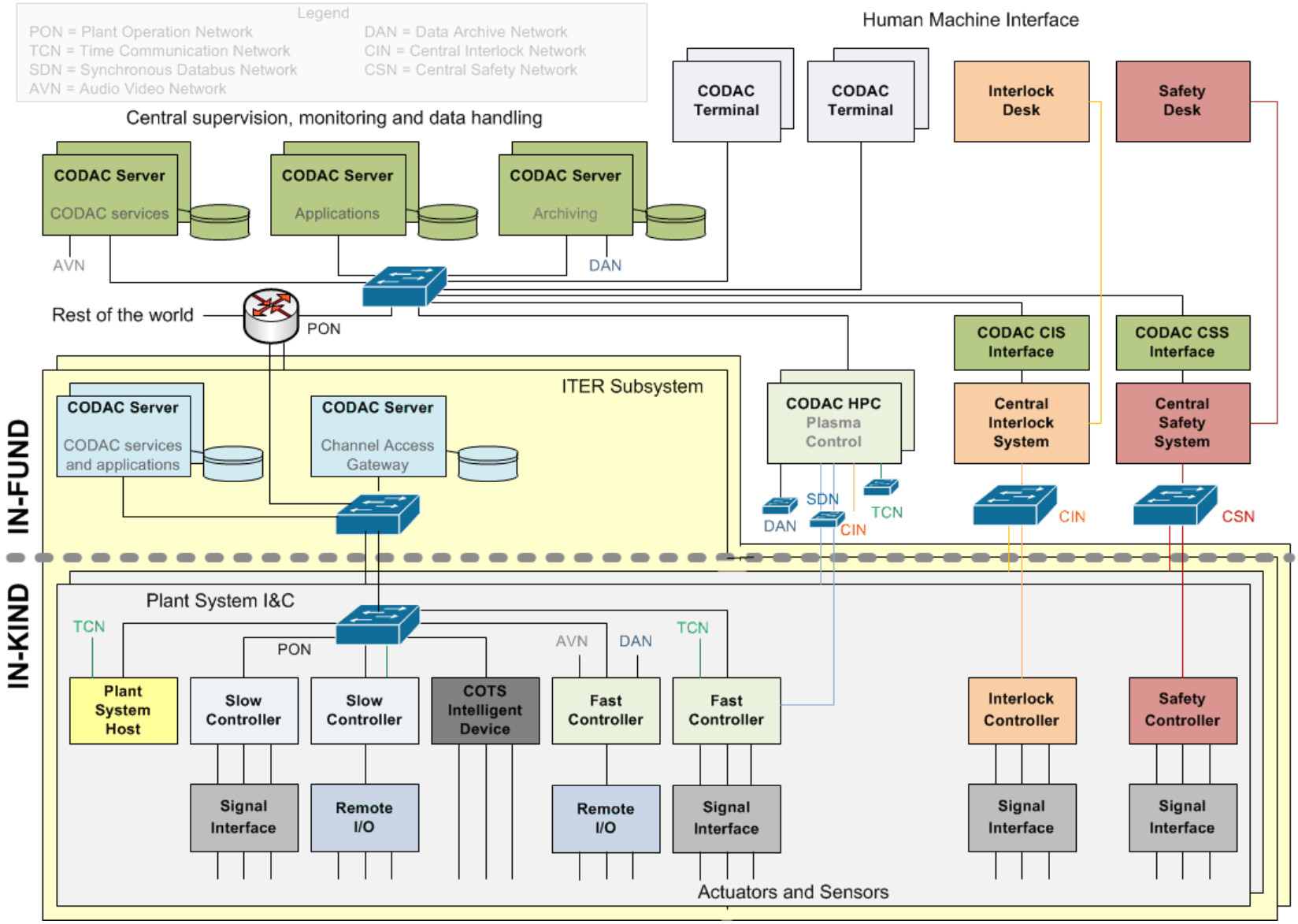
⇒ Reduced total cost

Architecture



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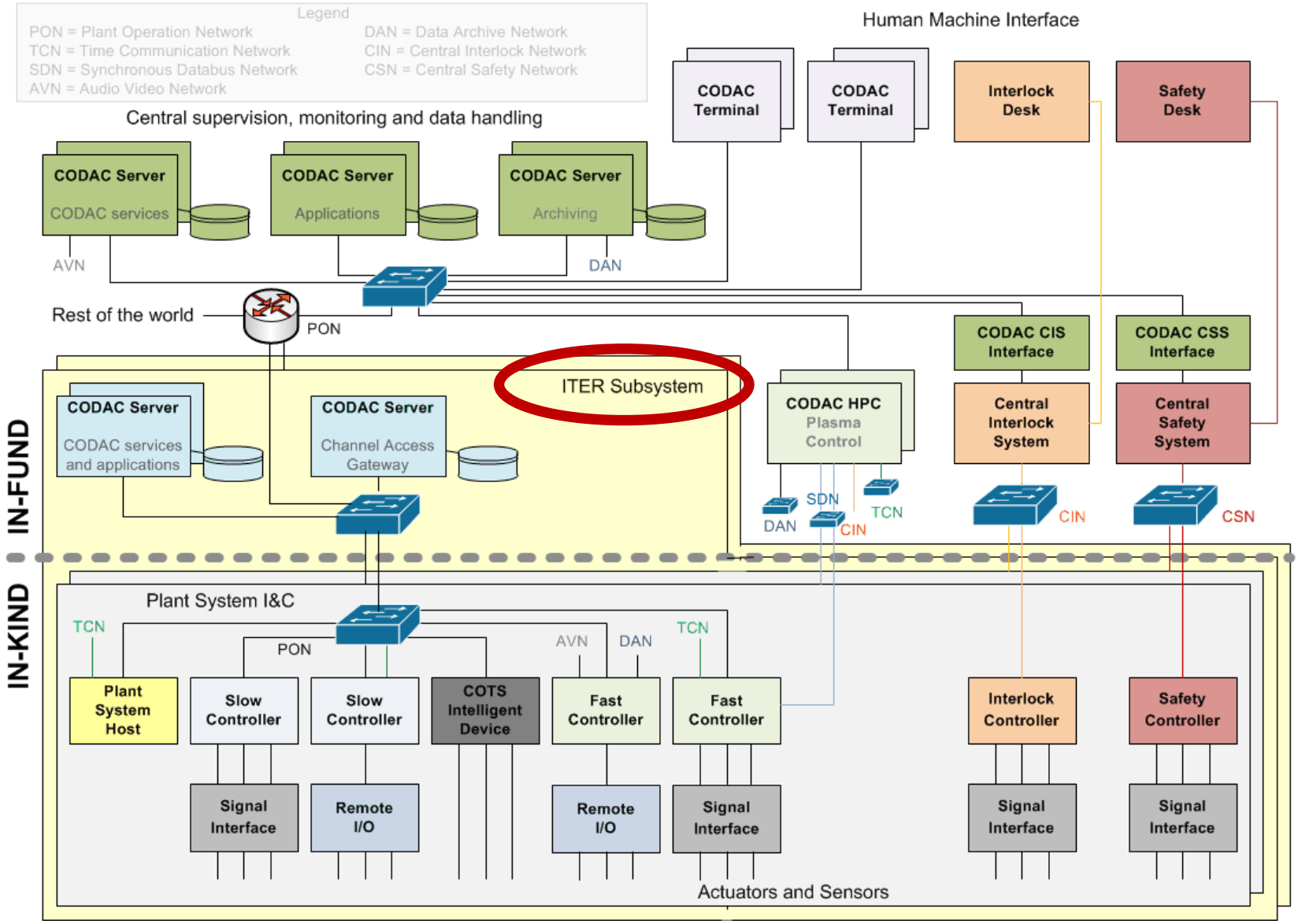

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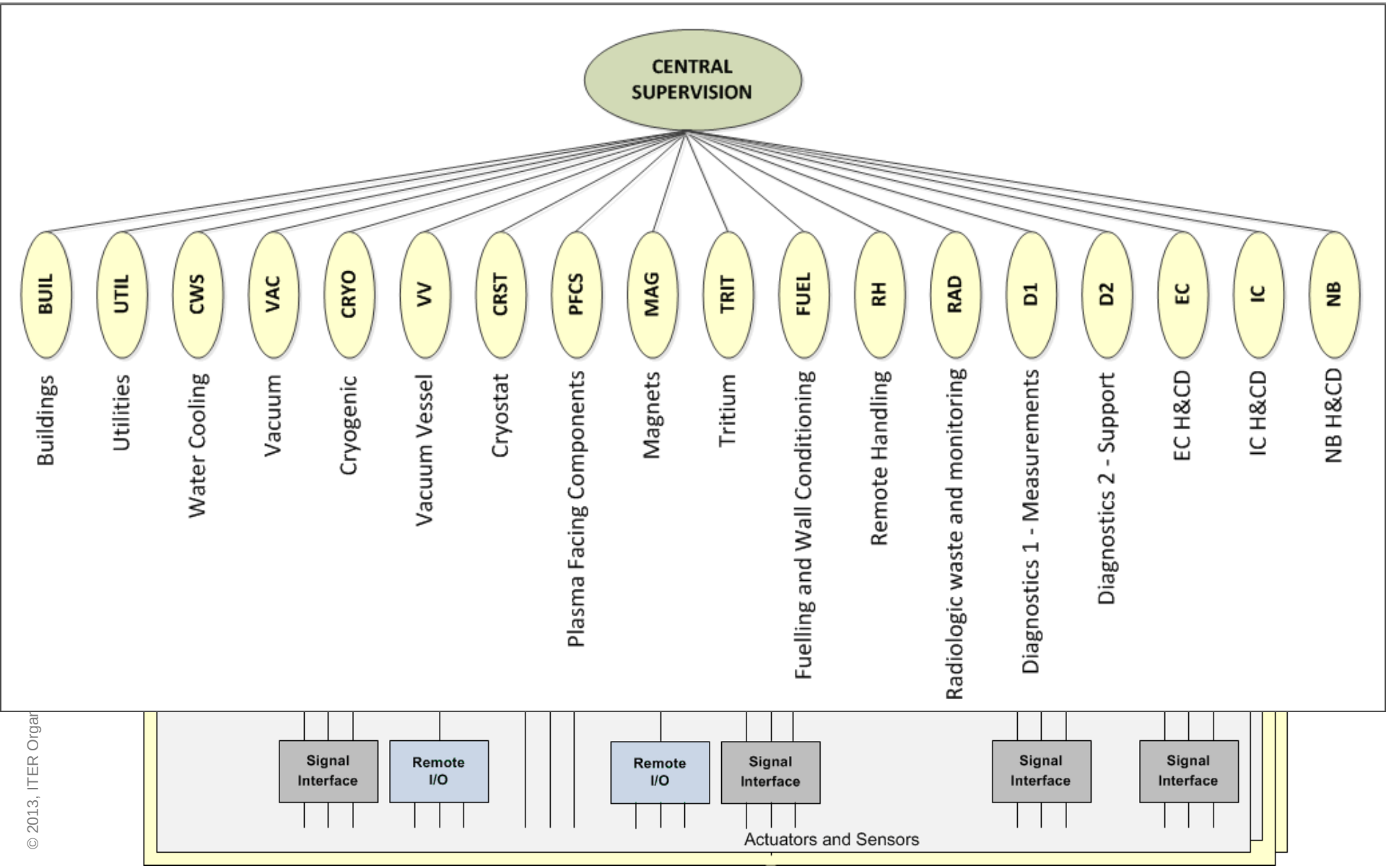

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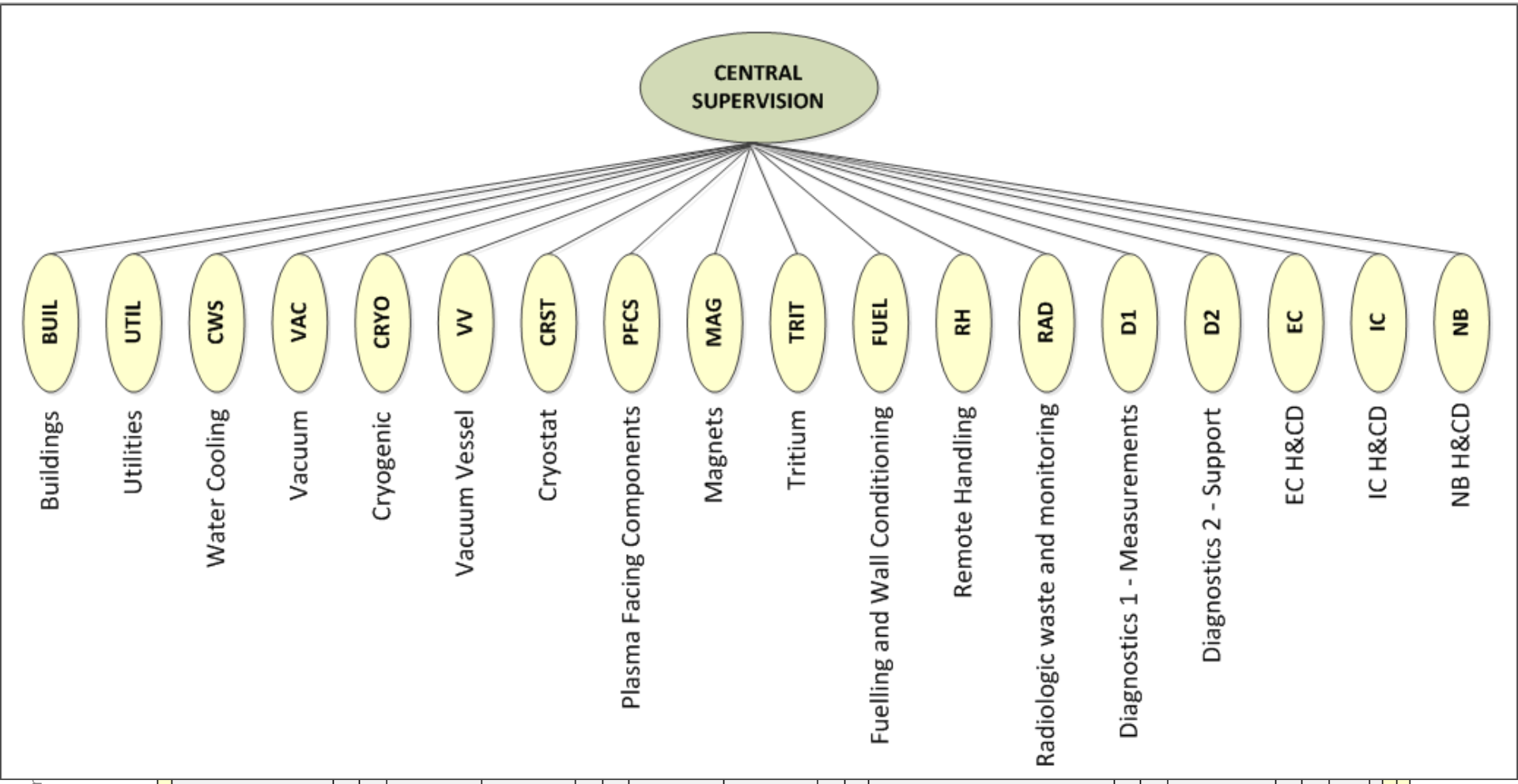
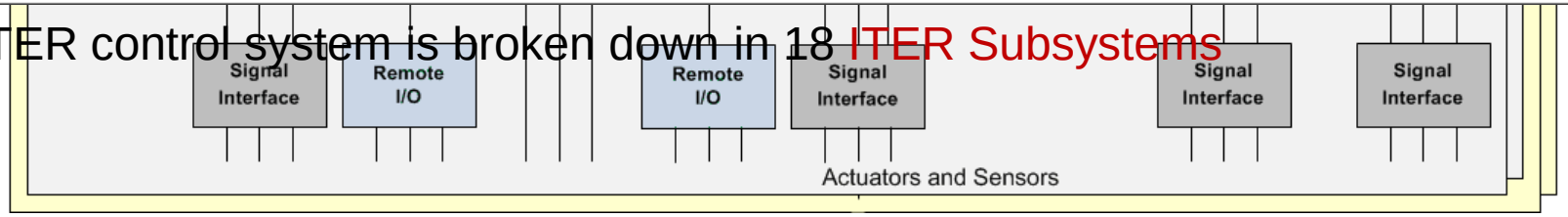


- ITER control system is broken down in 18 ITER Subsystems



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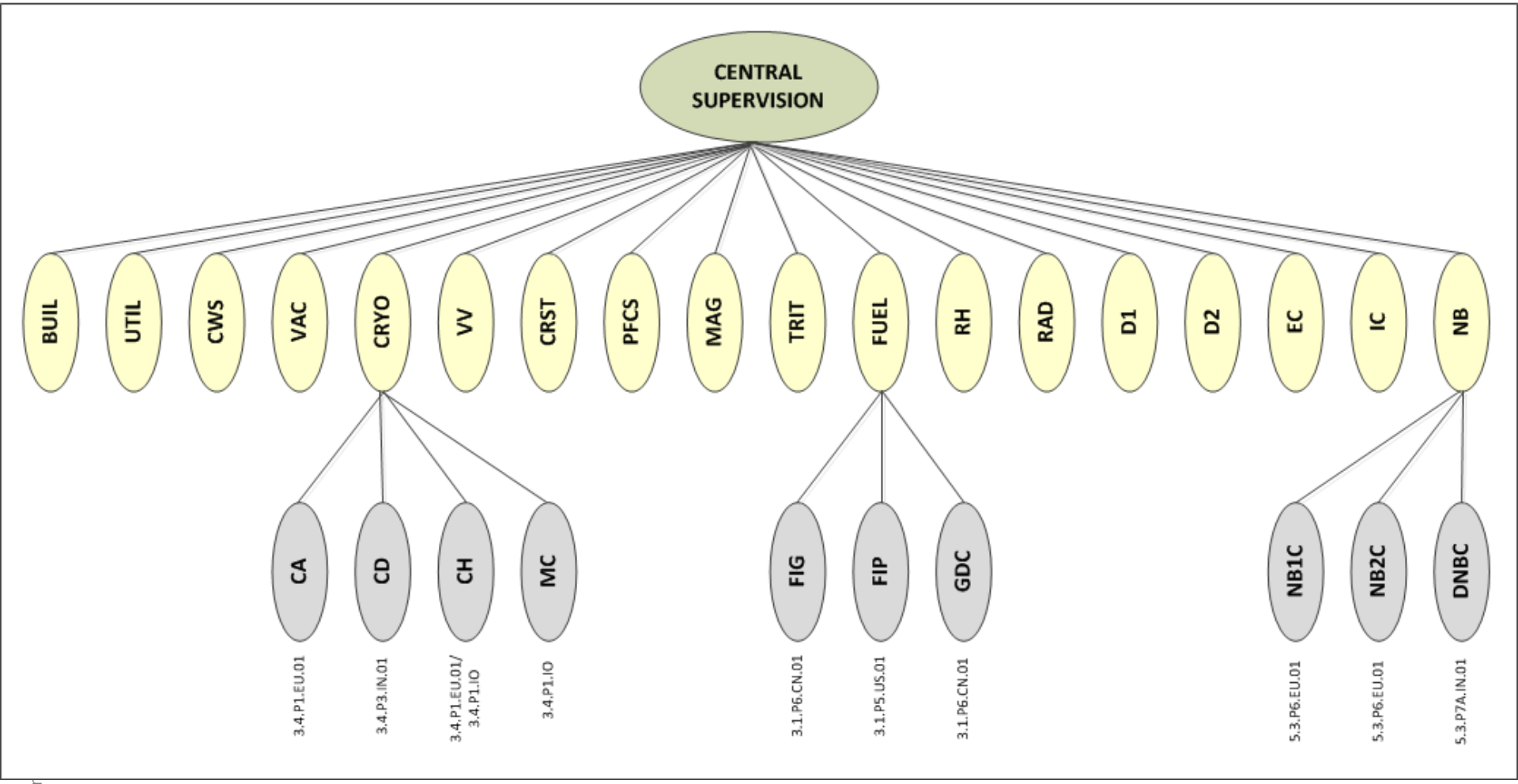

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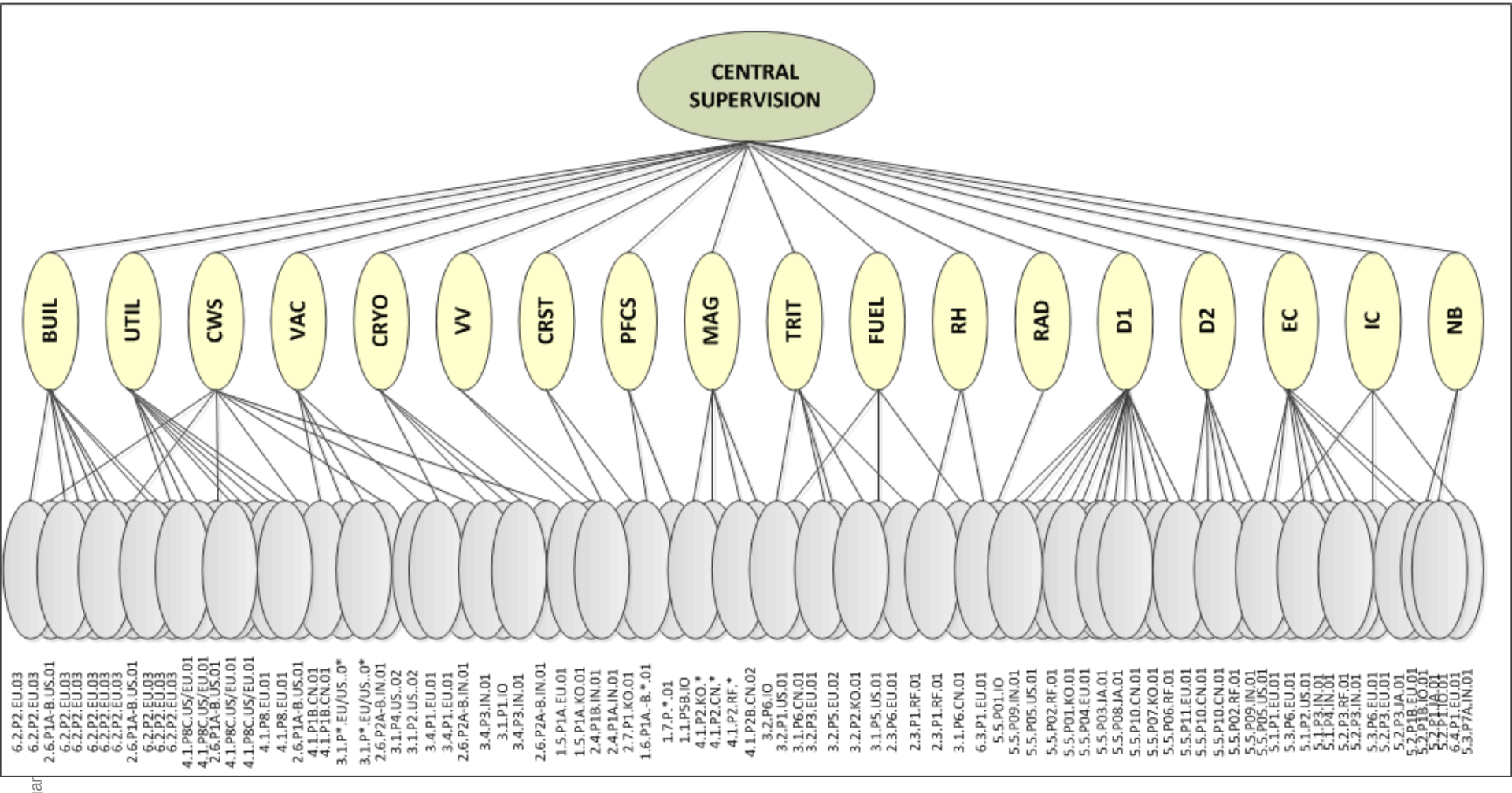
- An ITER Subsystem contains one or many local control systems
- A local control system is a deliverable from a procurement arrangement

Architecture



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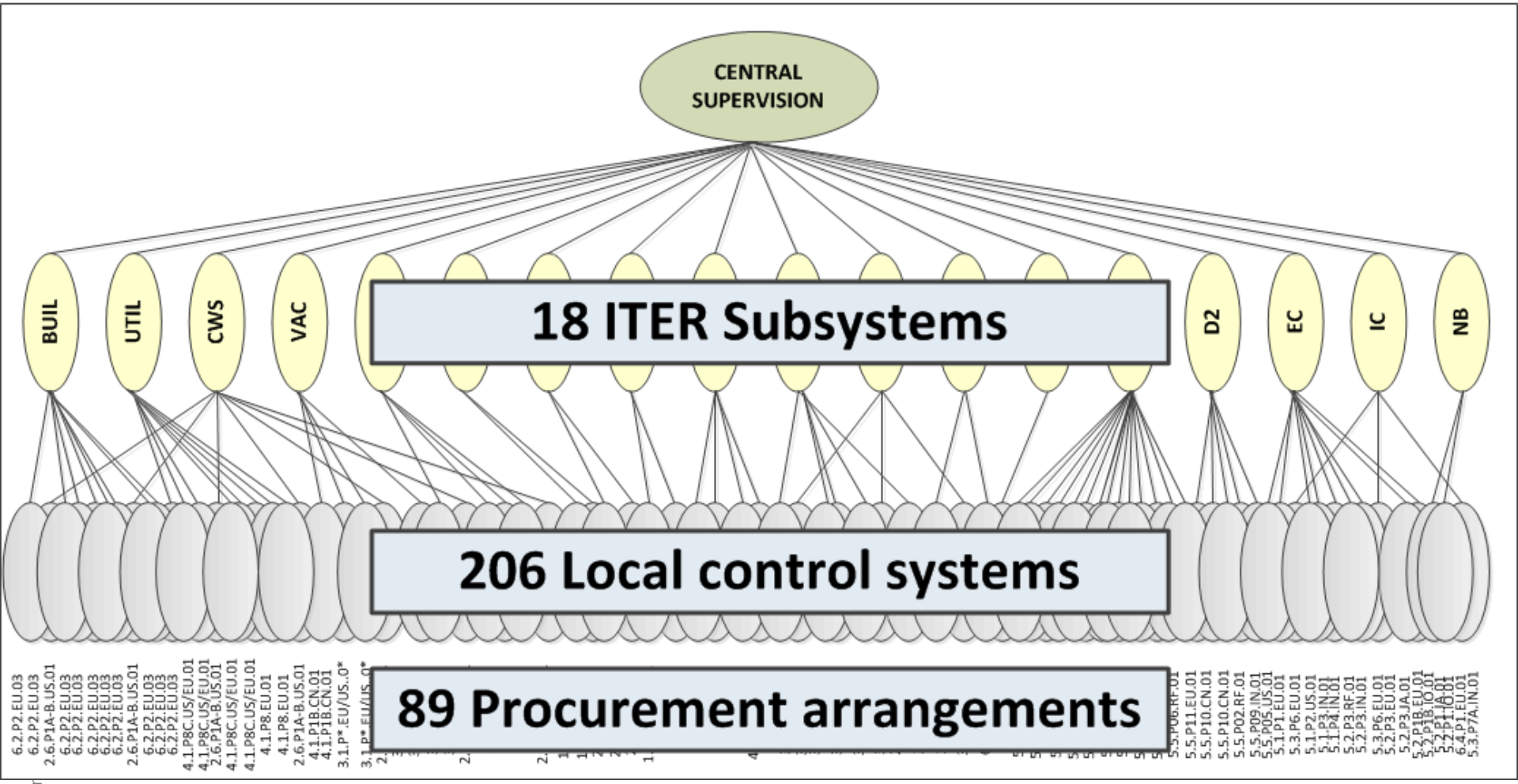

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The main challenge for ITER Control System is

INTEGRATION

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MITIGATION

- Define standards, specifications and interfaces applicable to all plant systems instrumentation and control (Plant Control Design Handbook - PCDH)

Final complete PCDH (v7) released May 2013

Nb	IDM ref	Insert title	Content
1	**27LH2V**	**PCDH**	**The core document which collects all requirements**
2	32GEBH	I&C architecture	Guideline for plant system I&C architecture
3	34SDZ5	CODAC overview	CODAC core system overview
4	34V362	CODAC interface	Scope of plant system I&C – Central I&C interface
5	2UT8SH	I&C naming	Naming convention in use for components, signals and variables
6	34QXCP	Self-description	The data required for generating the plant system I&C interface
7	353AZY	I&C specifications	Scope and how to for I&C specs required at FDR
8	3VVU9W	I&C integration	Scope and scenarios for FAT and SAT for I&C
9	2NRS2K	SW and QA	General requirements for SW QA
10	3QPL4H	PLC SW	Specific requirements for PLC SW
11	3WCD7T	Alarm handling	Scope and introduction to alarm handing
12	3XLESZ	HMI	Scope and introduction to HMI
13	B7N2B7	PON archiving	Scope and introduction to PON archiving
14	AC2P4J	PSOS management	Scope and introduction to PSOS-COS synchronisation
15	354SJ3	Diagnostic data	Scope and introduction to diagnostic data
16	75ZVTY	Interlock functions	How to identify interlocks
17	2YNEFU	PCDH-N	Specific requirements and guidelines applicable to N-Safety
18	35W299	CWS CS	Application of I&C specs recommendation to a simple case study
19	2LT73V	Acronyms	Table of abbreviations and acronyms used in PCDH
20	34QECT	Glossary	PCDH glossary
21	C8X9AE	Integration kit	Content of the HW kit delivered by IO for integrating I&C systems
22	3PZ2D2	PIS design	Guidelines for Plant Interlock System design
23	7LELG4	PIS integration	Guidelines for Plant Interlock System configuration and integration
24	7L9QXR	PIS Operation	Guidelines for Plant Interlock System operation and maintenance
25	C99J7G	PSS design	Guidelines for Plant Safety System design
26	3299VT	Signal interface	Guidelines for signal interface to controllers
27	333J63	PLC catalogue	IO standard PLC catalogue
28	333K4C	FC guidelines	Guidelines for technology selection of fast controllers
29	345X28	FC catalogue	IO standard Fast Controller catalogue
30	35LXVZ	I&C Cubicle	IO standard I&C cubicle
31	4H5DW6	I&C Cubicle conf.	Guidelines for I&C cubicle HW integration

http://www.iter.org/org/team/chd/cid/codac/plantcontrolhandbook

The main challenge for ITER Control System is

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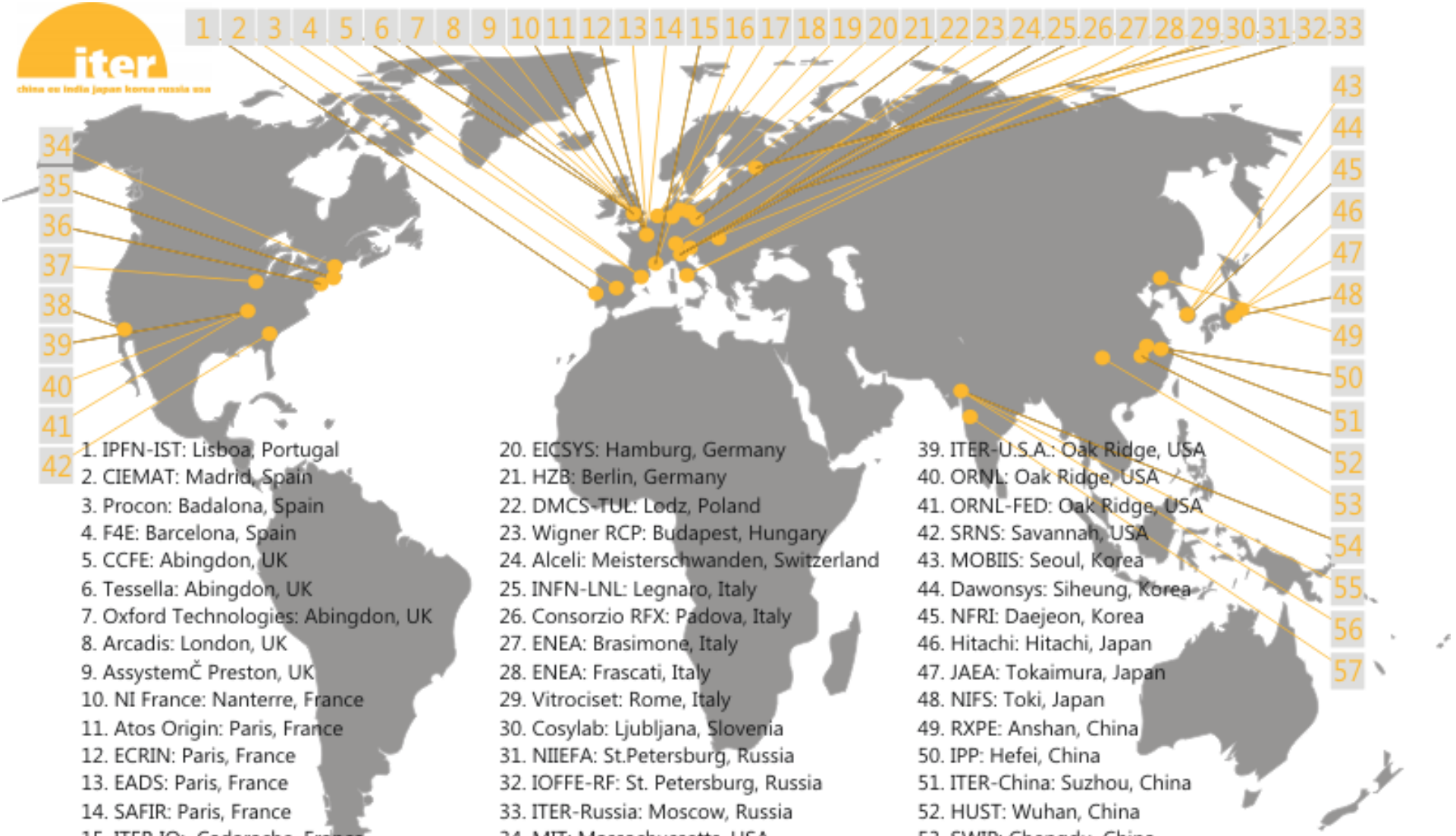
- Define standards, specifications and interfaces applicable to all plant systems instrumentation and control (PCDH)
- Develop and distribute a control system framework that implements standards defined in PCDH and guarantees that the local control system can be integrated into the central system (CODAC Core System)
  - Based on EPICS
  - Deployed on most computers/controllers (central and local)
  - Released twice per year (latest version v4.1 July 2013)
  - Distributed over Internet

CODAC Core System registered user organizations (Sep '13)



1. IPFN-IST: Lisboa, Portugal
2. CIEMAT: Madrid, Spain
3. Procon: Badalona, Spain
4. F4E: Barcelona, Spain
5. CCFE: Abingdon, UK
6. Tessella: Abingdon, UK
7. Oxford Technologies: Abingdon, UK
8. Arcadis: London, UK
9. AssystemČ Preston, UK
10. NI France: Nanterre, France
11. Atos Origin: Paris, France
12. ECRIN: Paris, France
13. EADS: Paris, France
14. SAFIR: Paris, France
15. ITER IO: Cadarache, France
16. CEA Cadarache: Cadarache, France
17. Intermodalics, Leuven, Belgium
18. ITER-NL: Eindhoven, Netherlands
19. NAT: Bonn, Germany
20. EICSYS: Hamburg, Germany
21. HZB: Berlin, Germany
22. DMCS-TUL: Lodz, Poland
23. Wigner RCP: Budapest, Hungary
24. Alceli: Meisterschwanden, Switzerland
25. INFN-LNL: Legnaro, Italy
26. Consorzio RFX: Padova, Italy
27. ENEA: Brasimone, Italy
28. ENEA: Frascati, Italy
29. Vitrociset: Rome, Italy
30. Cosylab: Ljubljana, Slovenia
31. NIIEFA: St.Petersburg, Russia
32. IOFFE-RF: St. Petersburg, Russia
33. ITER-Russia: Moscow, Russia
34. MIT: Massachussetts, USA
35. BNL: Brookhaven, USA
36. PPPL: Princeton, USA
37. HDF Group: Champaign, USA
38. General Atomics: San Diego, USA
39. ITER-U.S.A.: Oak Ridge, USA
40. ORNL: Oak Ridge, USA
41. ORNL-FED: Oak Ridge, USA
42. SRNS: Savannah, USA
43. MOBIIS: Seoul, Korea
44. Dawonsys: Siheung, Korea
45. NFRI: Daejeon, Korea
46. Hitachi: Hitachi, Japan
47. JAEA: Tokaimura, Japan
48. NIFS: Toki, Japan
49. RXPE: Anshan, China
50. IPP: Hefei, China
51. ITER-China: Suzhou, China
52. HUST: Wuhan, China
53. SWIP: Chengdu, China
54. ITER-India: Gandhinagar, India
55. IPR: Gandhinagar, India
56. OSPL: Ahmedabad, India
57. TCS: Pune, India

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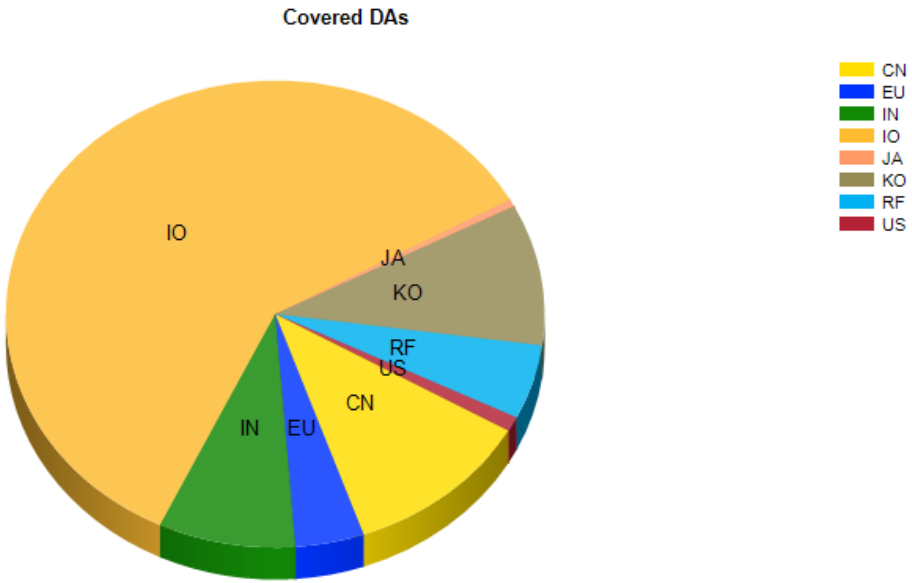
- Provide user support and organize training

CODAC Core System Hands-on Workshops

- Four days hands-on workshop with hardware and exercises
- Maximum 10 participants
- Two instructors
- 13 sessions, 136 people trained by Oct 2013
- Now starting providing online training



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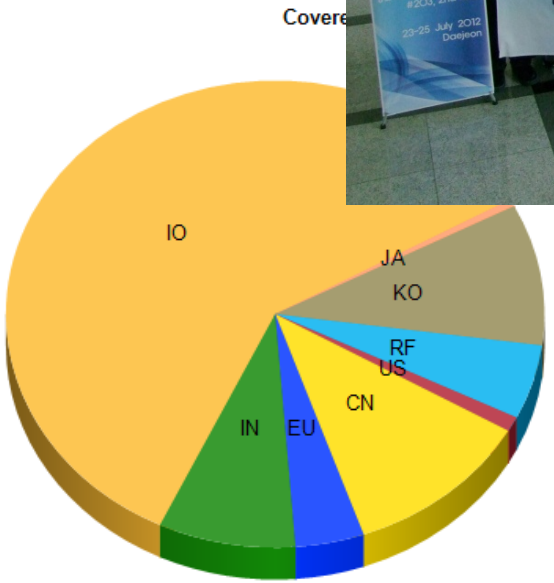

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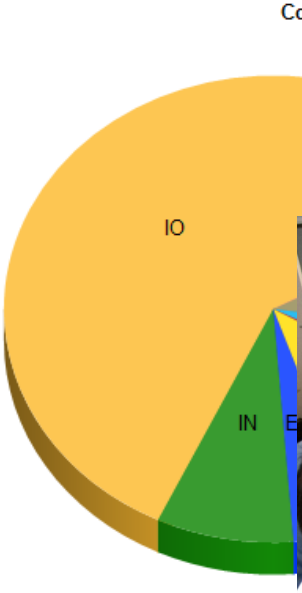

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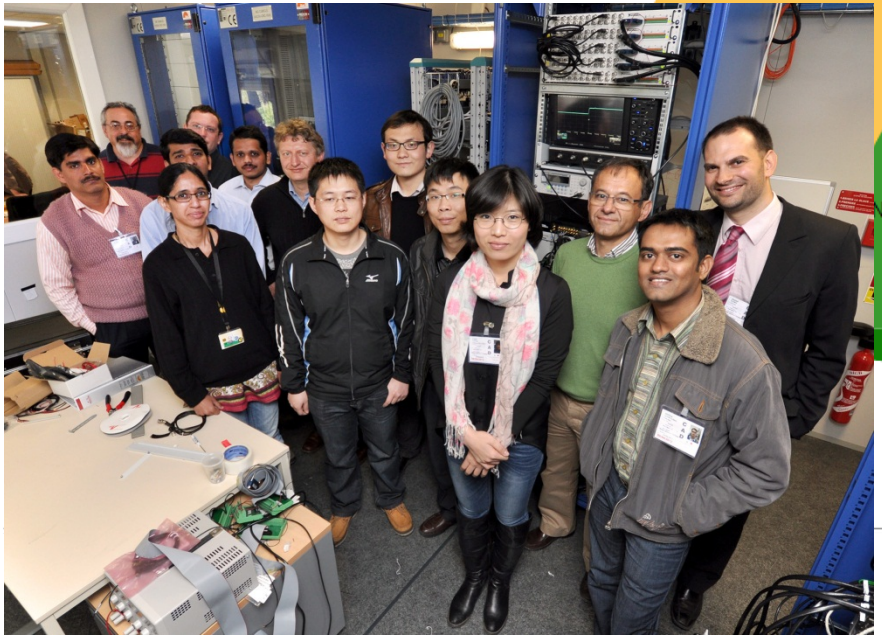

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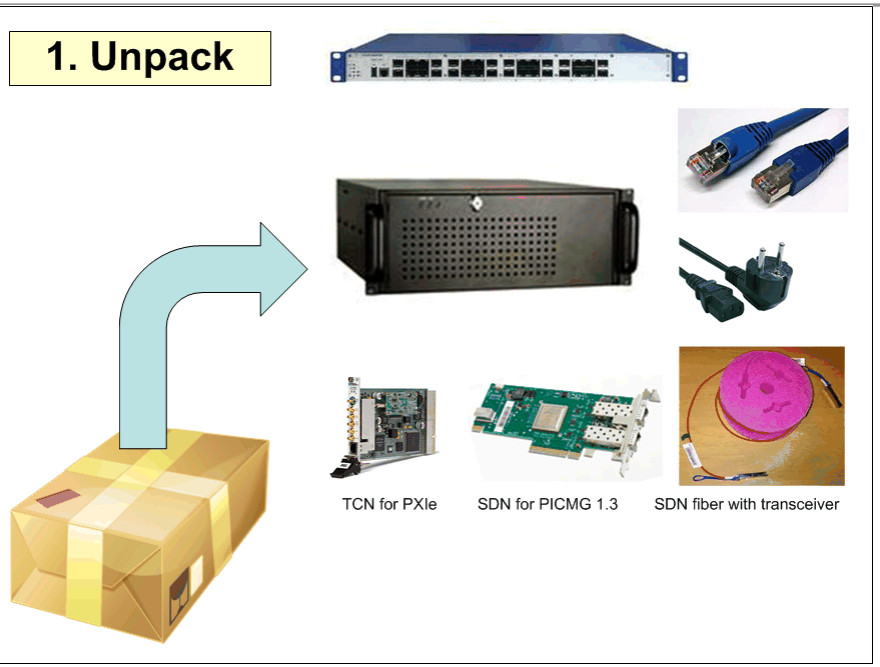
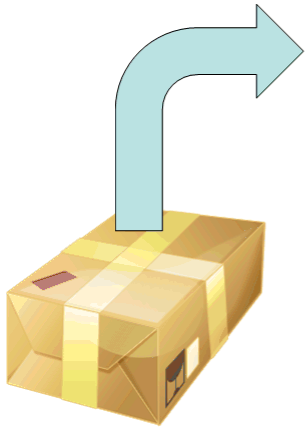
- Provide I&C Integration Kit free of charge (set of computers and network equipment to interface local system with central system)

I&C Integration Kit (1 per PS I&C = 206)



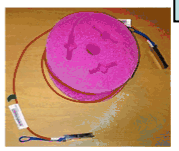
I&C Integration Kit (1 per PS I&C = 206)

1. Unpack



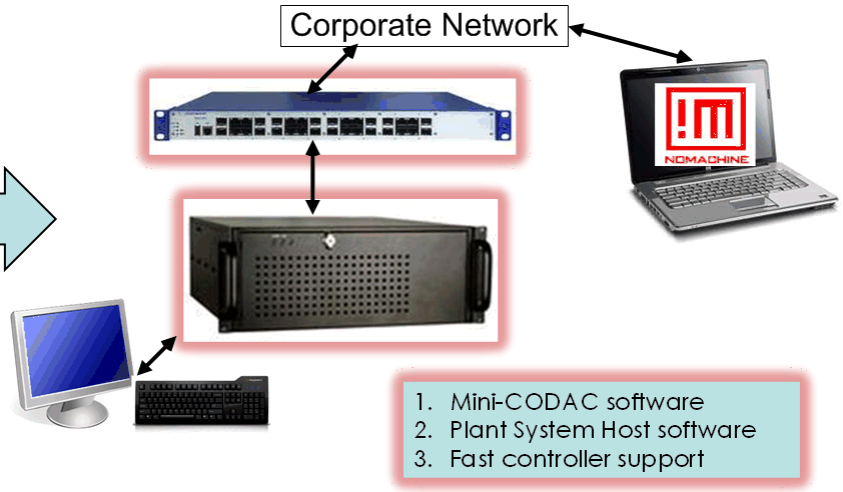
TCN for PXIe

SDN for PICMG 1.3



SDN fiber with transceiver

2. Fire up and discover CODAC tools



1. Mini-CODAC software
2. Plant System Host software
3. Fast controller support

I&C Integration Kit

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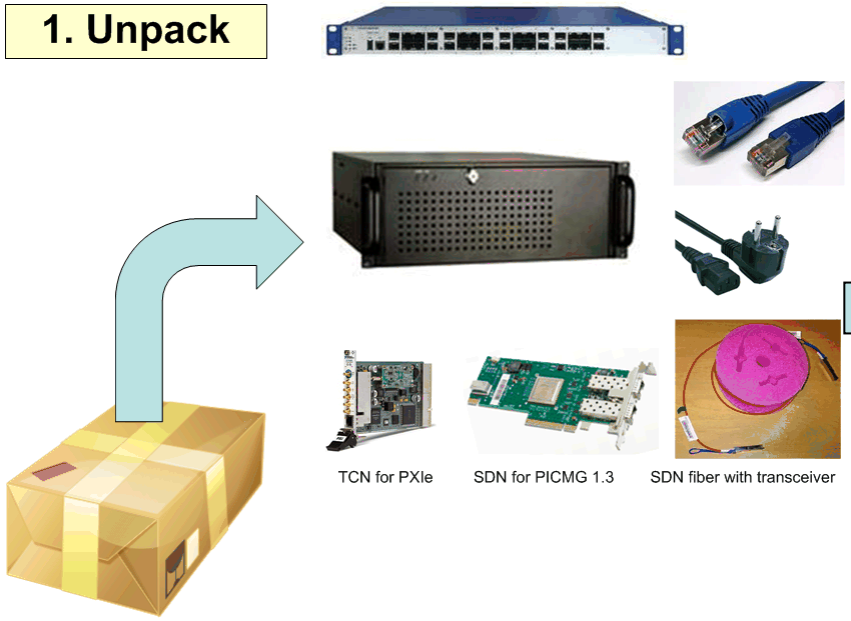

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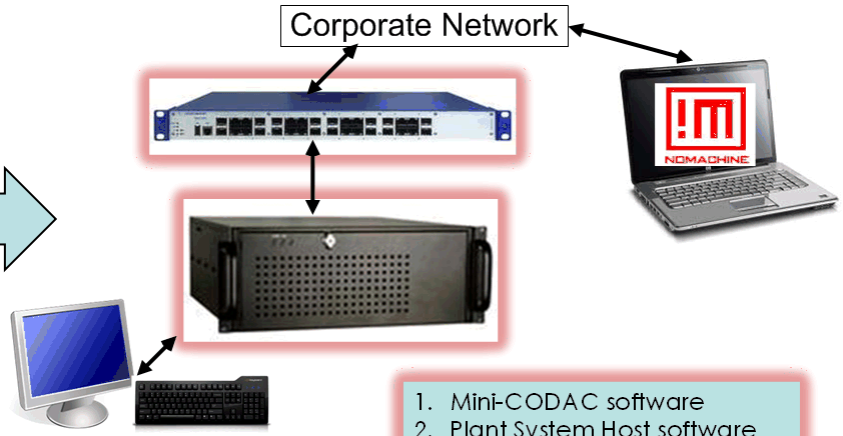

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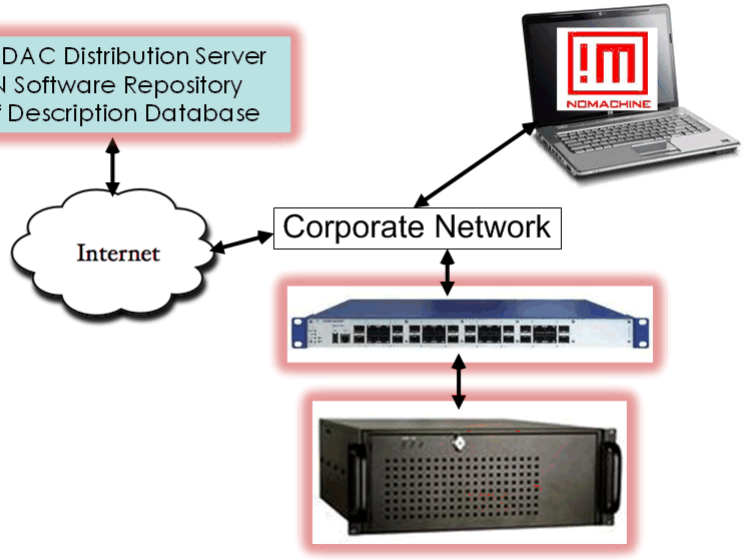
3. Start using collaborative tools

1. CODAC Distribution Server
2. SVN Software Repository
3. Self Description Database



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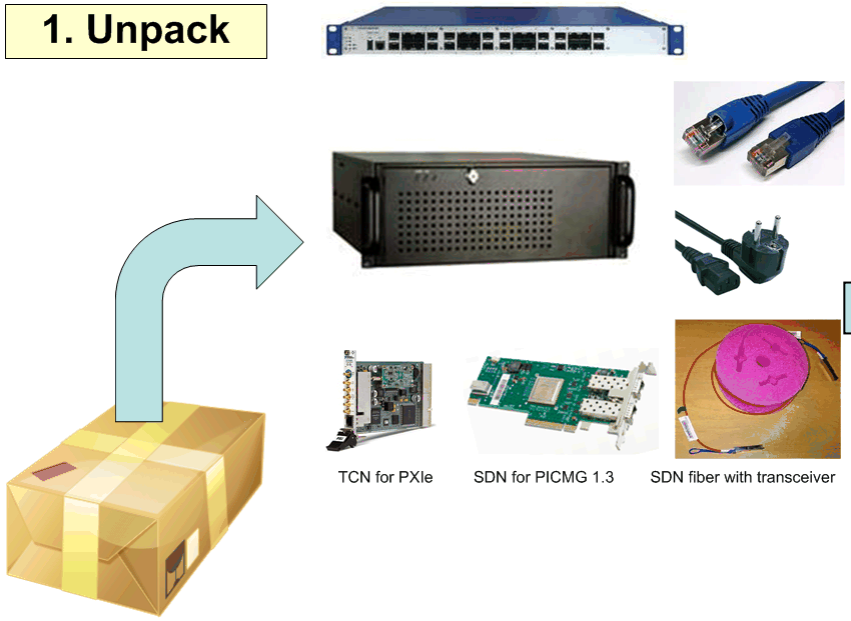

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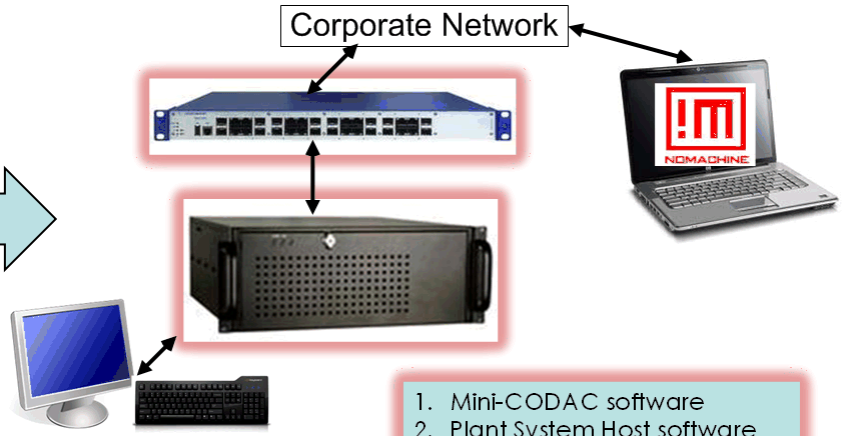

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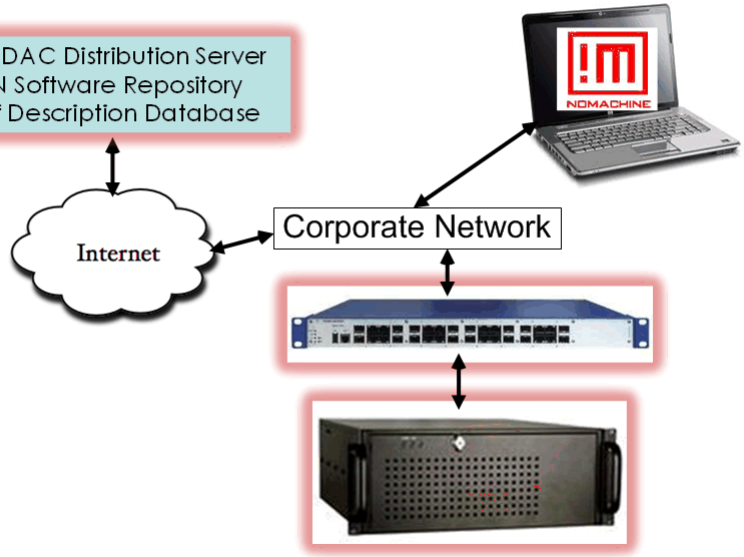
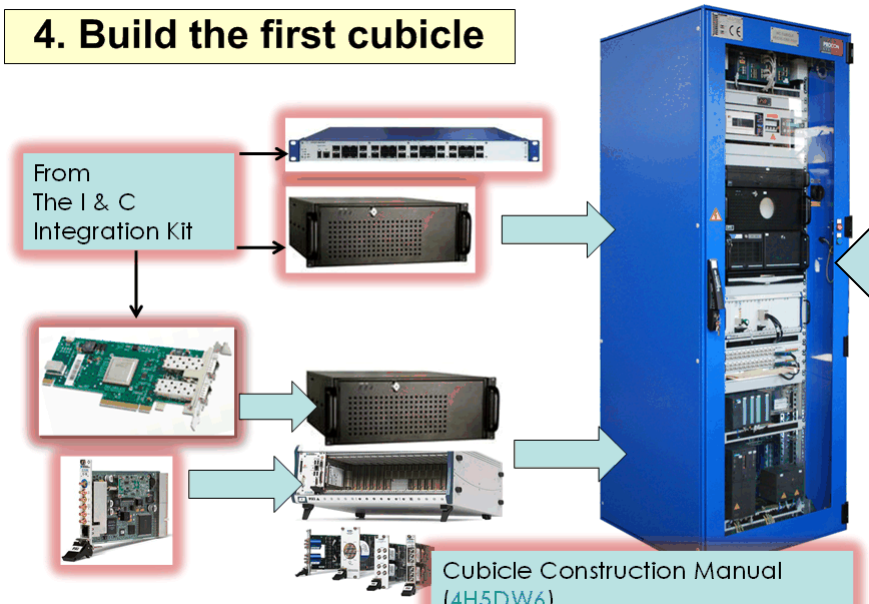


4. Build the first cubicle

From
The I & C
Integration Kit



Cubicle Construction Manual
(4H5DW6)

I&C Integration Kit (1 per PS I&C = 206)

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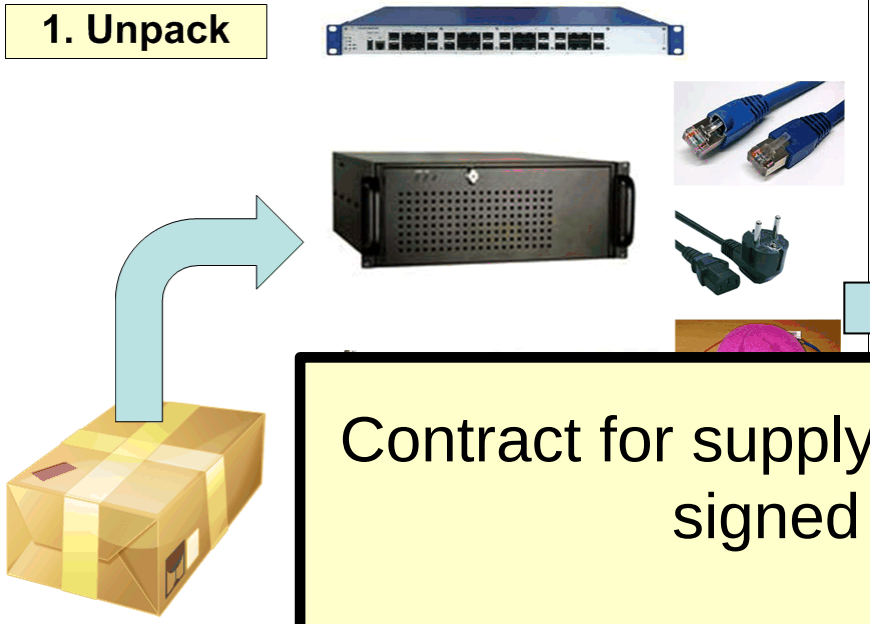

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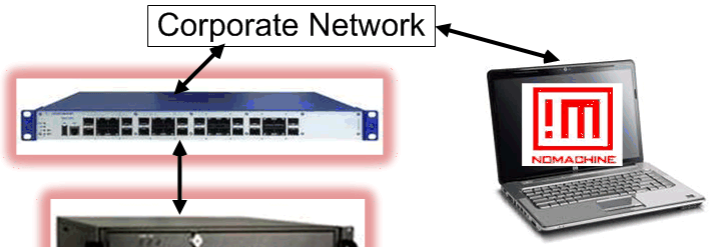
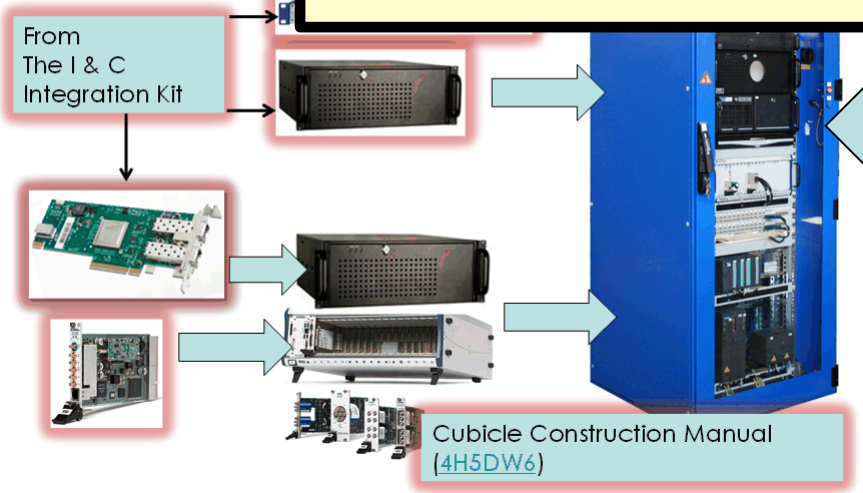


DAC software
stem Host software
ntroller support

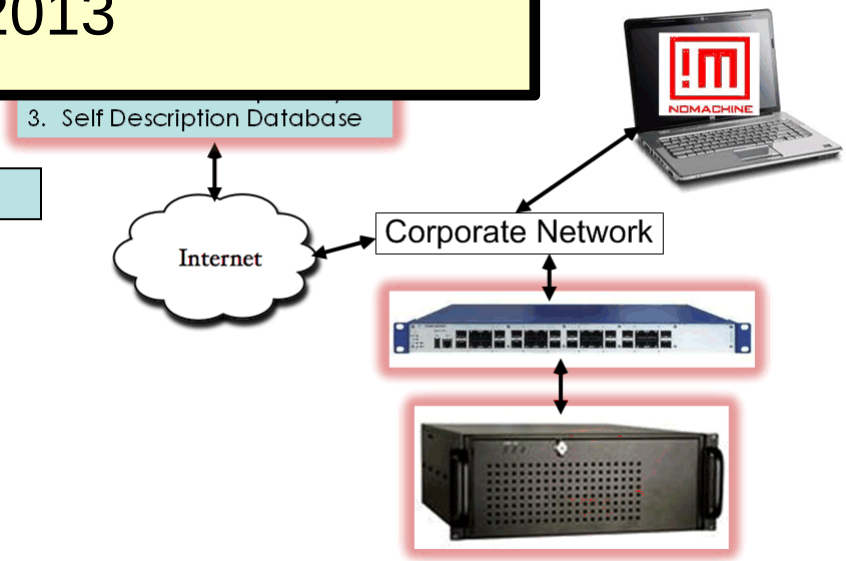
Contract for supply of I&C Integration Kit signed July 2013

First batch of 10 set to be shipped October 2013

4. Build the firs

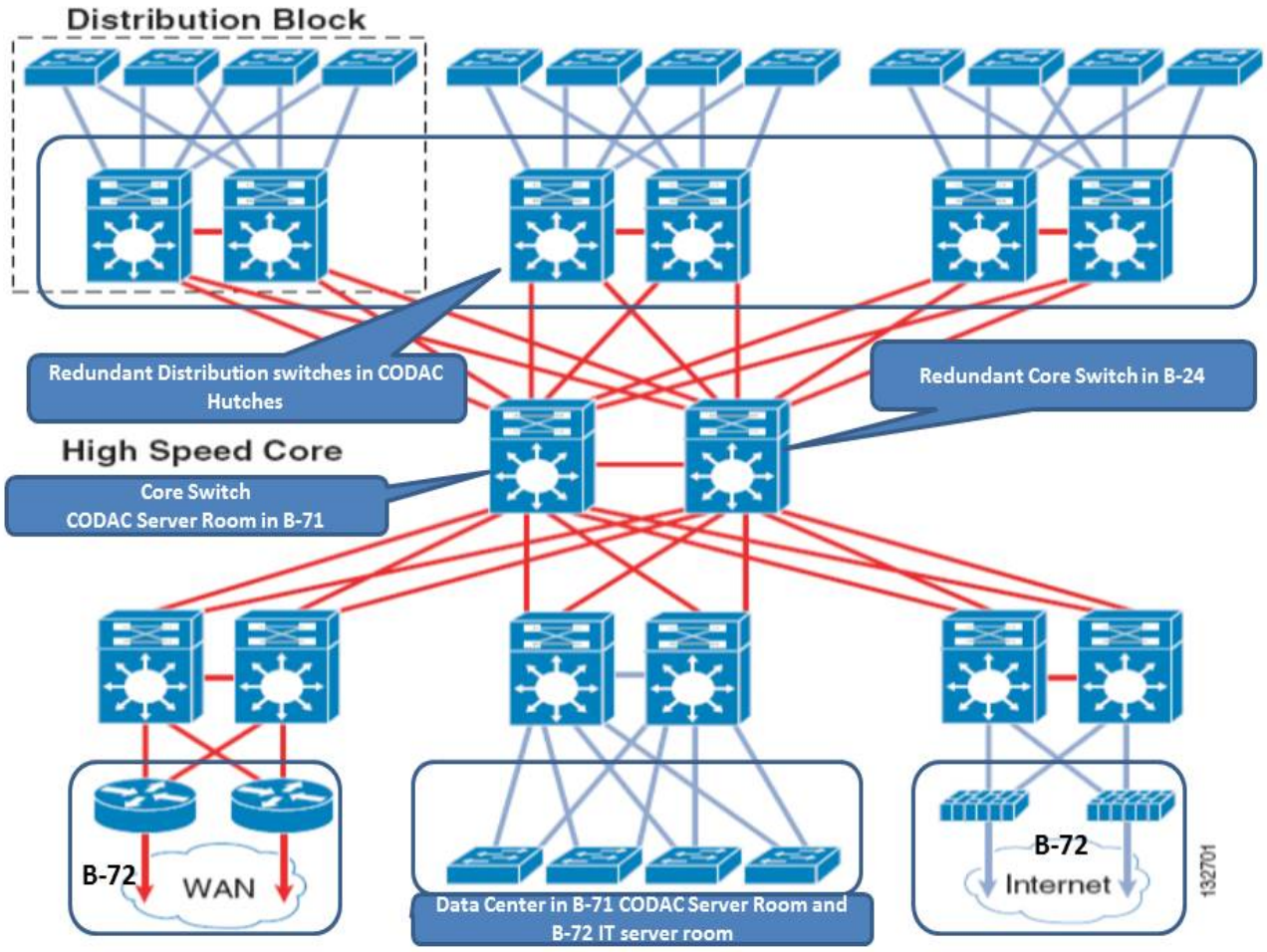


tools

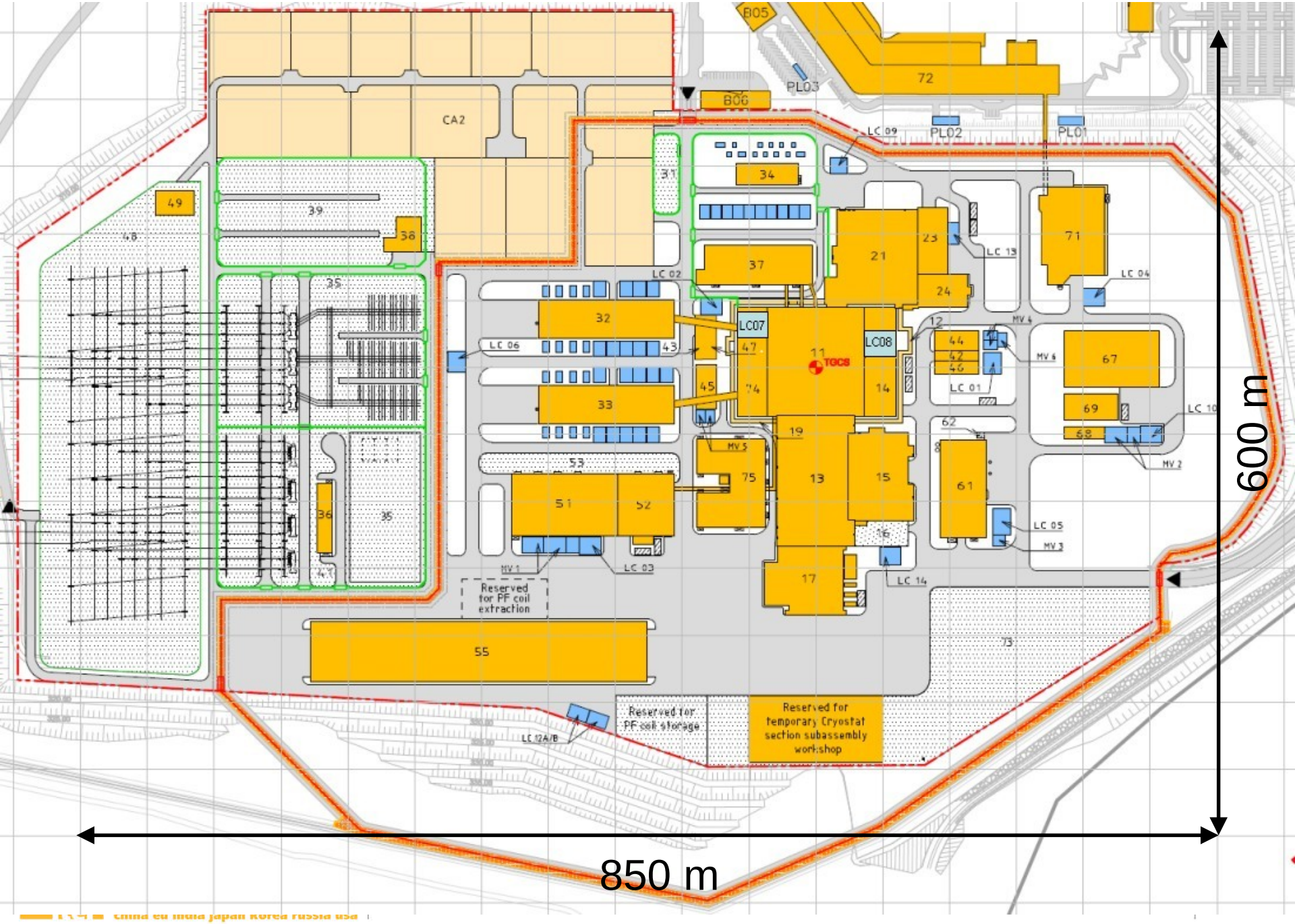


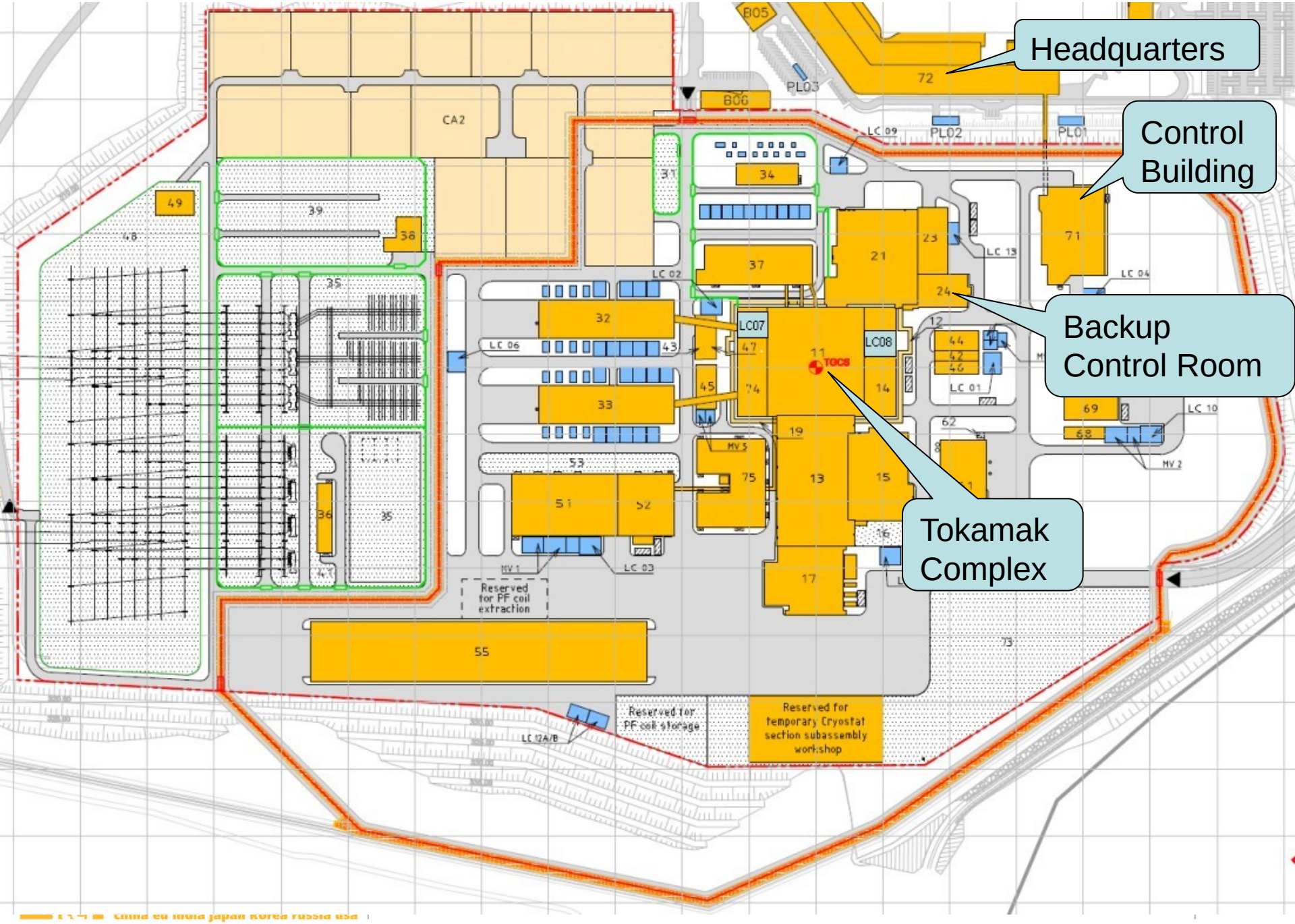
Infrastructure

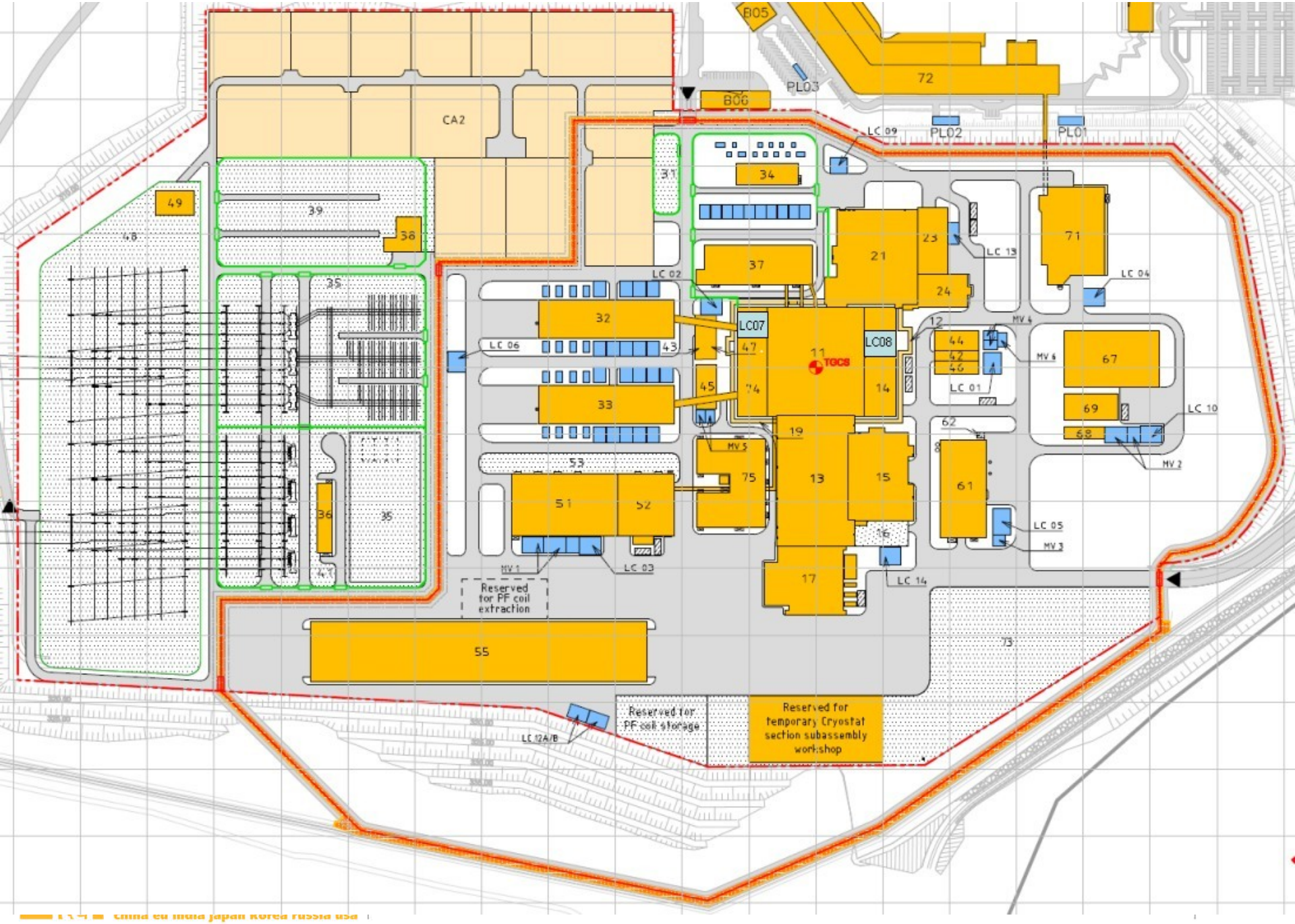
Dual star network infrastructure configuration

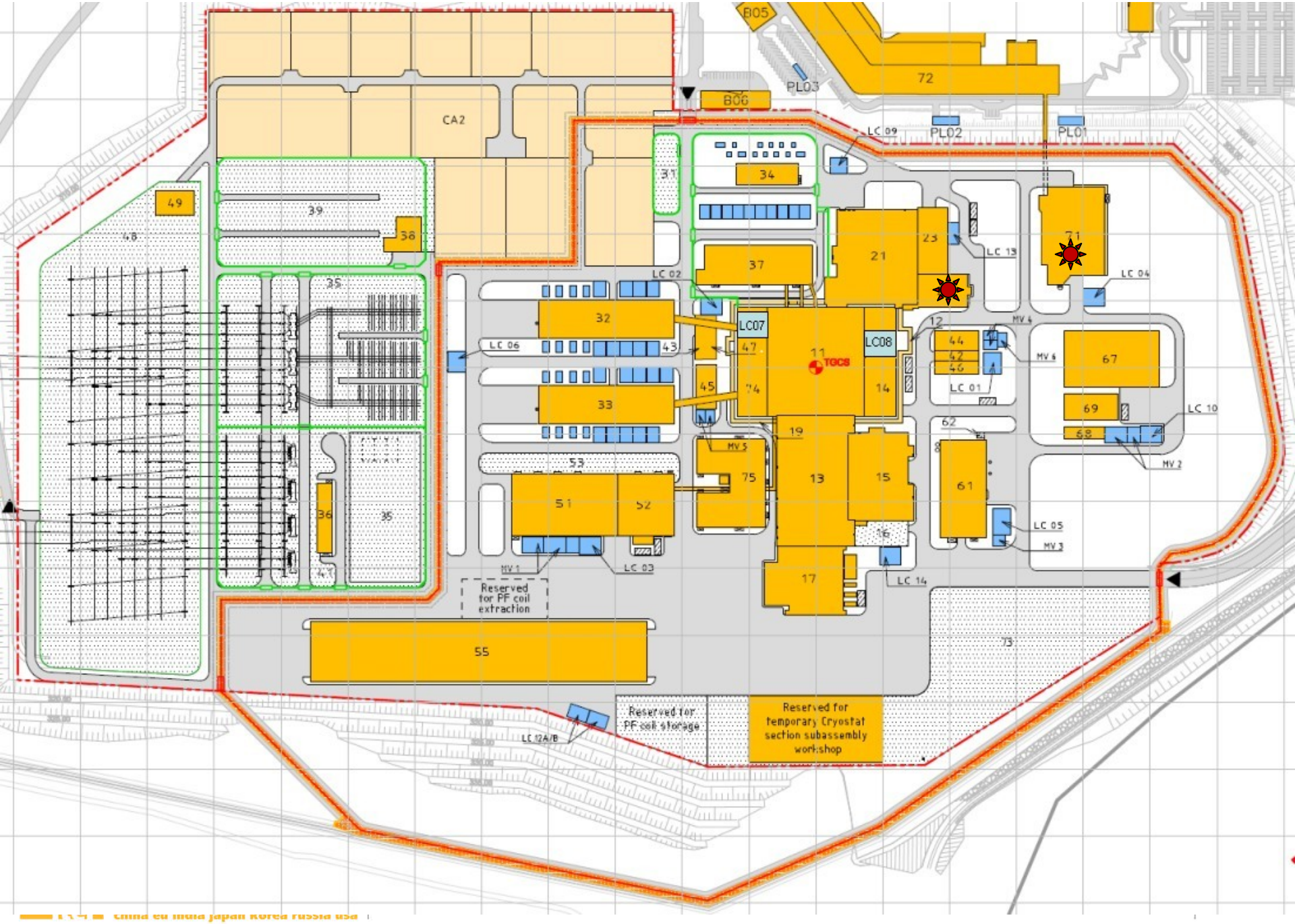


- Provides intra and inter building connectivity
- Supports 5 CODAC, 1 interlock, 2 safety and 1 IT fiber optic networks
- Supports 1 interlock and 2 safety hardwired networks


B05
72
PL03
B06
CA2
PL02
PL01
LC 09
34
31
49
39
38
48
37
21
23
LC 13
71
LC 04
LC 02
24
35
32
LC07
LC08
12
MV 4
44
42
46
LC 01
MV 6
67
LC 06
43
47
11
TCCS
14
45
74
33
69
LC 10
68
MV 2
62
19
MV 5
53
75
13
15
61
51
52
LC 05
MV 3
36
35
16
MV 1
LC 03
17
LC 14
Reserved for PF coil extraction
55
73
Reserved for PF coil storage
Reserved for temporary Cryostat section subassembly workshop
LC 12A/B
600 m
850 m


Headquarters
Control Building
Backup Control Room
Tokamak Complex
B05
B06
PL03
PL02
PL01
72
CA2
LC 09
34
31
49
39
38
48
37
21
23
71
LC 13
LC 04
LC 02
24
32
LC07
LC08
12
LC 06
43
47
11
TGCS
44
42
46
LC 01
45
74
14
33
69
LC 10
62
MV 5
19
MV 2
53
75
13
15
51
52
16
36
35
LC 03
MV 1
17
Reserved for PF coil extraction
55
73
Reserved for PF coil storage
Reserved for temporary Cryostat section subassembly workshop
LC 12A/B


B05
72
PL03
B06
PL02
PL01
CA2
LC 09
34
31
49
48
39
38
37
21
23
LC 13
71
LC 04
LC 02
24
35
32
LC07
LC08
12
MV 4
44
42
46
LC 01
MV 6
67
69
LC 10
68
MV 2
LC 06
43
47
11
TCCS
14
45
74
33
19
62
MV 5
53
75
13
15
61
51
52
16
LC 05
MV 3
36
35
MV 1
LC 03
17
LC 14
Reserved for PF coil extraction
55
73
Reserved for PF coil storage
LC 12A/B
Reserved for temporary Cryostat section subassembly workshop


B05
72
PL03
B06
PL02
PL01
CA2
LC 09
34
31
49
48
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38
37
21
23
LC 13
71
LC 04
35
LC 02
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LC07
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TCCS
LC08
12
MV 4
44
42
46
LC 01
MV 6
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33
19
62
MV 5
68
MV 2
53
75
13
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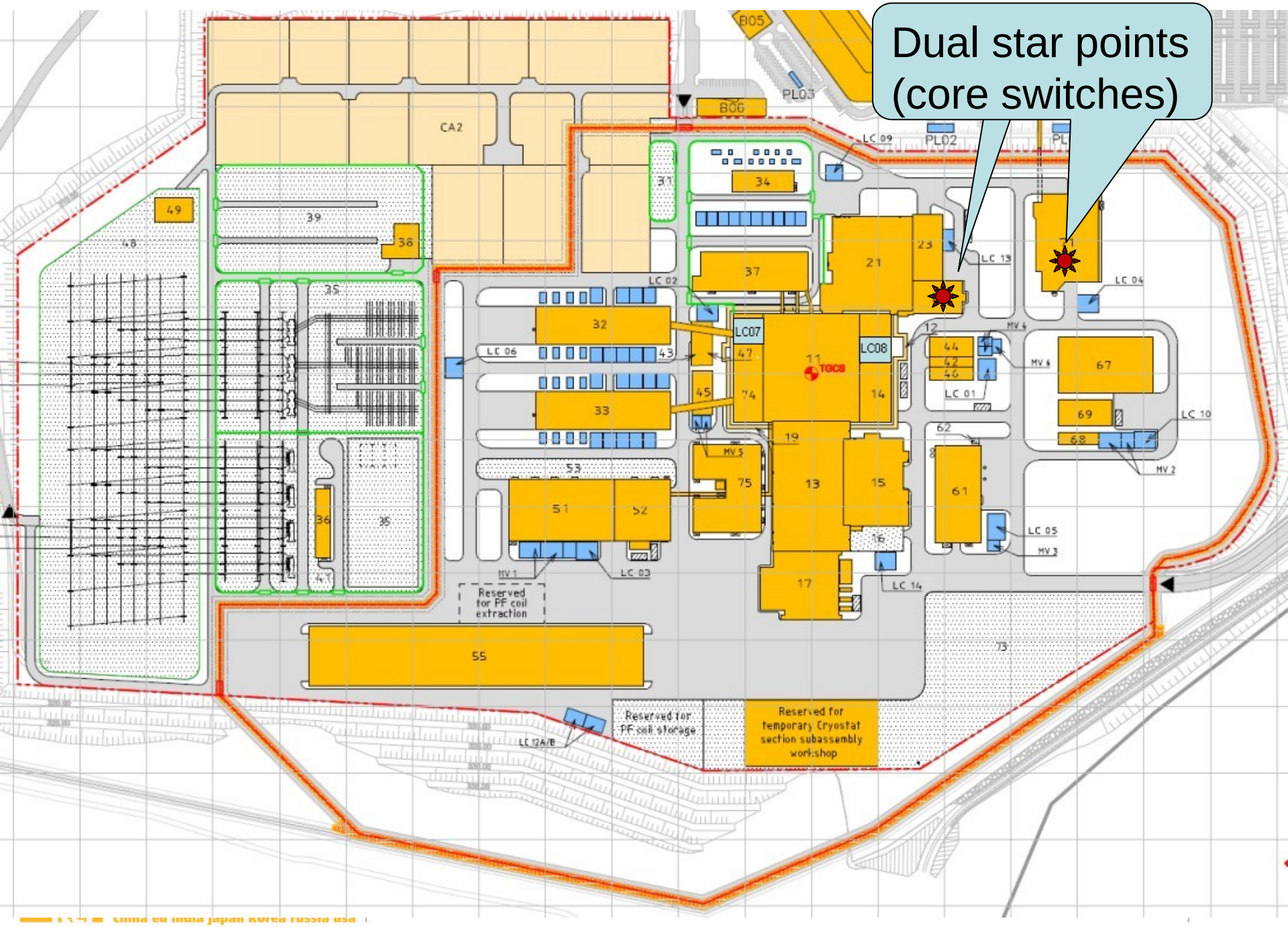
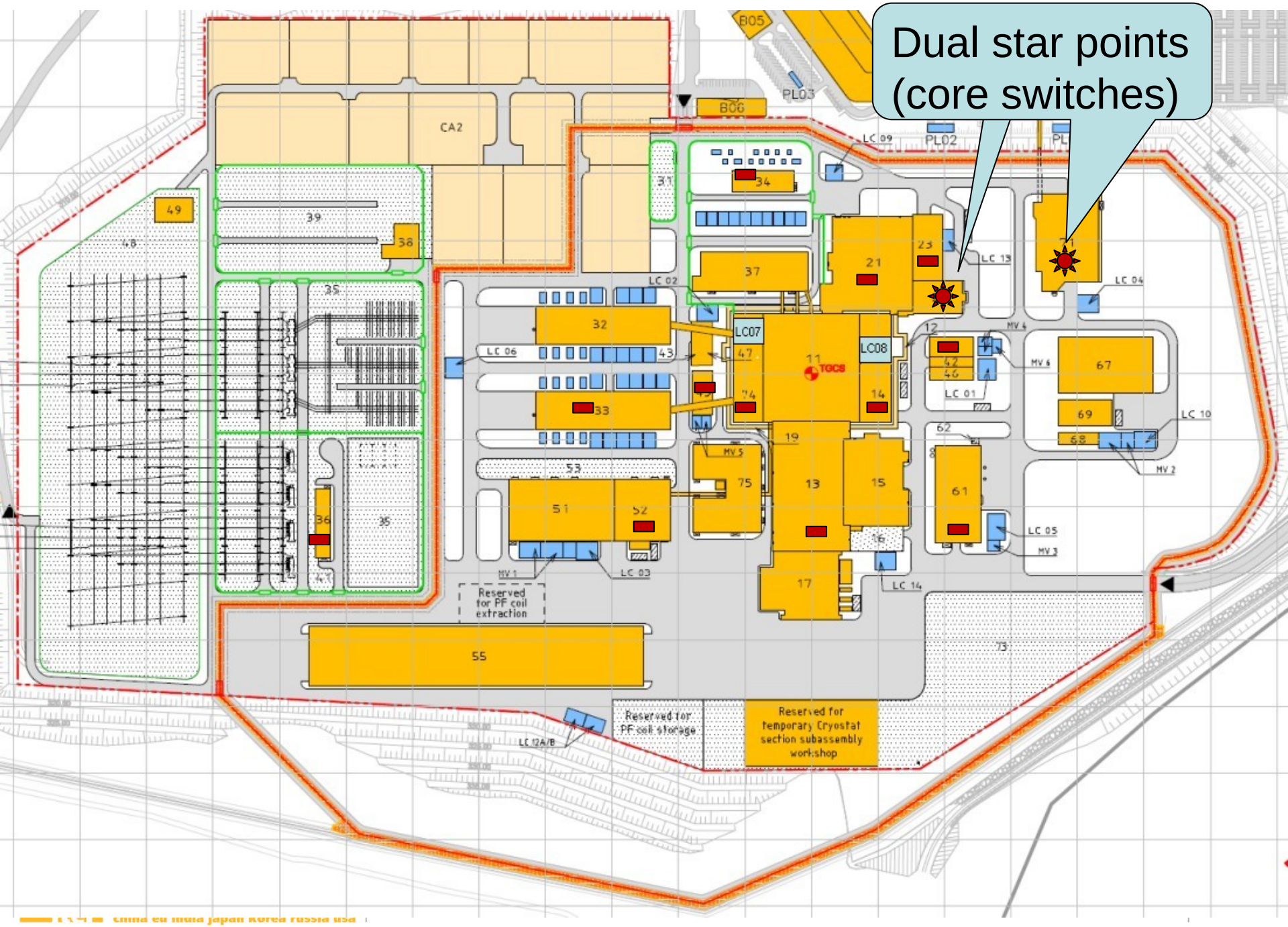
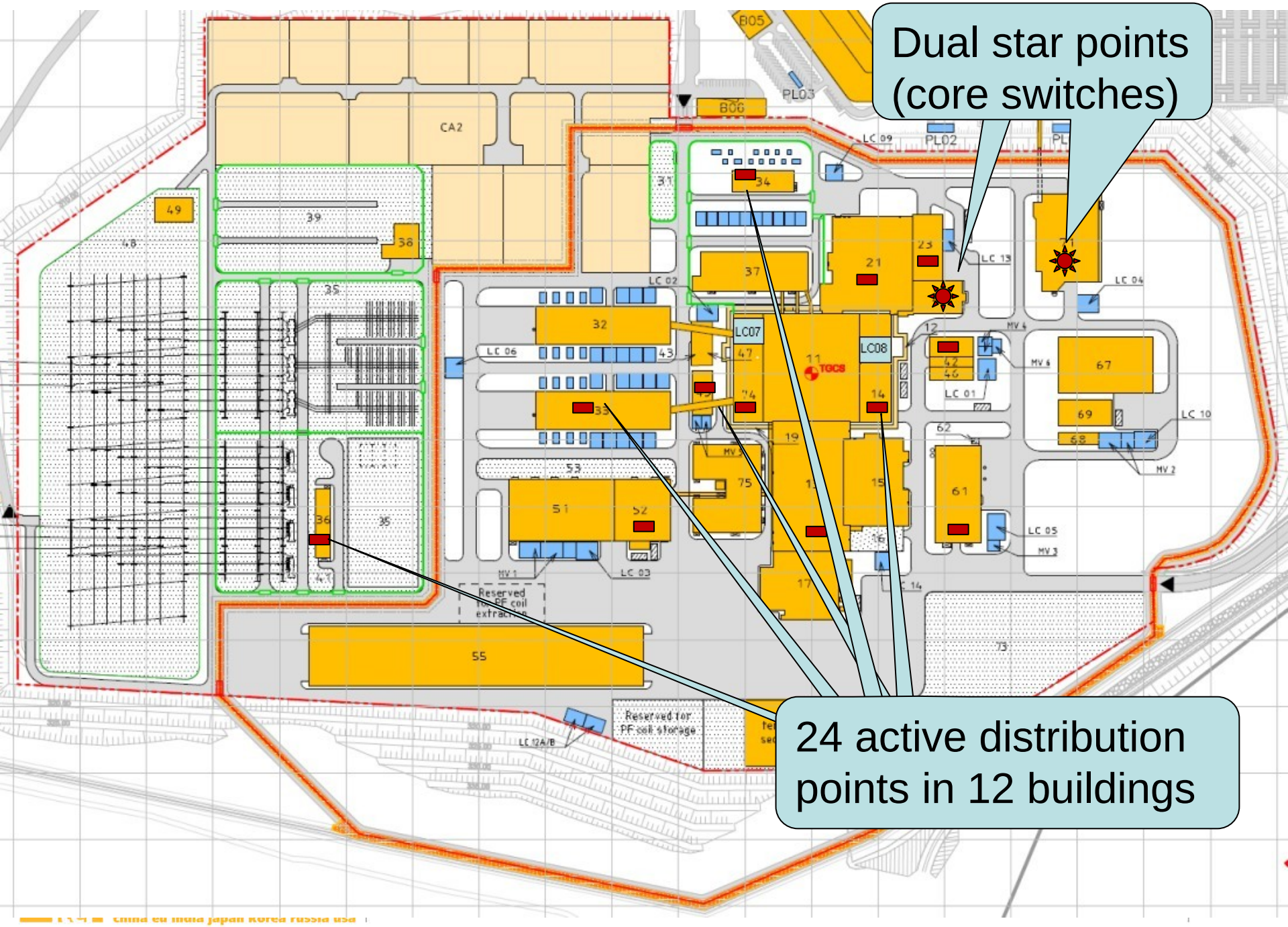
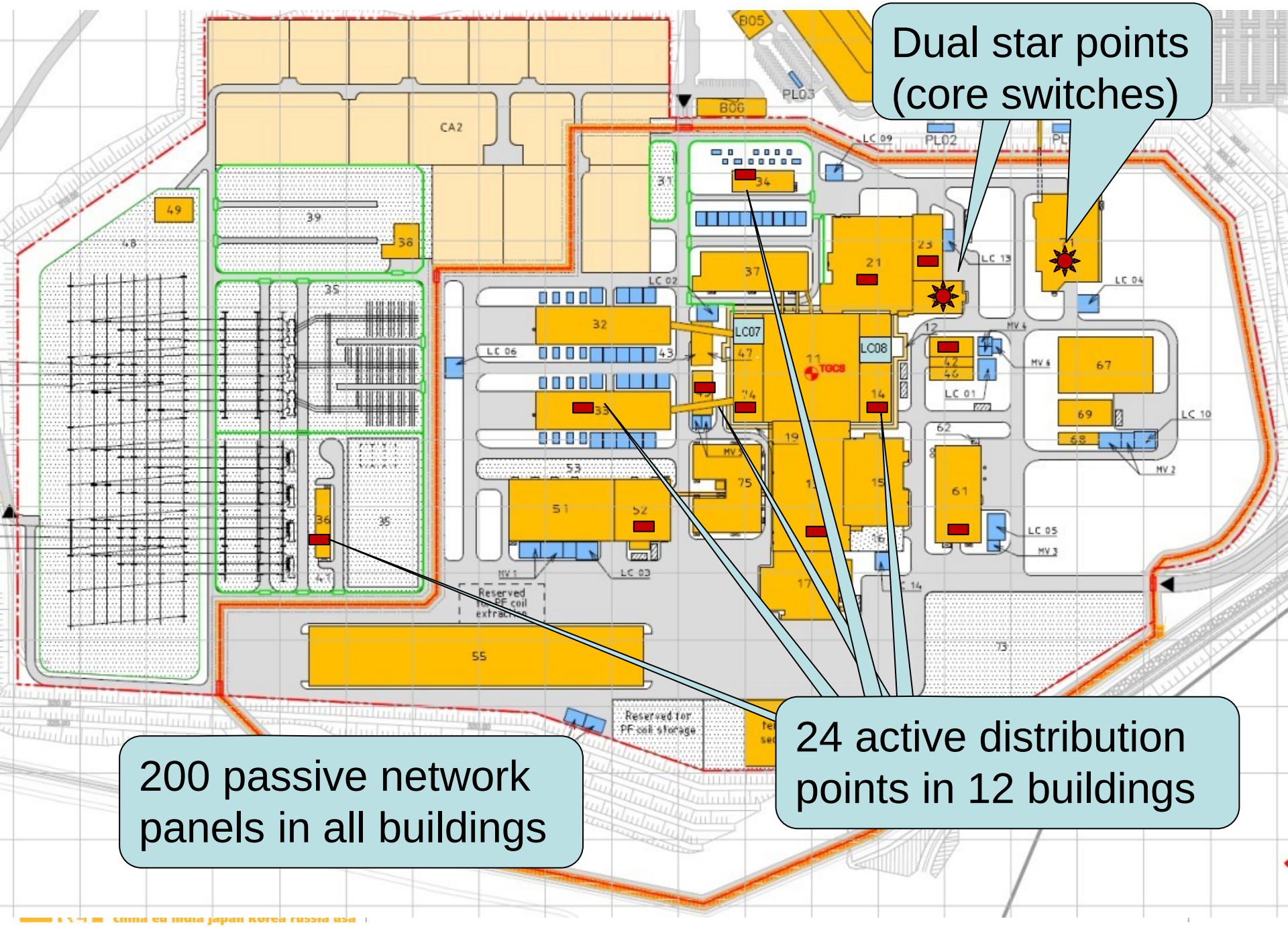
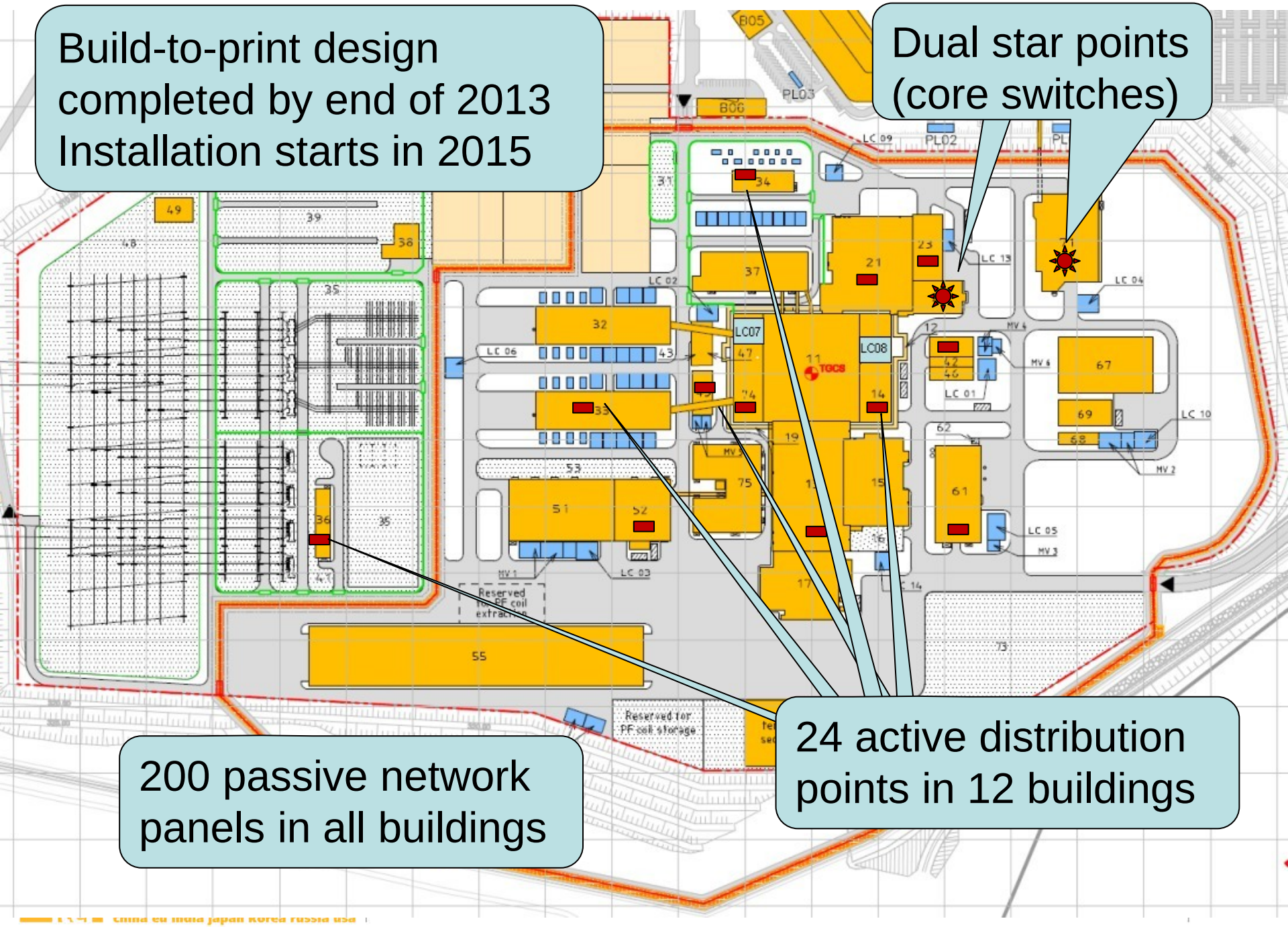
61
51
52
16
LC 05
MV 3
36
35
MV 1
LC 03
17
LC 14
Reserved for PF coil extraction
55
73
Reserved for PF coil storage
Reserved for temporary Cryostat section subassembly workshop
LC 12A/B


Dual star points
(core switches)
B05
PL03
B06
CA2
PL02
LC 09
34
31
49
39
38
37
21
23
LC 13
LC 04
LC 02
32
LC07
LC08
12
MV 4
LC 06
43
47
11
TGCS
44
42
46
MV 6
67
LC 01
45
74
14
33
69
LC 10
62
19
MV 5
68
MV 2
53
75
13
15
61
51
52
16
LC 05
MV 3
MV 1
LC 03
17
LC 14
Reserved
for PF coil
extraction
55
73
Reserved for
PF coil storage
Reserved for
temporary Cryostat
section subassembly
workshop
LC 12A/B


Dual star points
(core switches)
B05
PL03
B06
CA2
PL02
LC 09
LC 13
LC 04
LC 02
LC 06
LC07
LC08
TGCS
LC 01
LC 10
MV 1
MV 2
MV 3
MV 4
MV 5
MV 6
LC 03
LC 05
LC 14
LC 12A/B
Reserved for PF coil extraction
Reserved for PF coil storage
Reserved for temporary Cryostat section subassembly workshop

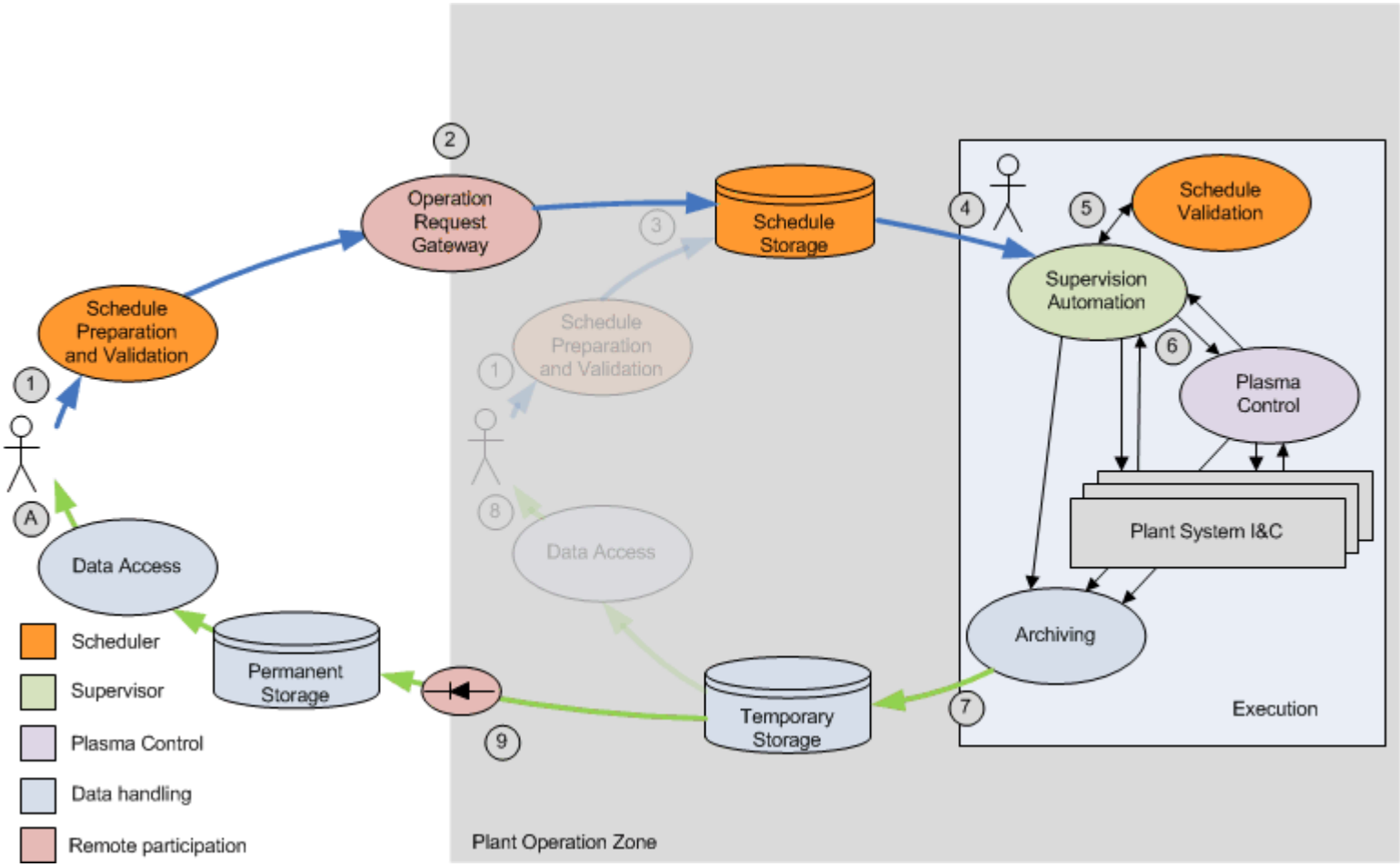

Dual star points
(core switches)
24 active distribution
points in 12 buildings
B05
B06
PL03
PL02
CA2
LC 09
LC 13
LC 04
LC 02
LC 06
LC07
LC08
LC 01
LC 10
LC 05
LC 03
LC 14
LC 12A/B
MV 1
MV 2
MV 3
MV 4
MV 5
MV 6
TGCS
Reserved for PF coil storage
Reserved for PF coil extraction


Dual star points
(core switches)
24 active distribution
points in 12 buildings
200 passive network
panels in all buildings
B05
B06
PL03
PL02
CA2
LC 09
LC 13
LC 04
LC 02
LC 06
LC07
LC08
LC 01
LC 10
LC 05
LC 03
MV 1
MV 2
MV 3
MV 4
MV 5
MV 6
TGCS
Reserved for PF coil storage
Reserved for PF coil extraction

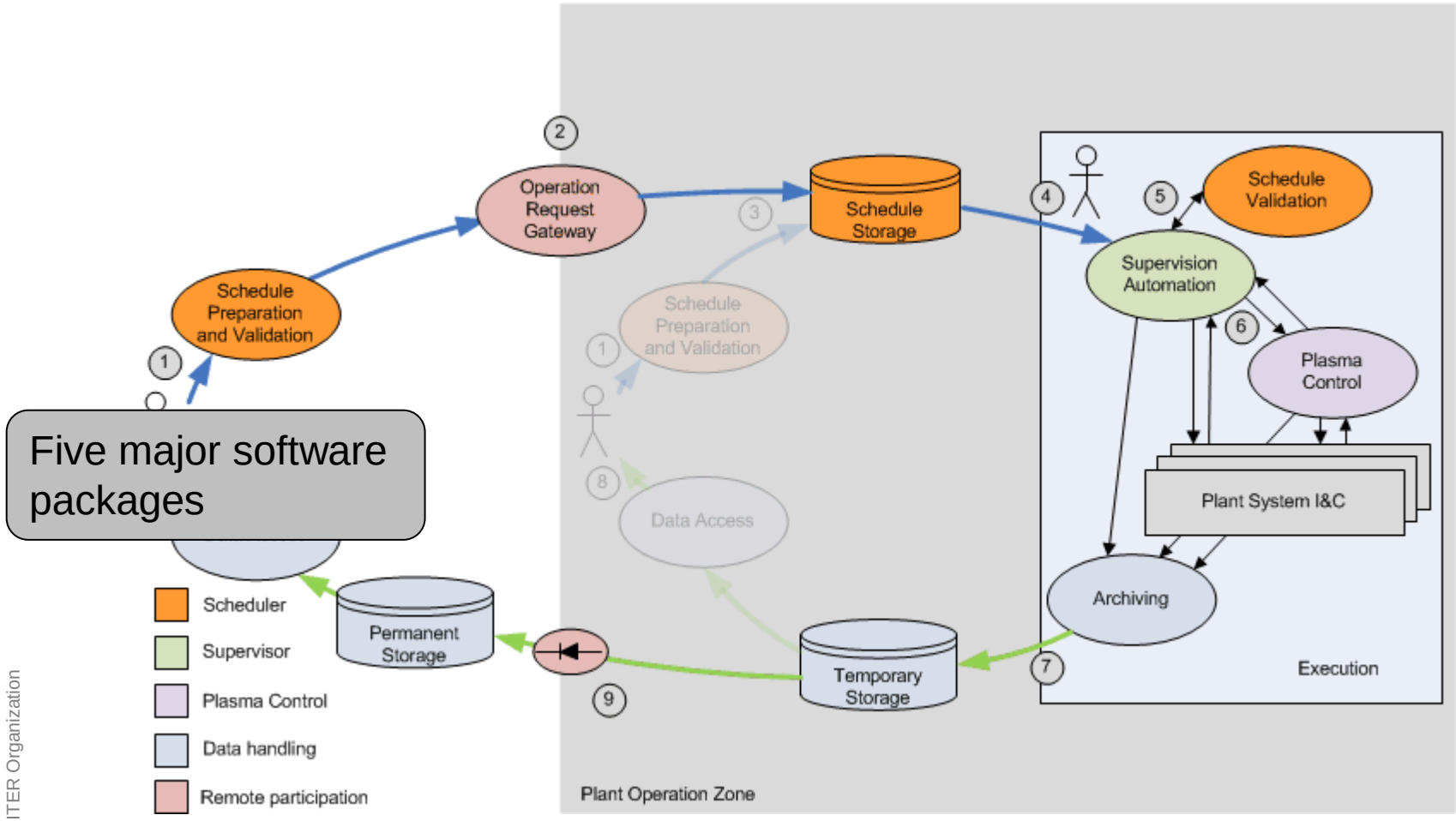

Build-to-print design completed by end of 2013
Installation starts in 2015
Dual star points (core switches)
24 active distribution points in 12 buildings
200 passive network panels in all buildings
B05
B06
PL03
PL02
LC 09
LC 13
LC 04
LC 02
LC 06
LC07
LC08
LC 01
LC 10
LC 05
LC 03
MV 1
MV 2
MV 3
MV 4
MV 5
MV 6
TCCS
Reserved for PF coil storage
Reserved for PF coil extraction

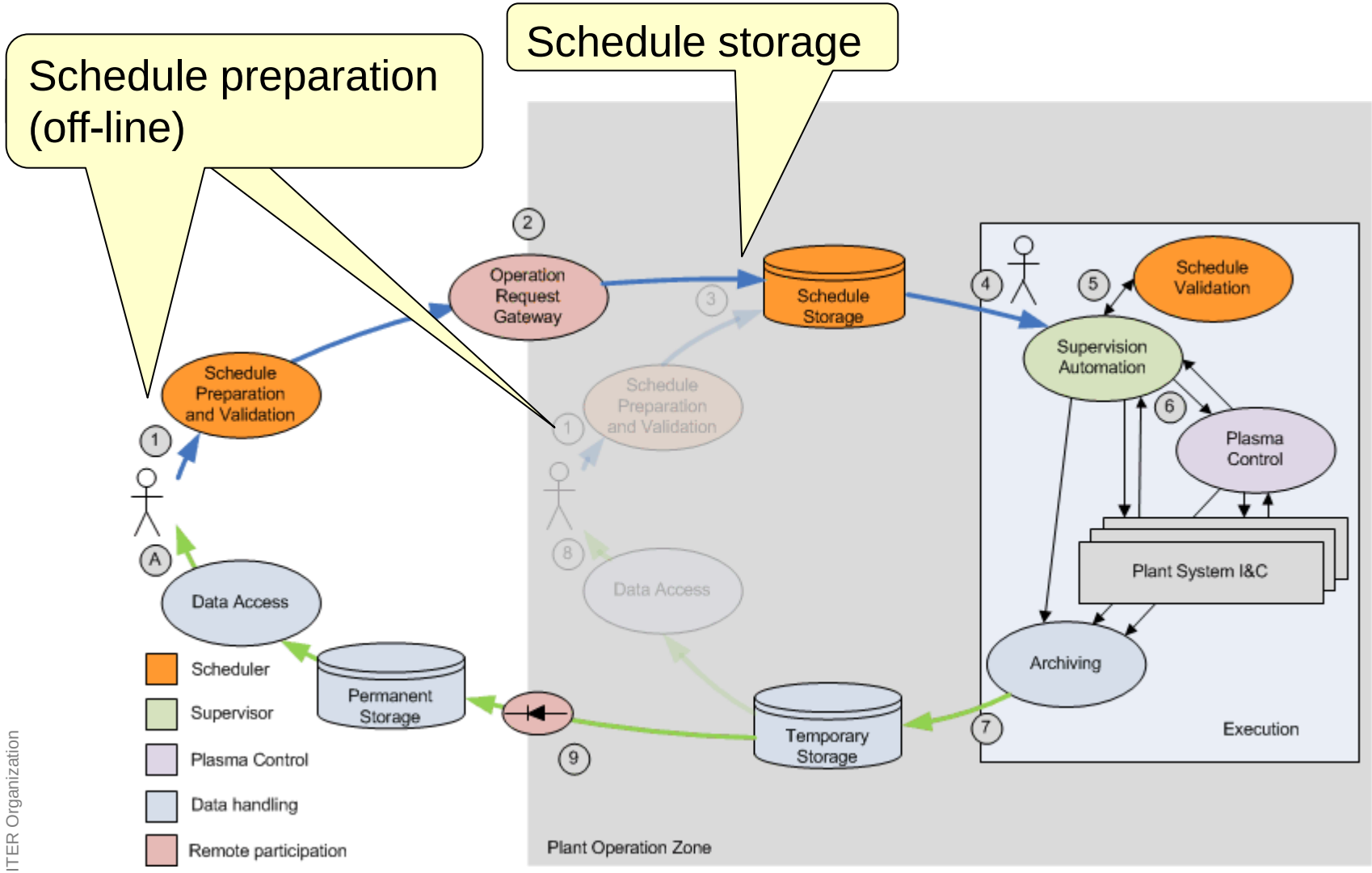
High Level Applications

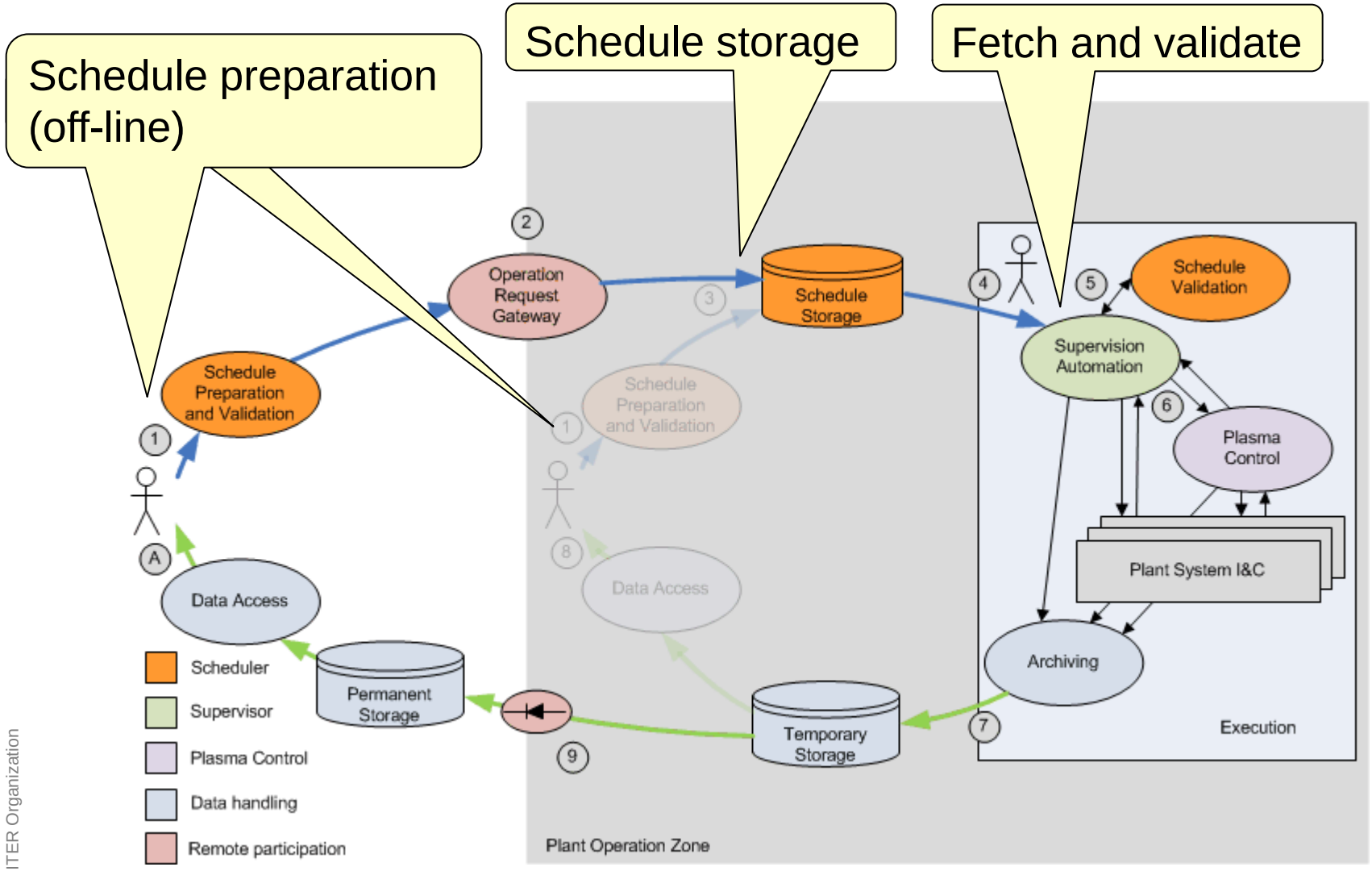
High Level Applications – Main Data Flow



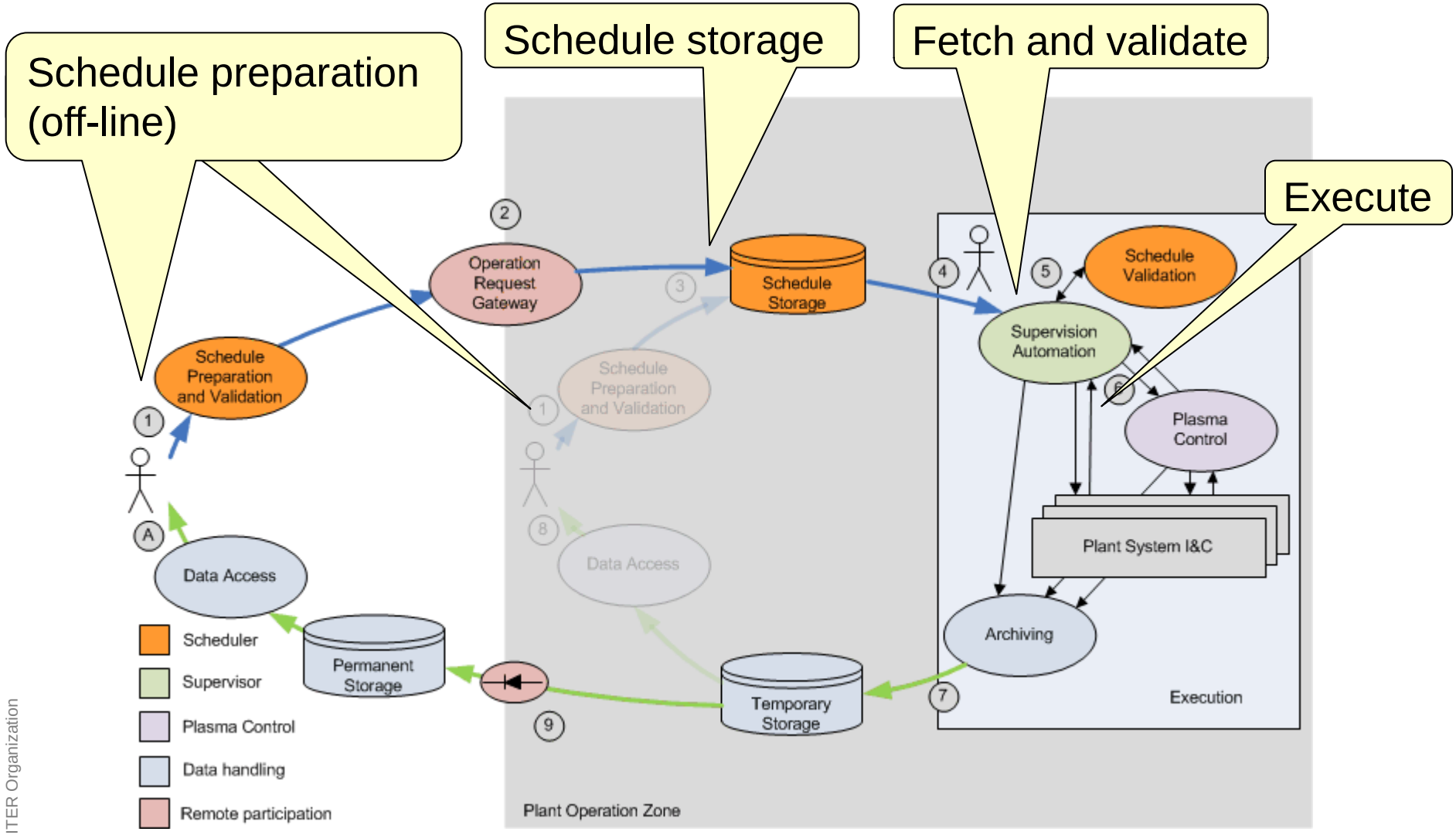
High Level Applications – Main Data Flow

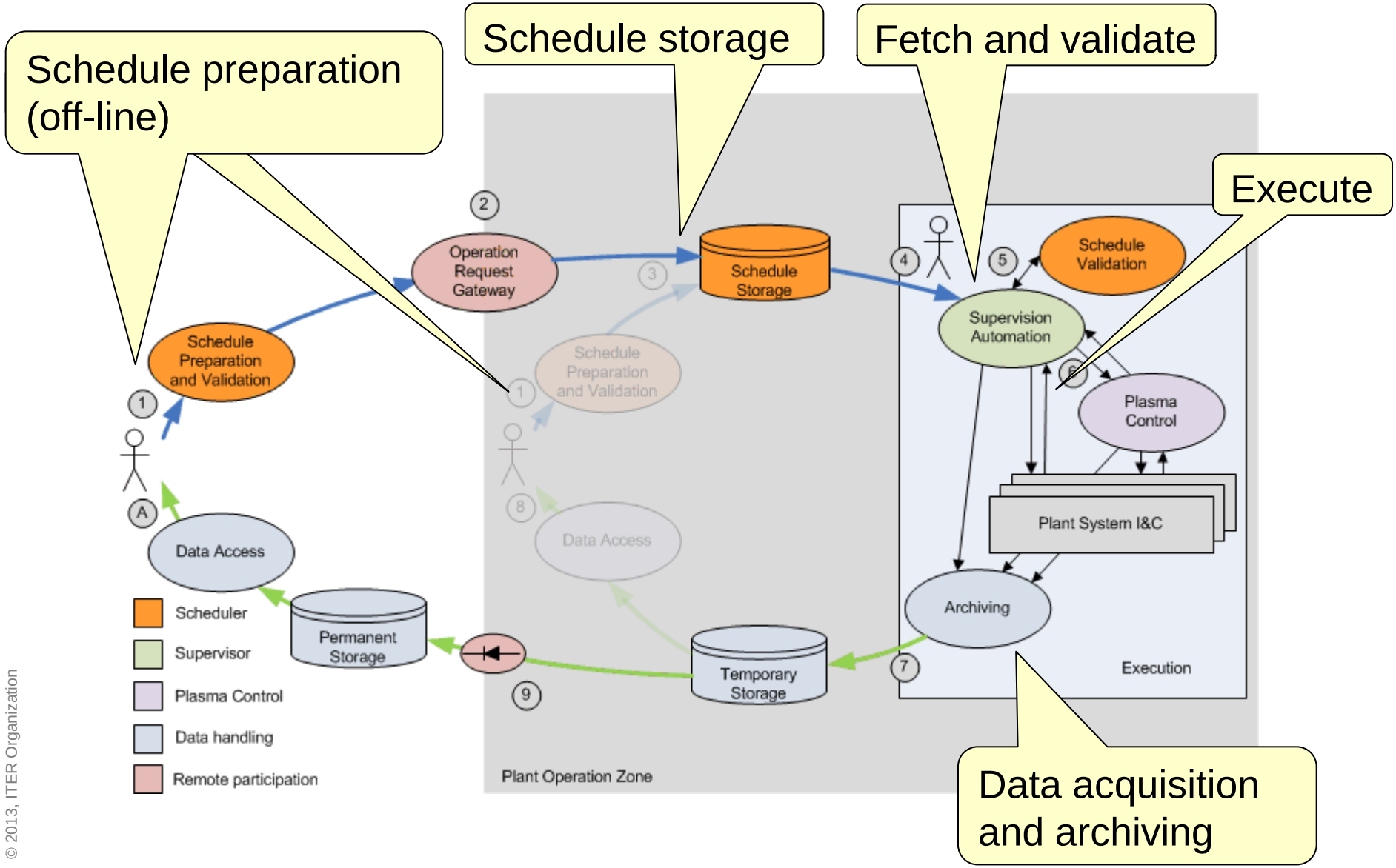


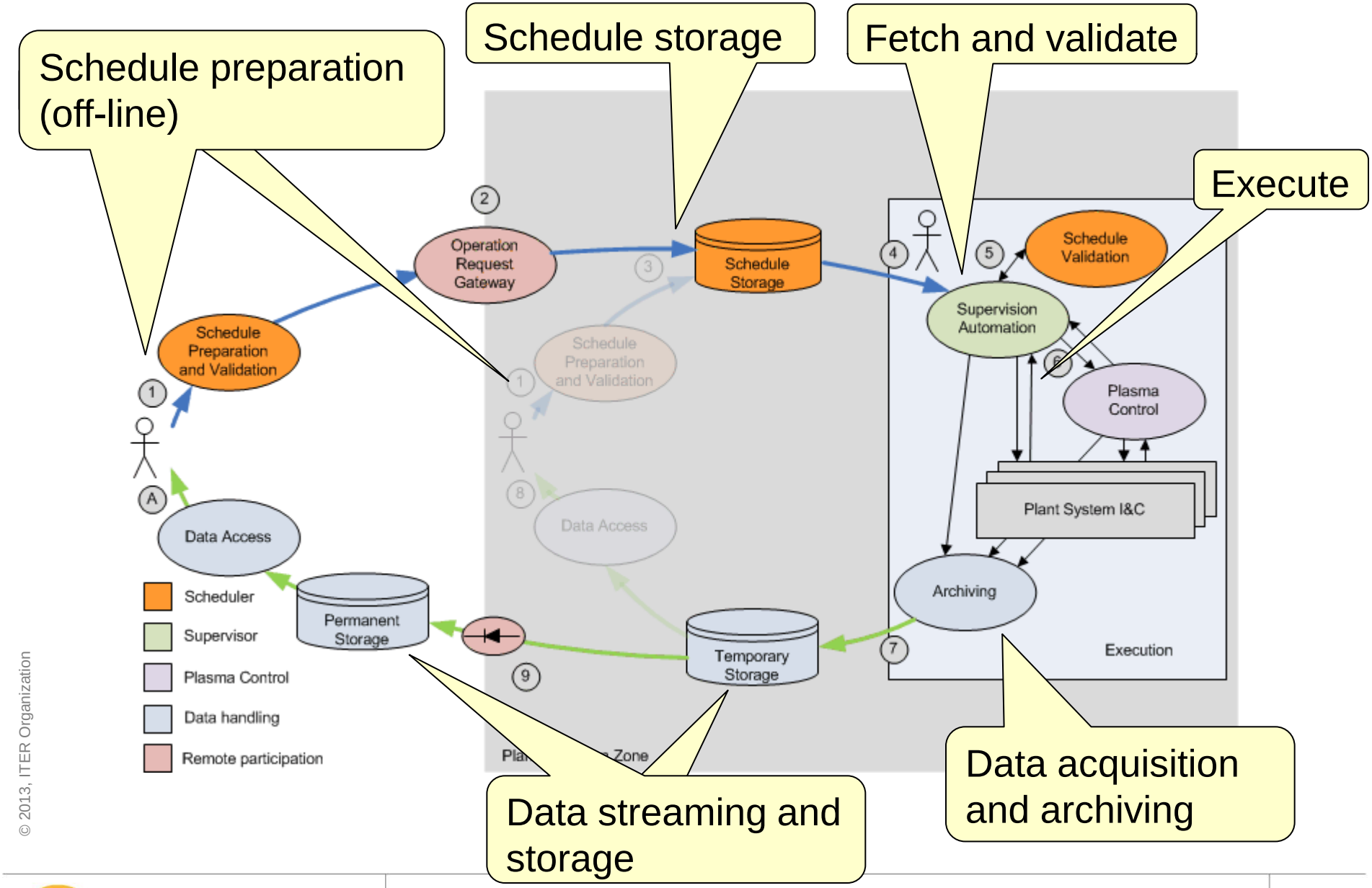


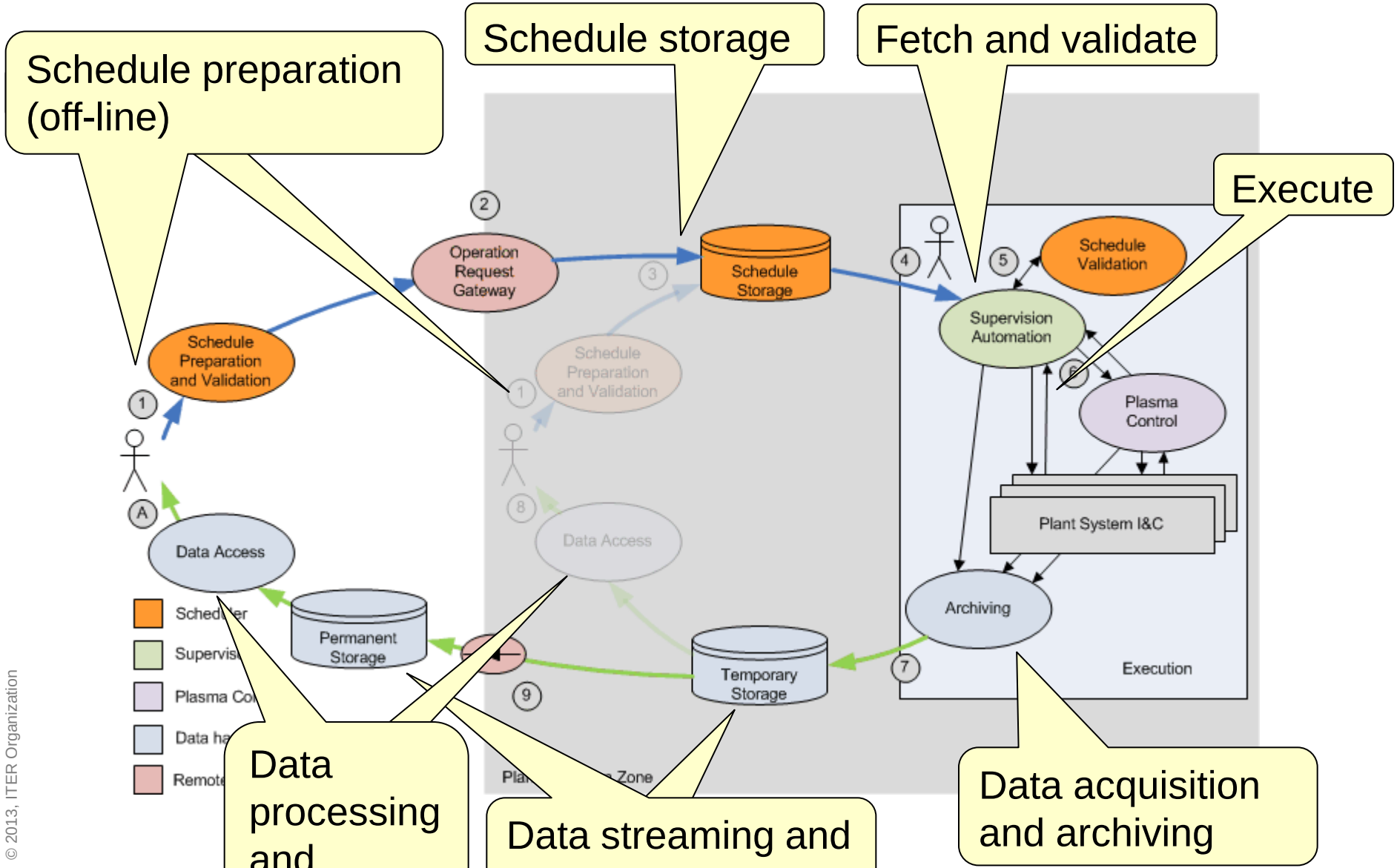


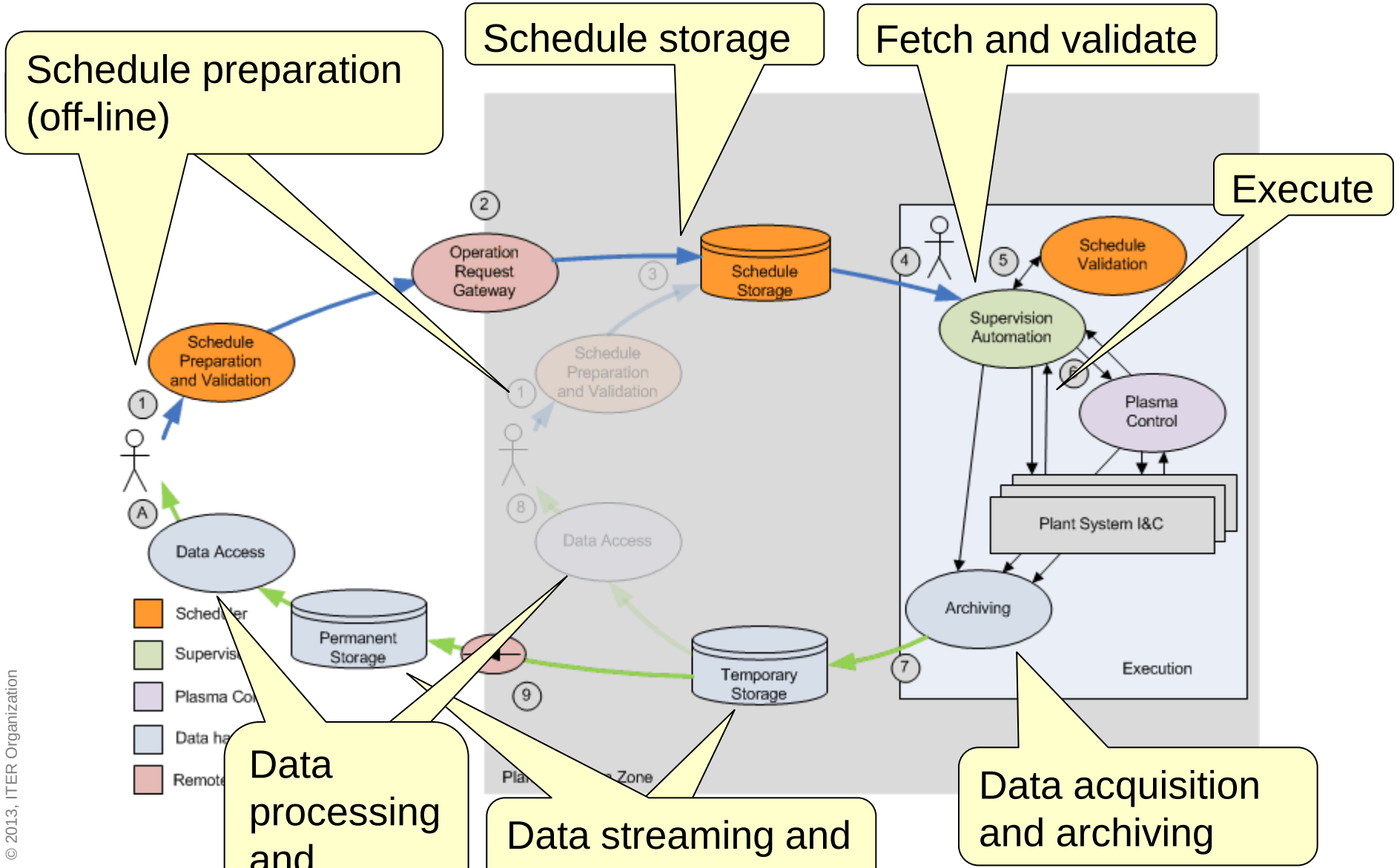
High Level Applications – Main Data Flow

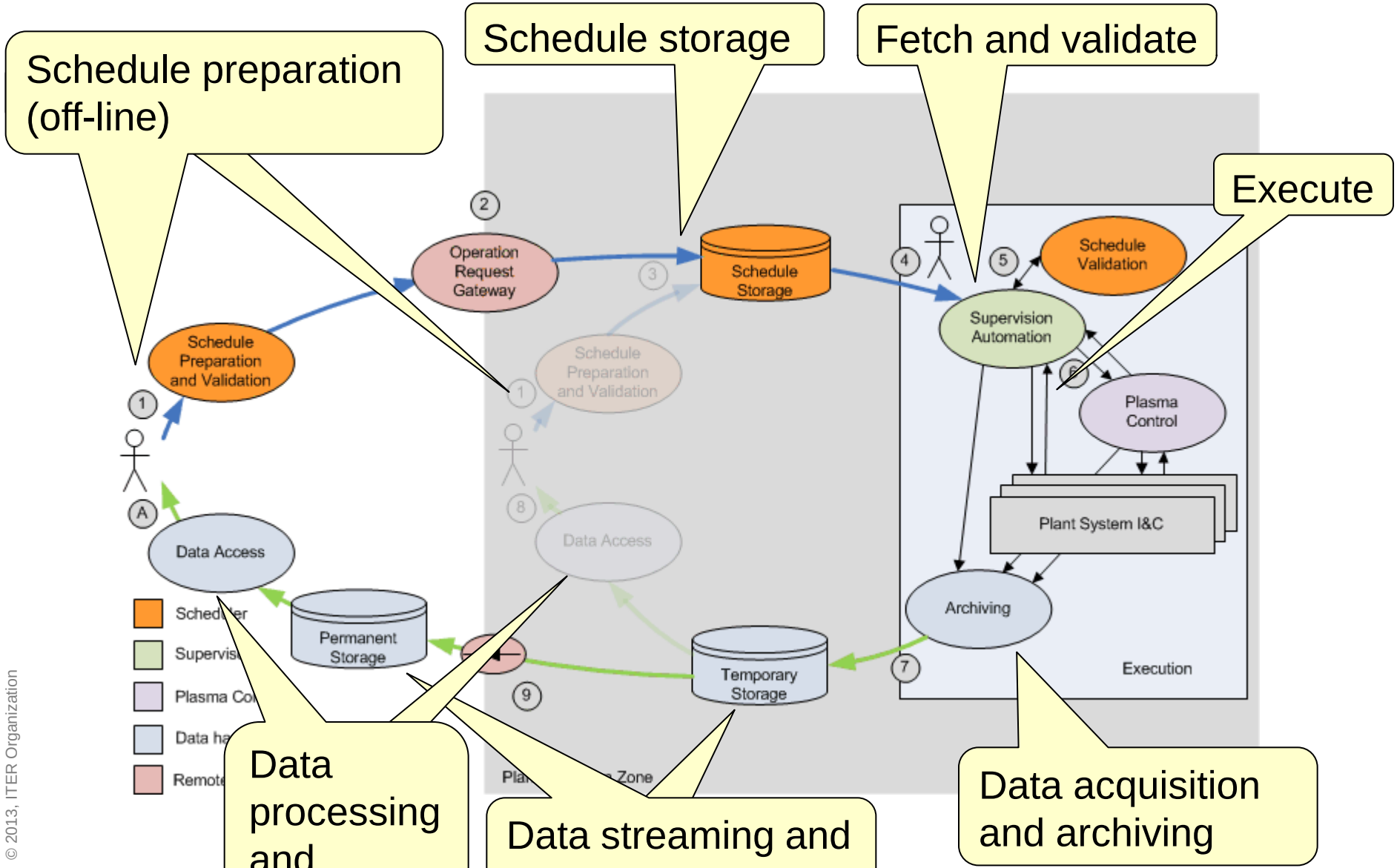




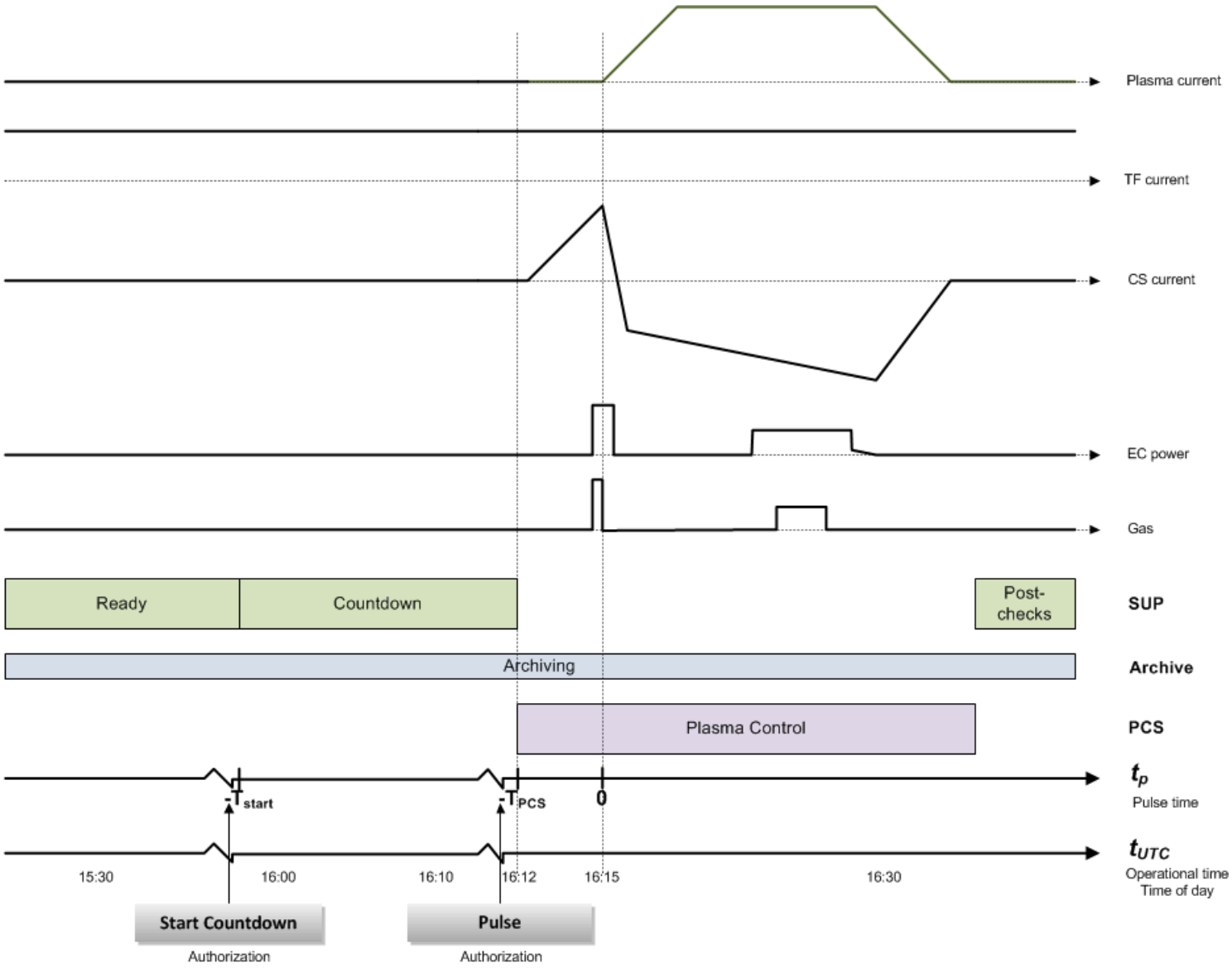








Timing diagram for a plasma pulse



Conclusions

Conclusions

- CODAC Final Design Review part 1 (everything except high level applications) will be held in Jan 2014
- Main components for mitigation of risks during integration are in place
  - Plant Control Design Handbook
  - CODAC Core System
  - I&C Integration Kit
  - Training
- Detailed design of network infrastructure ready for tender of supply and installation
- CODAC Final Design Review part 2 Jan 2016

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  - Training
- Detailed design of network infrastructure ready for tender of supply and installation
- CODAC Final Design Revi

MOPPC079, Di Maio, CODAC Core System
THPPC004, Pande, PLC interface
TUPPC103, Utzel, Control System Studio
TUPPC003, Abadie, Configuration (SSD)
MOPPC014, Simrock, Diagnostics
TUCOCA02, Vergara, Interlock