Laser Megajoule Facility (L.M.J.)

Control system status report

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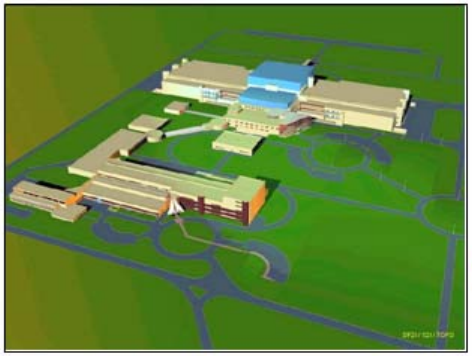
PRESENTATION OVERVIEW

- The Laser MegaJoule (L.M.J.) facility
- Prototype = the Laser Integration Line (L.I.L.) facility
- The control system architecture and industrial policy
- The high level supervisory software
- The control system road map

The Laser Megaloule (L.M.J.) facility

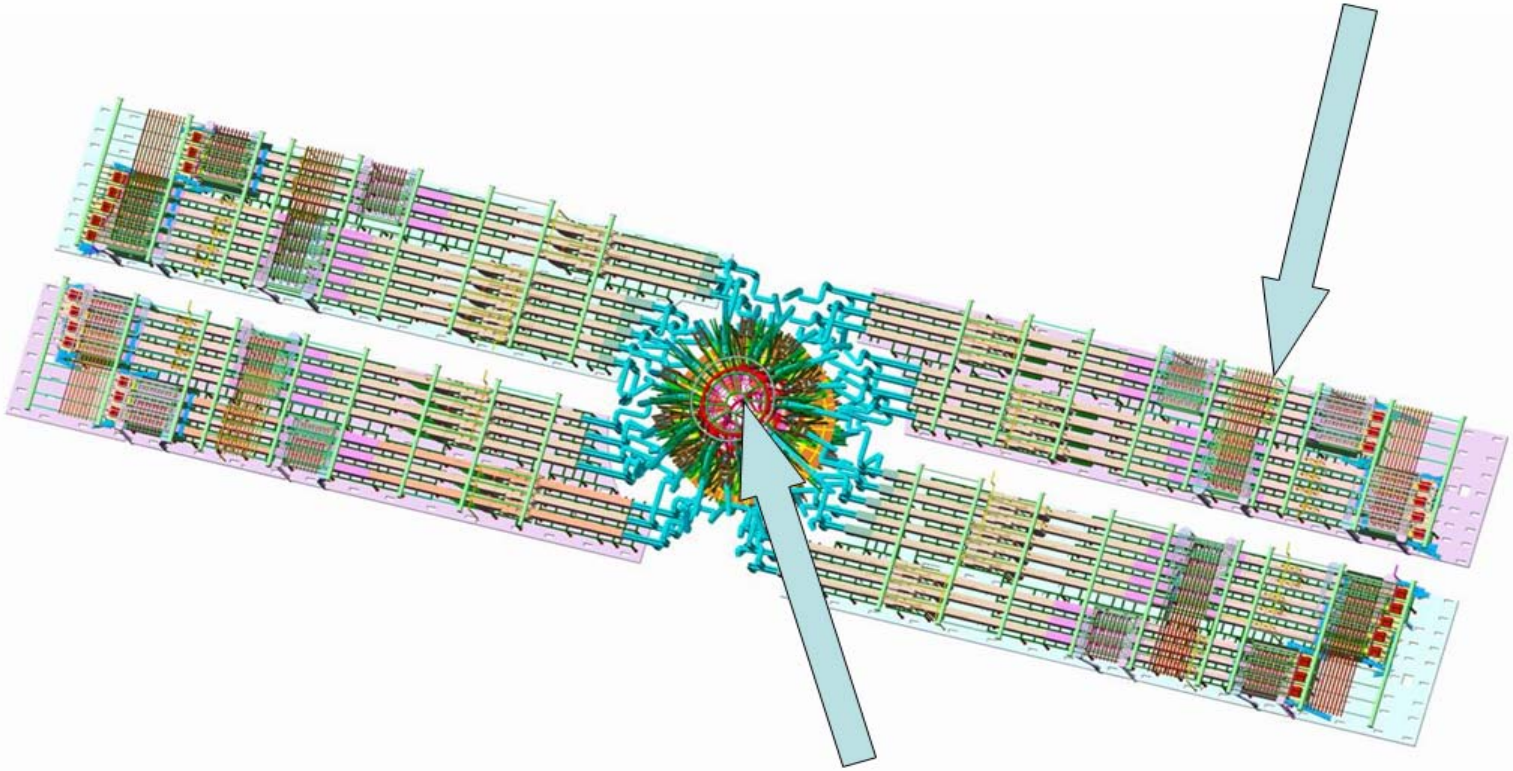
- The **Simulation program** forms the basis for the guarantee of the safety and reliability of French nuclear weapons
  - similar to the US Stockpile Stewardship Program
- LMJ is a cornerstone of this program
  - The LMJ project is similar to the US NIF project
- Prototype = LIL



LMJ & LIL (CEA/CESTA site near Bordeaux)

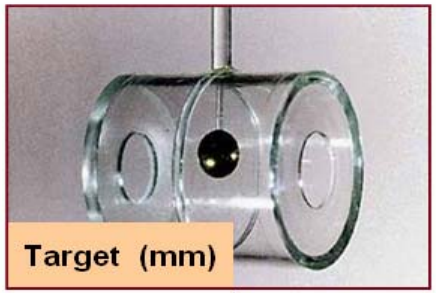
The LMJ facility overview

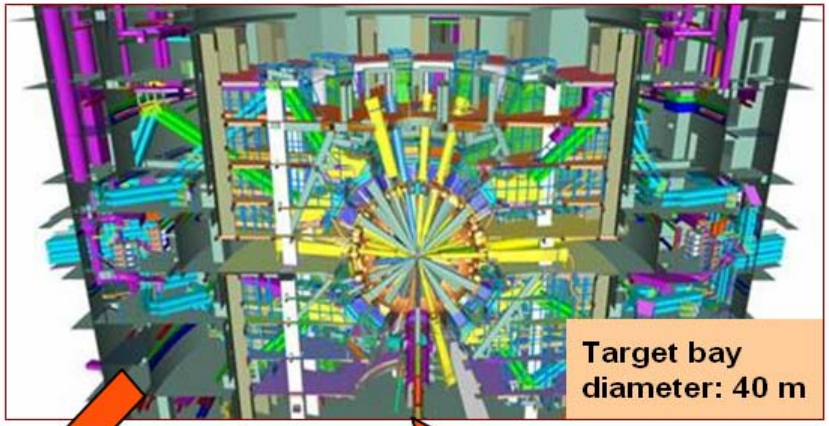
30 bundles of 8 beams located in 4 bays = 240 beams

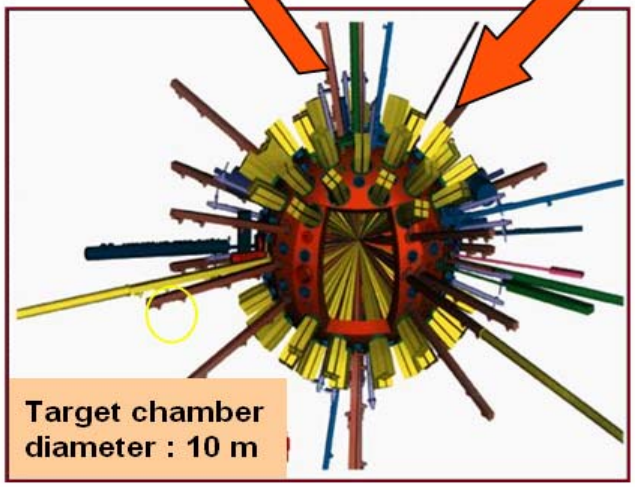


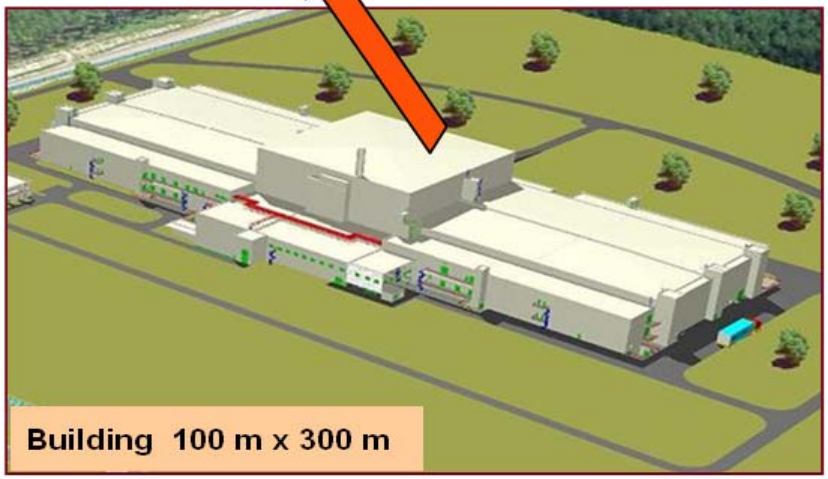
1.8 MJ of 350 nm UV light on a target

Conducting an experiment with LMJ









The LMJ building

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LMJ Project status

The LIL facility = the LMJ prototype

- LIL was commissioned in March 2002

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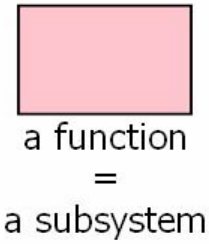
LMJ Control system functionality (simplified)



Shot Director

Maintenance Management System

Power Conditioning Control

Laser Parameters Settings

Laser Diagnostics Acquisition

Laser Alignment

Vacuum Control

Target Alignment

Target Diagnostics Acquisition

Personnel Safety

CAPACITOR BANK

PULSE GENERATION

AMPLIFIER

EXPERIMENT

LMJ BUILDING

Access Control

Building monitoring

TIMING

Shot Data Processing

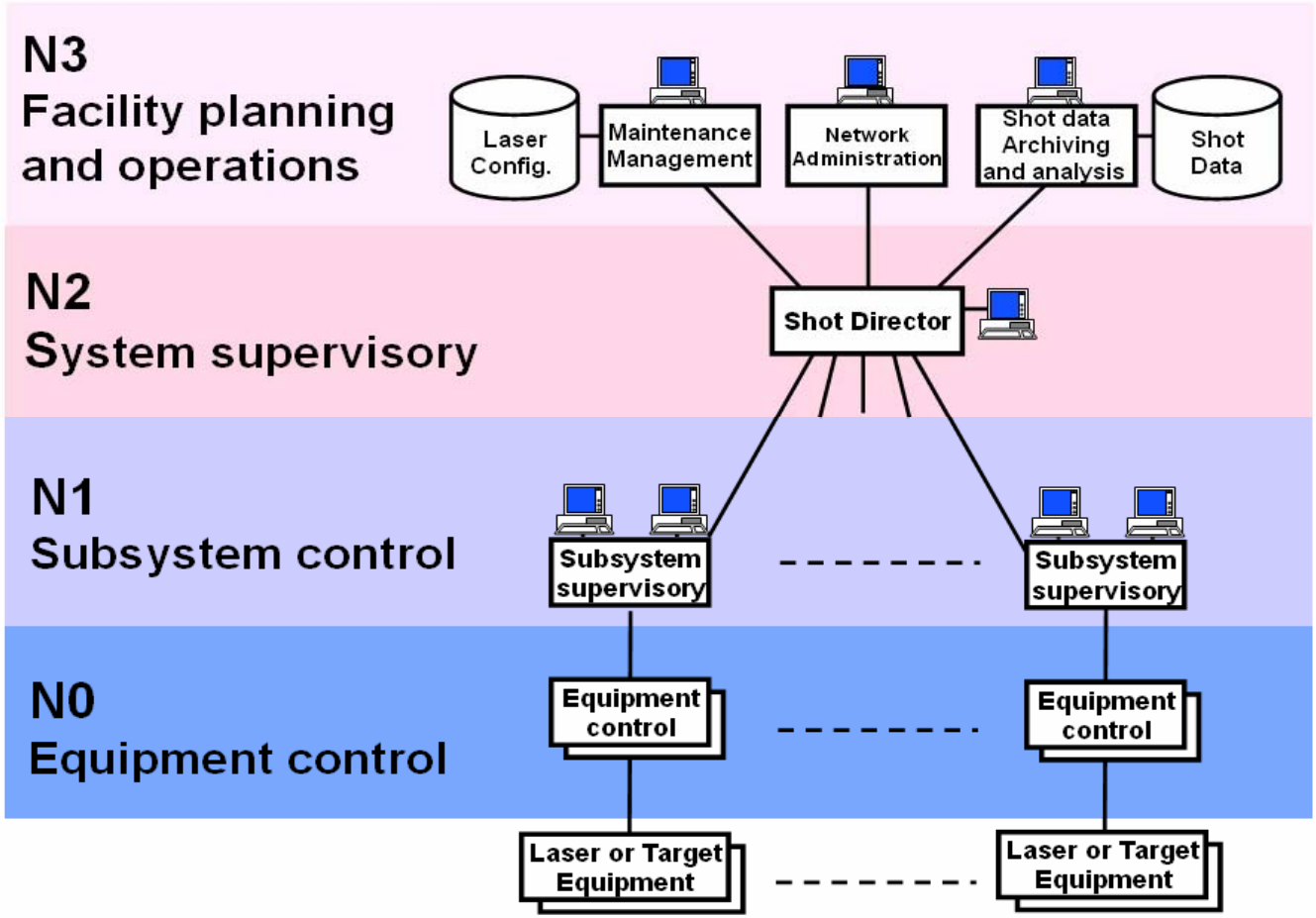
The LMJ control system
a layered architecture

Control Points
500 000

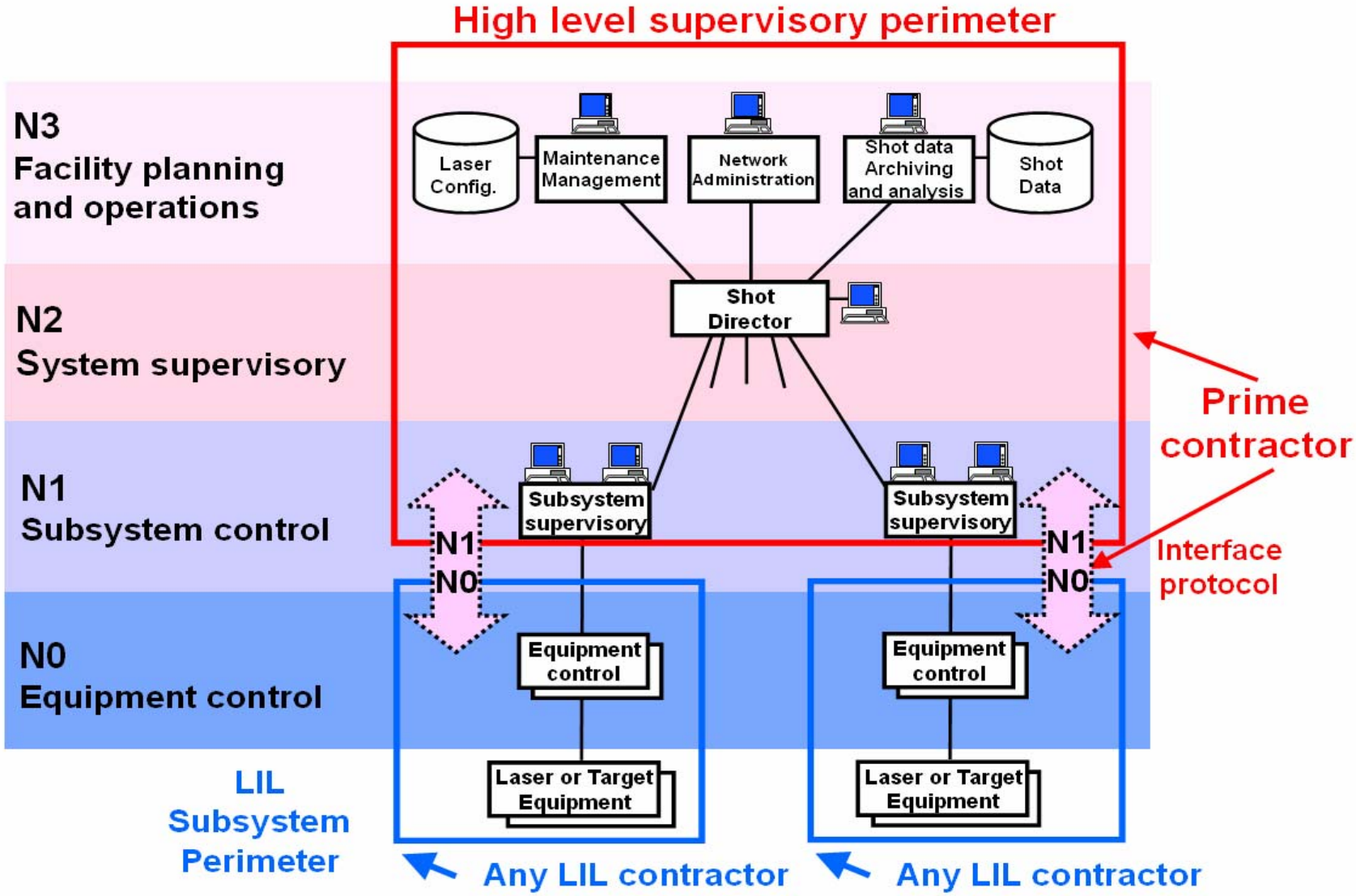
Alarms
150 000

Processors
700

Shot data
~1 GB / shot
2 years on line

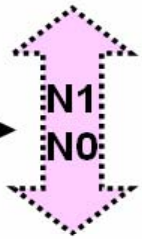


LIL industrial policy



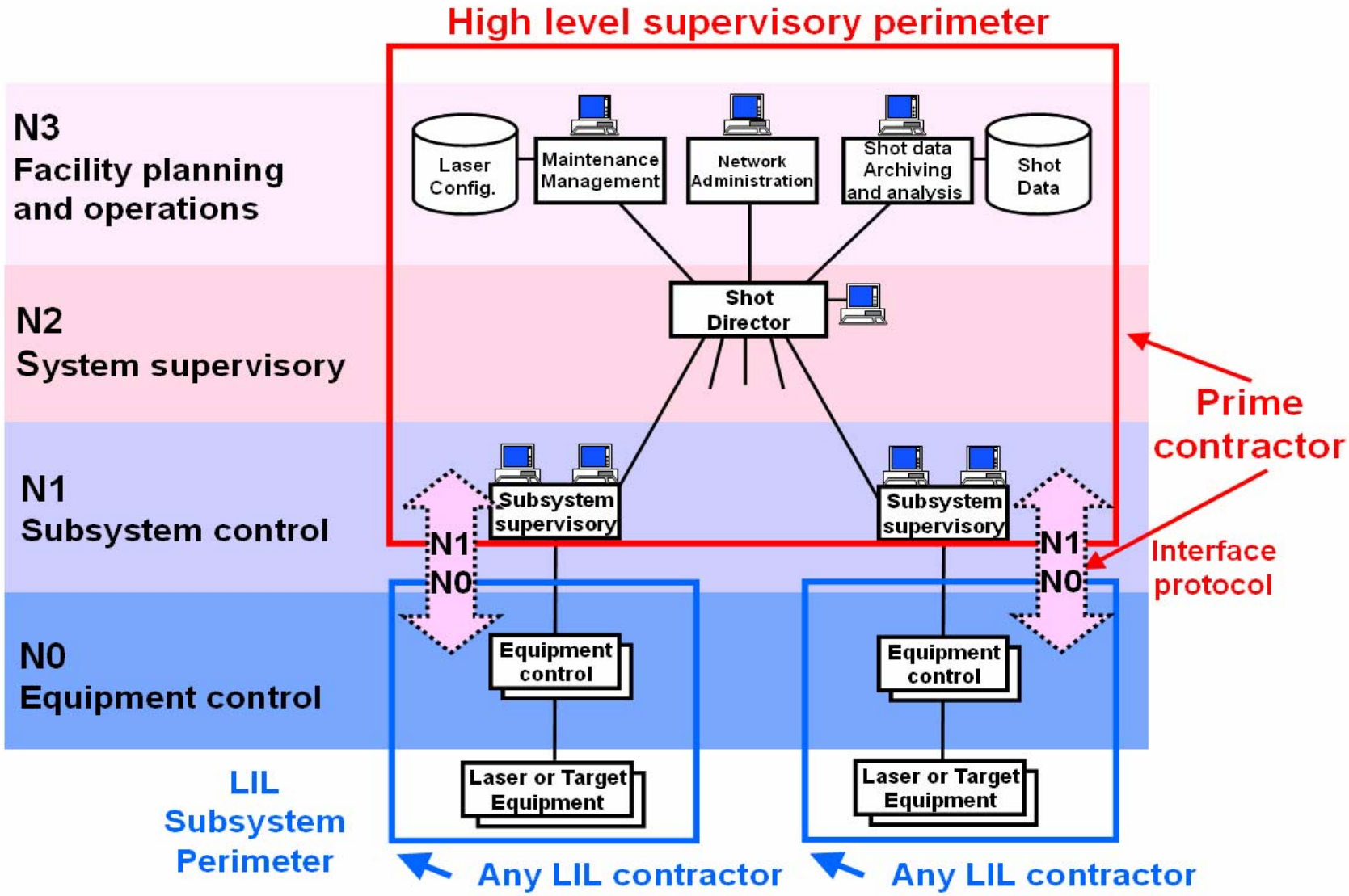
LIL experience feedback

- Development phase
  - Frequent changes brought to the high level supervisory software
    - because of unexpected modification of the equipment hardware under development
    - the interface level between contracts was too low
  - Interface toolkit not standard and insufficiently tested
  - Subsystem software behavior insufficiently specified

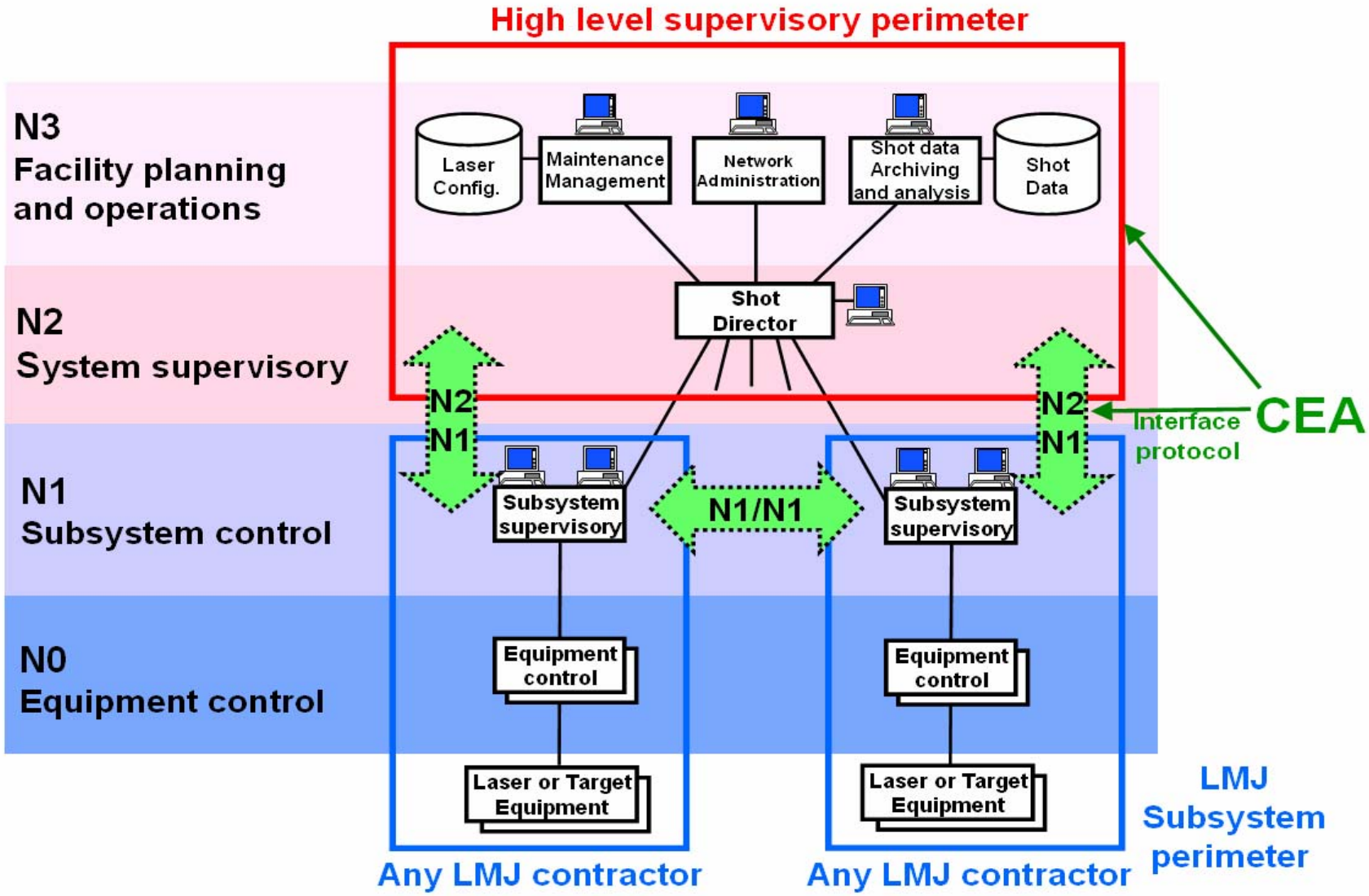


- Factory acceptance
  - Factory acceptance tests were degraded by an acceleration of the Project planning
- Integration with surrounding subsystems
  - Difficult Integration due to limited factory acceptance tests
  - Integration platform not sufficiently representative

LMJ industrial policy



LMJ industrial policy



Mandatory LMJ Interface protocol and library of basic mechanisms

- The (N1-N1 and N1-N2) interface protocols are fully standardized

Low level protocol = Web-Services + OPC-DA
(OPC- UA is under consideration)

High level protocol = a library of basic mechanisms imposed to every LMJ contractor via a data model

- Fault tolerance Management
- Alarms & lifecycle States Management
- Maintenance Management
- Network Administration
- Post Shot Data Management
- Reservations Management
- Shot planning
- Sequences Management
- Shot Data Configuration Management
- Synchronization Management
- Working Modes Management

Transverse requirements (1/3)

- The LMJ control system = a dozen contracts (one by subsystem)
- Necessity of transverse requirements to guarantee a certain level of standardization.
- Three examples of requirements in this presentation

1. Objectives for software reliability

Procedure recommended by the French company Mathix :

1. **Contractors perform tests based on the software mission profile**
2. **They plot cumulated number of failures vs. test duration on a chart**
3. **Shape of this chart + LIL experience feedback + Mathix know-how = an estimate of the present and future software reliability (required for factory acceptance by CEA)**

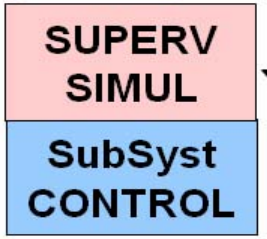
Transverse requirements (2/3)

2 – Mandatory hardware and software

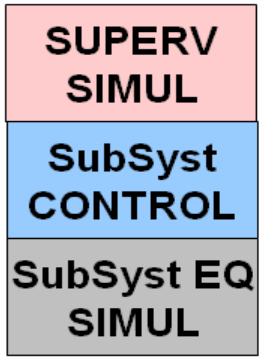
Mandatory choices	Layer N0	Layer N1	Layer N2	Layer N3
Processor	PLC (Schneider or Siemens) or industrial PC	PC		
Language for PC	Free			
Language for PLC	CEI 61131-3 standard			
Operating system	Free	Windows Vista or later		
SCADA		Panorama E2		
N1, N2, N3 Networks	Ethernet 100 Mbits or Gigabits - Brand: Alcatel-Lucent			
Field Bus	Free			
Instrument Bus	IEEE488, VXI, IEEE1394			
N1, N2, N3 sotware interface	Imposed in the LMJ interface protocol			
Development tools	Free			

Transverse requirements (3/3)

3 – Tests and Integration



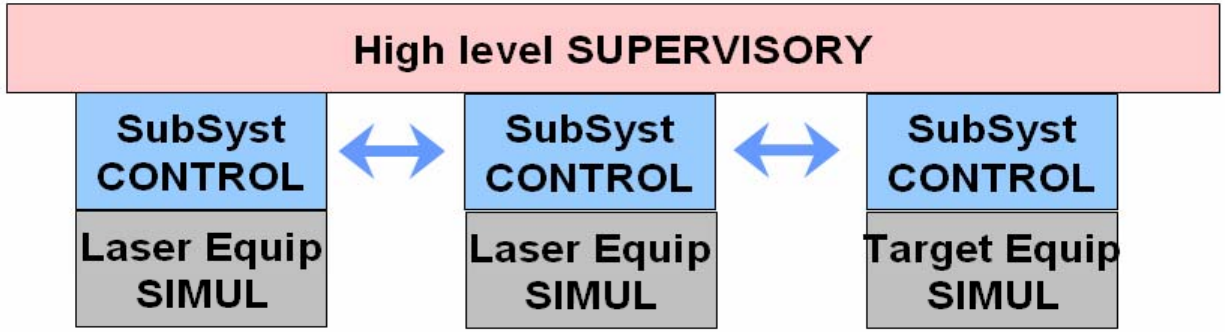
- **Development phase**
  - Closer management of the contractors during design and qualification phases.
  - Use of an interface simulator to avoid dependence between subsystems and high level supervisory developments



- **Factory acceptance tests**
  - The software under test will be connected to two simulators
    - an upward simulator supplied by CEA simulating the high level supervisory
    - a downward simulator, developed by the subsystem contractor, simulating the totality of his equipment hardware (30 bundles) (otherwise this test could not have been conducted until the end of the production)
  - Factory tests had to be refined to make them more exhaustive

Transverse requirements (3/3)

- **Integration Platform**
  - Built with real software (N0 to N3) **+** laser and target equipment simulators.



  - Subsystems will then be integrated one after another.
  - Objectives:
    - Verify software installation procedure
    - Verify operation and conduct virtual shots

Offsite testing = no impact on LMJ operation

- **On site qualification**
  - qualification performed bundle by bundle from a dedicated control-room before connection to the operational control network

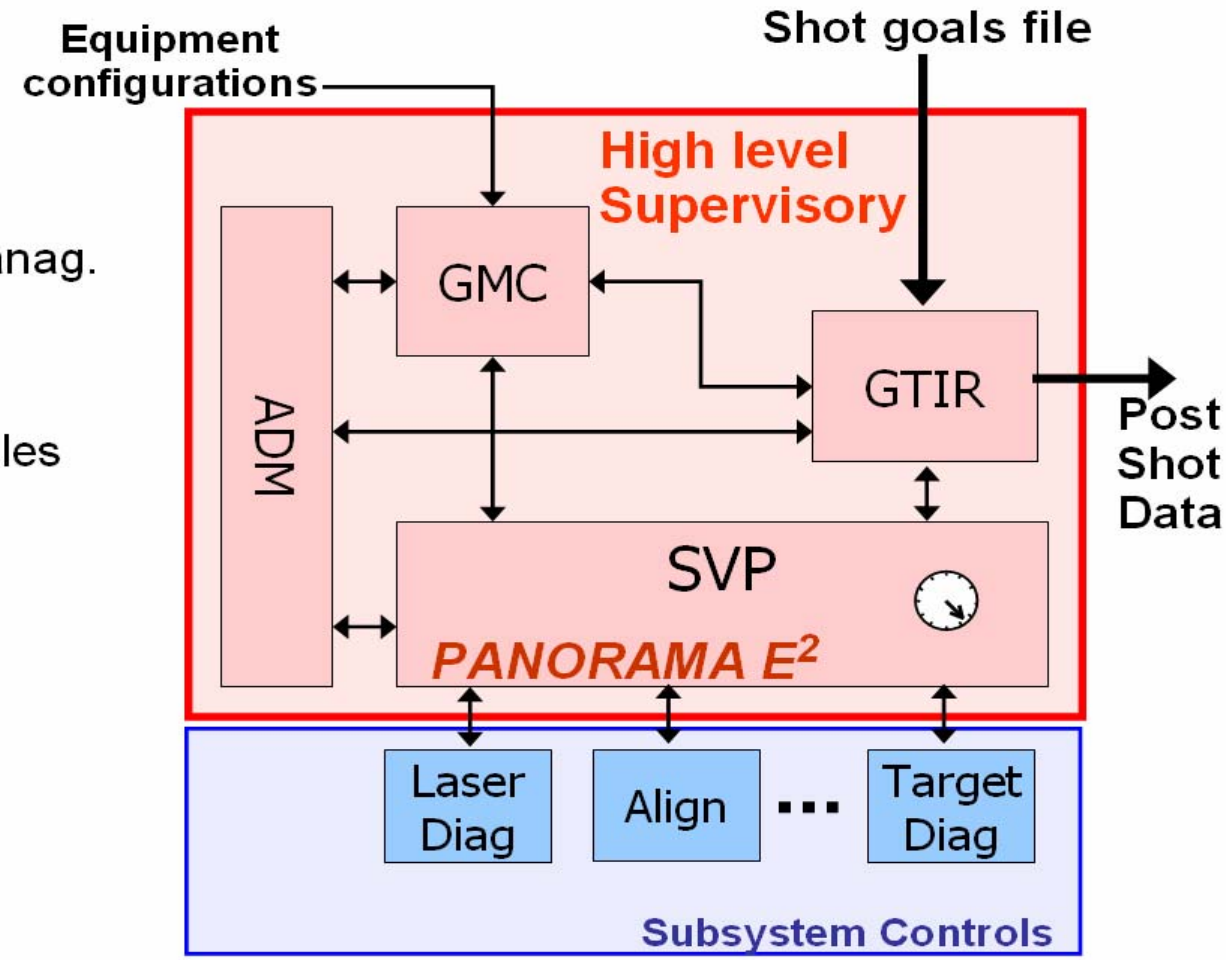
High level Supervisory software

GMC
- Equipment Configuration Manag.
- Maintenance management

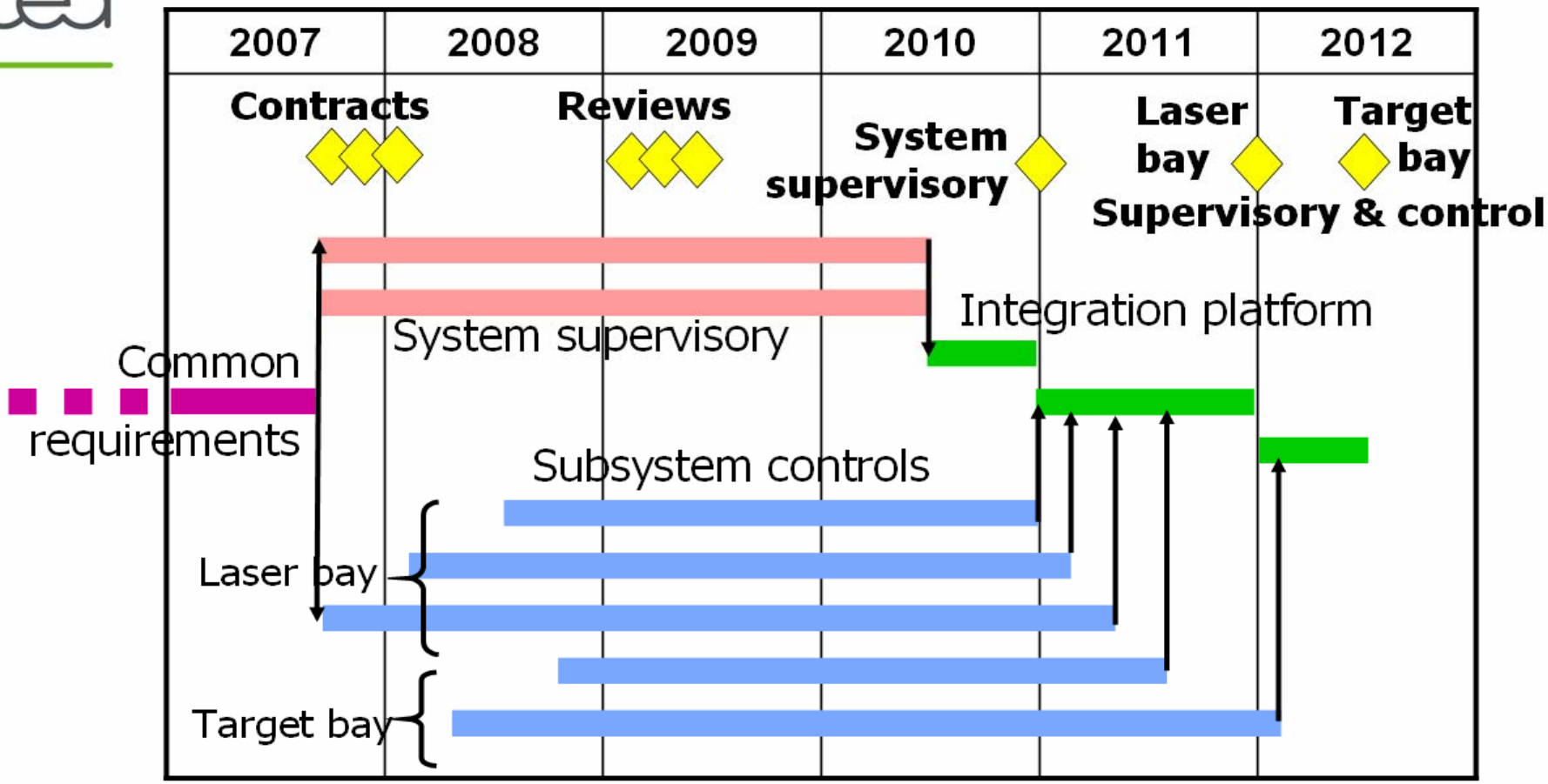
GTIR
- Management of shot goals files
- Shot data processing and archiving

SVP
- Shot sequence execution

ADM
- Network administration



The LMJ control system road map



Any questions ?