OAJ Control System

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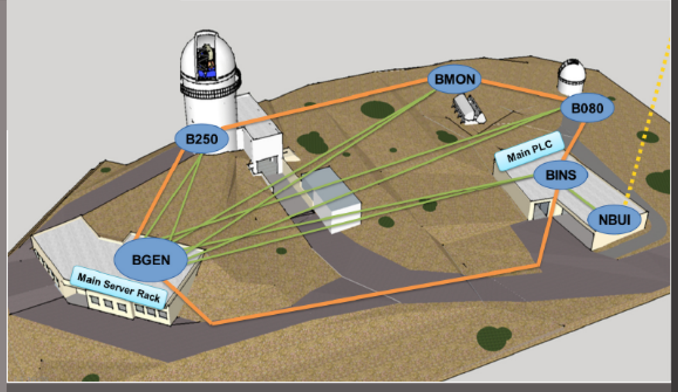
Abstract

The Observatorio Astrofísico de Javalambre (OAJ) is a new astronomical facility located at the Sierra de Javalambre (Teruel, Spain) whose primary role will be to conduct all-sky astronomical surveys leveraging two unprecedented telescopes with unusually large fields of view:
The JST/T250, a 2.55m telescope with a 3deg field of view, and the JAST/T80, an 83cm telescope with a 2deg field of view.
The immediate objective of these telescopes for the next years is carrying out two unique photometric surveys covering several thousands square degrees: J-PAS and J-PLUS, each of them with a wide range of scientific applications, like e.g. large structure cosmology and Dark Energy, galaxy evolution, supernovae, Milky Way structure and exoplanets. JST and JAST will be equipped with panoramic cameras being developed within the J-PAS collaboration, JPCam and T80Cam respectively, which make use of large format (~ 10k x 10k) CCDs covering the entire focal plane.

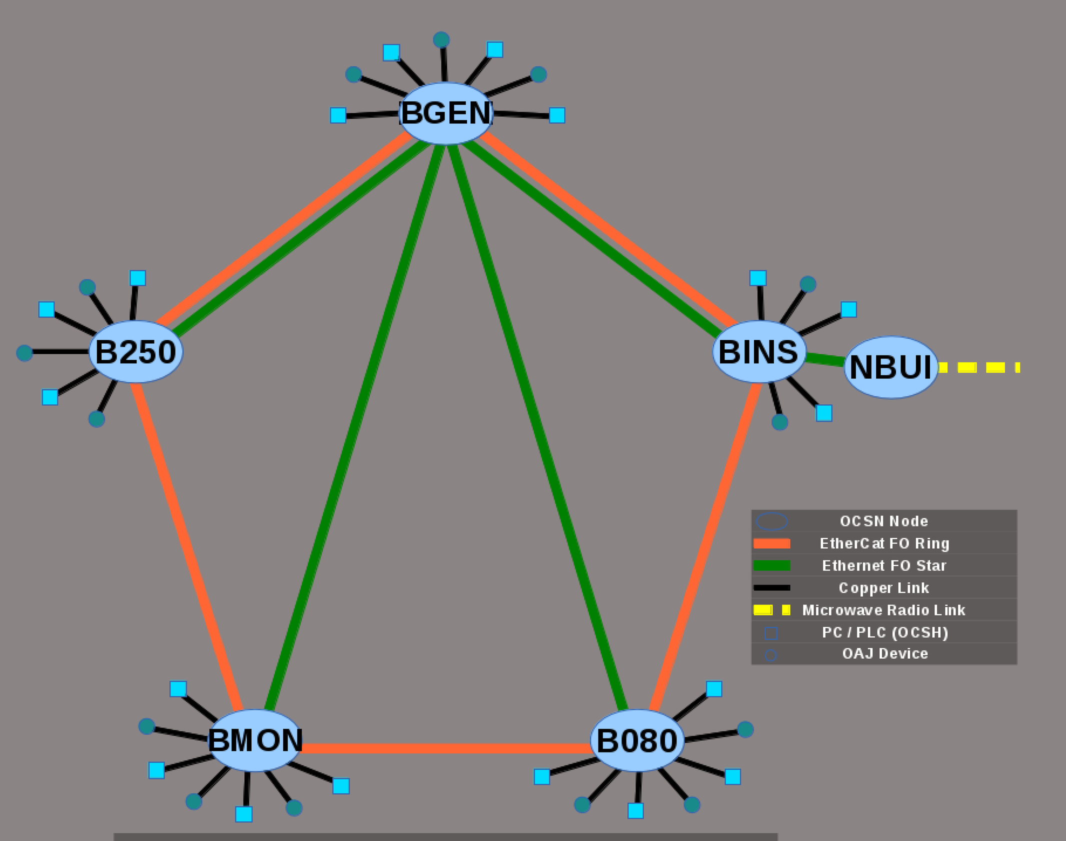
CEFCA engineering team has been designing the OAJ control system as a global concept to manage, monitor, control and service the observatory systems, not only astronomical but also infrastructure and other facilities. In order to provide quality, reliability and efficiency for the OAJ control system its design is based on CIA (Control Integrated Architecture) and OEE (Overall Equipment Effectiveness) as keys to improve day and night operation processes.
The OCS (Observatory Control System) comprises a low level hardware layer including IOs connected directly to sensors and actuators deployed around the whole observatory, telescopes and astronomical instrumentation, and a high level software layer as a tool for efficient observatory operation. We will give an overview of OAJ's control system from an engineering point of view, giving details on the design criteria, technology, architecture, standards, functional blocks, model structure, deployment, goals, current status and next steps in its development.

Observatory Control System's Network - OCSN

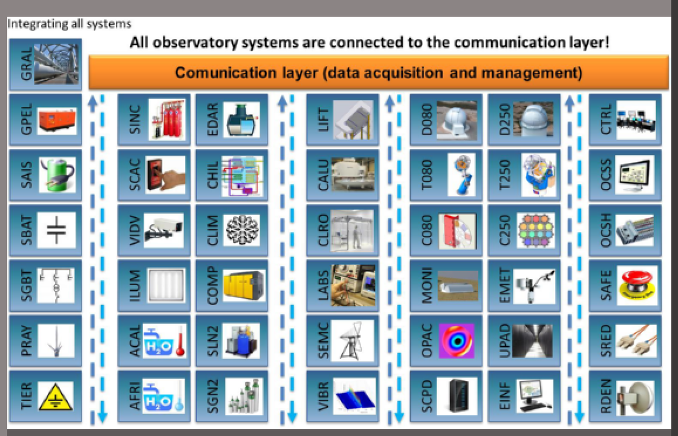
The OCS is a global tool which has the responsibility of controlling, monitoring and managing all systems at the observatory. These systems are widespread all around the Observatory and connected to the OCS Network's main nodes by Ethernet/EtherCAT copper links. There are five main nodes each located in a different observatory building. Nodes are linked by an EtherCAT Ring and an Ethernet Double Star network, both using 10Gbps Multi-Mode Optic Fiber as their physical medium. This topology provides communication path redundancy and interference inmunity. In addition a 700 Mbps microwave radiolink connects the observatory to CEFCA's headquaters located 40 km away in Teruel.



Observatory Buildings & OCSN Nodes



OCSN Topology



Observatory Systems (Abridged)

OCSN Nodes & OCS Servers

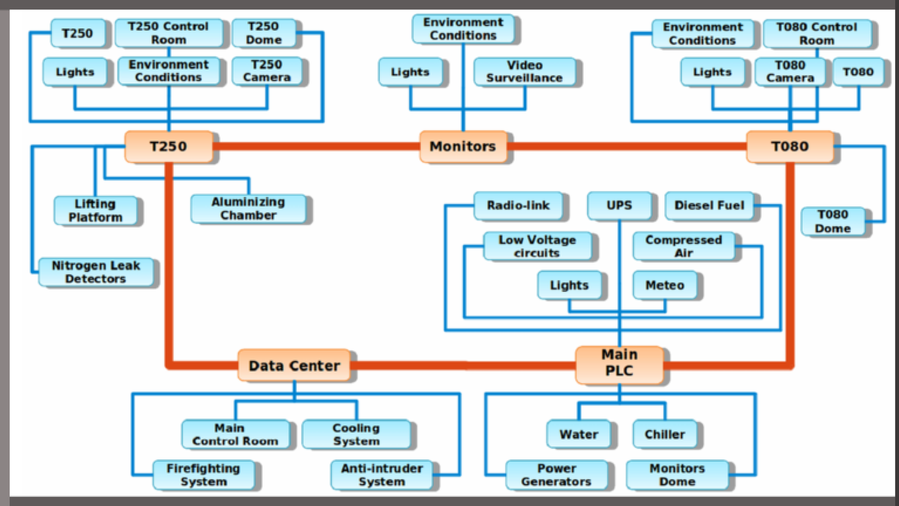
The OCSN nodes are based on CISCO networks' technology:

There is a main Core 4507R series switch at the primary node (BGEN) and a 3750X series switch at every other secondary node (B080, B250, BMON, BINS).

PLCs are Beckhoff's TwinCAT 2 embedded IEC 61131-3 running on C51xx series hardware for main PLC data concentrator and on CX50x0 and CX10x0 series hardware for local controls.

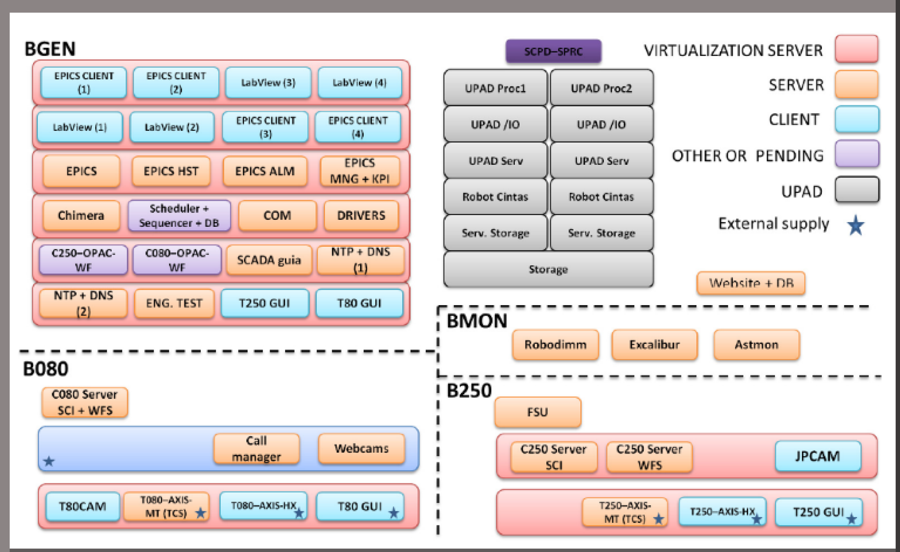
PCs are Dell's PowerEdge R510 Servers running VMware ESXI virtualization software.

All these systems are installed in four different racks, each located in a different building.



OCSN Nodes & OAJ Devices (Abridged)

OCS Racks



OCSN Nodes & OCS Servers (Abridged)

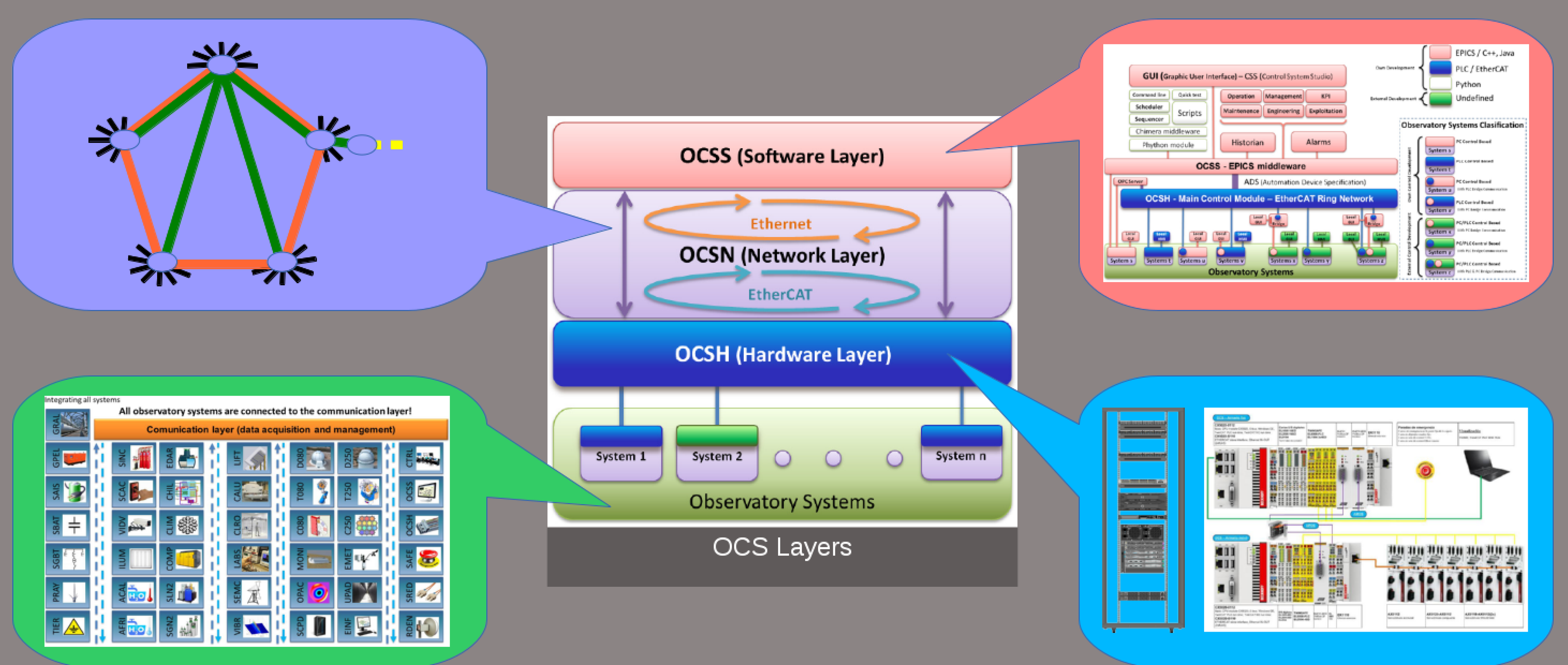
OCS Layers

The OCS can be decomposed into three functional layers: Hardware layer (OCSH), software layer (OCSS) and network layer (OCSN).

OCSS is a software layer, implementing the distributed control system that allows to operate the observatory as a whole.

OCSH is a distributed PLC (Programmable Logic Controller) and PC layer deployed all around the observatory. It provides the capability of connecting to and controlling any kind of actuators such as motors, pumps, fans, pneumatic and hydraulic pistons, machines, telescopes and instrumentation and also acquiring signals from sensors such as temperature, humidity, axis positions, vibrations, speed, acceleration, torque, voltage, intensity, light flux, etc.

OCSN, as already seen, is the network layer based on EtherCAT and Ethernet. Providing the capability of data exchange among the components of OCSH and OCSS layers.



OCS Layers

Heterogeneous Systems Integration: EPICS & ADS

Every system to be integrated into the OCS is coupled to an integration bridge. The bridge is in charge of translating the system's specific control interface to the two common control interfaces defined for the OCS:

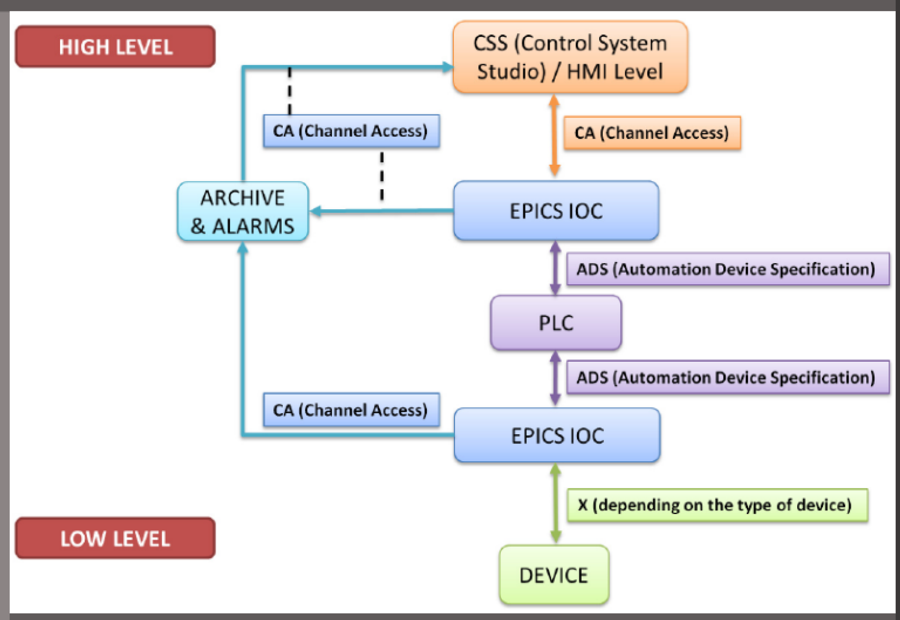
- ADS (Automation Device Specification) :
  For subsystem control and operation services.
- EPICS CA (Experimental Physics and Industrial Control System) :
  For commodity services such as monitoring, alarm management, data archival, logging, etc.

The general approach consists in translating every control and operation service provided by the system to be integrated into an ADS service. This is achieved by means of ADS generic Remote Procedure Call (RPC). ADS generic RPC allows computers on a network (ADS Clients) to command execution of services on other computers of the network (ADS Servers). Services are device specific and there are no restrictions on the amount or type of input/output data required/produced by the service.

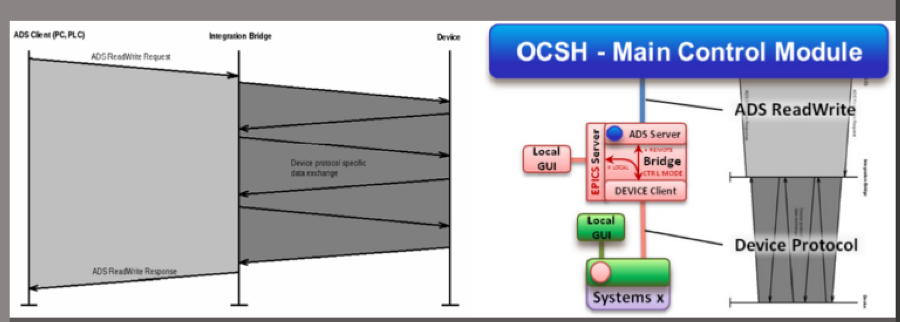
ADS RPC is based on the ADS protocol's ReadWrite Command.

The general sequence of message exchanges produced in the ADS Service request is as follows:

An ADS client issues an ADS ReadWrite Request addressed to an integration bridge. The integration bridge is coupled with the specific device whose service is being requested. The request message specifies the code of the requested service and also transports the service's associated input data (if any). The integration bridge decodes the message and performs any required device specific data conversion on input data. Then it proceeds to forward the service request to the device as specified by the device's control protocol. This process may involve a series of message exchanges between the integration bridge and the device. When the process is finished, the integration bridge sends the service overall result status and any output data produced to the ADS Client, all in a single ADS ReadWrite Response message (See Figure on the right), completing the ADS ReadWrite Command.

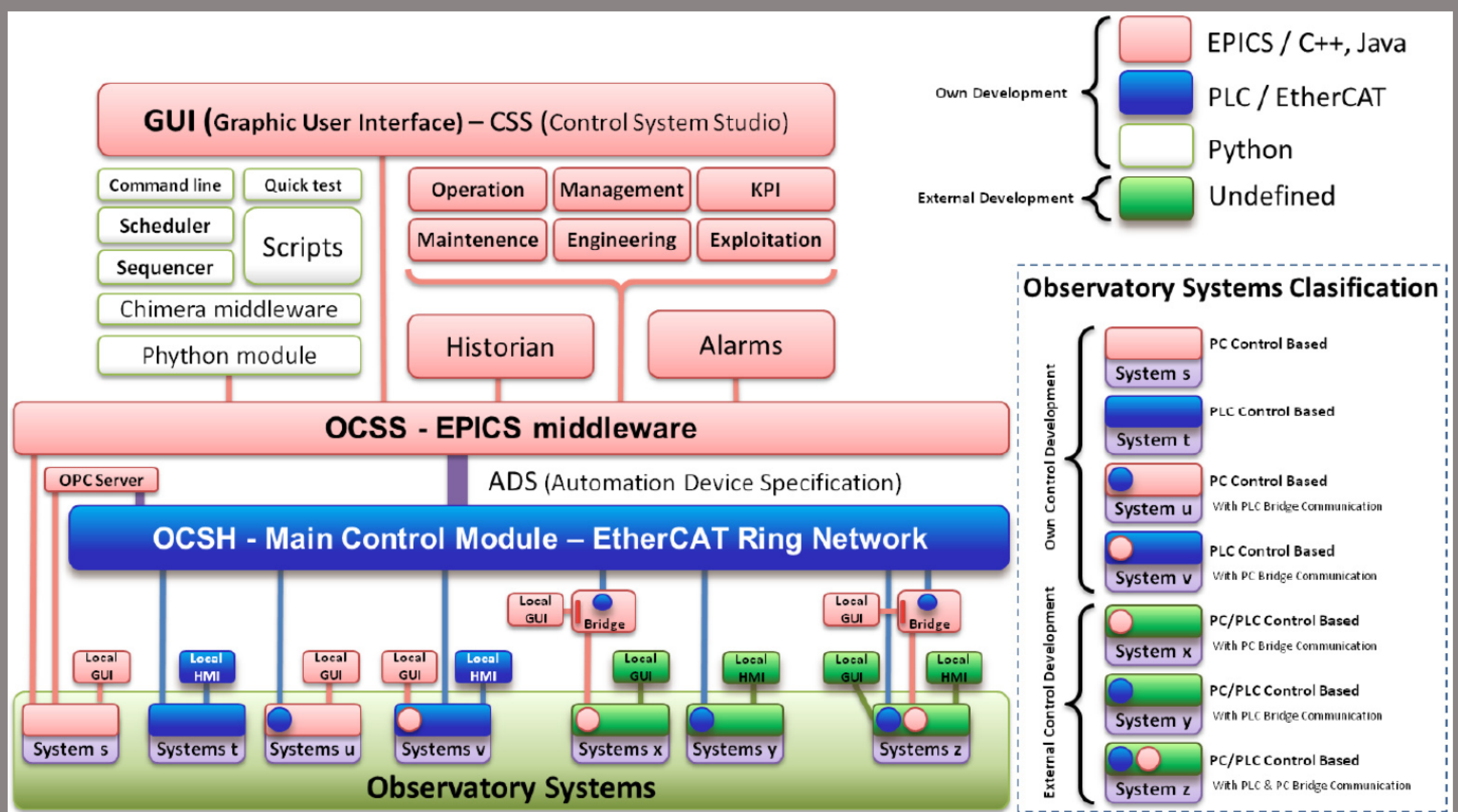


OCS's control interfaces: EPICS & ADS



OCS's Integration Bridge: ADS RPC

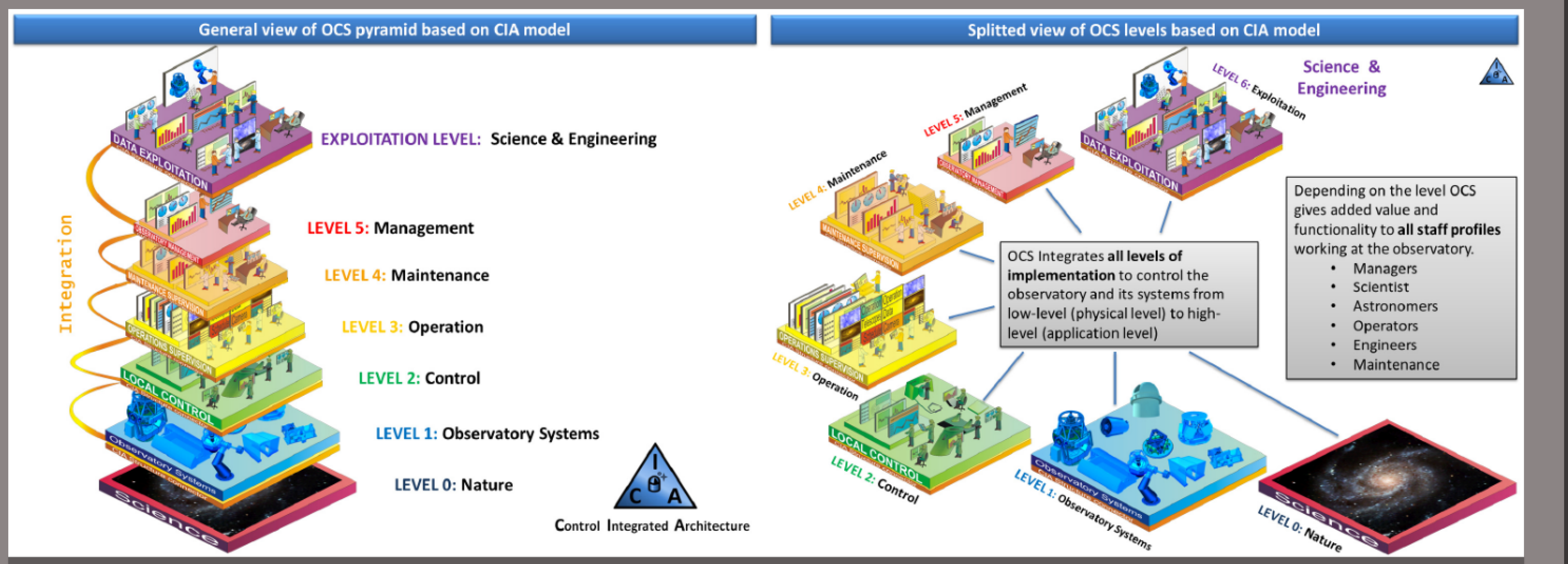
Heterogeneous Systems Integration: Software & Hardware Modules



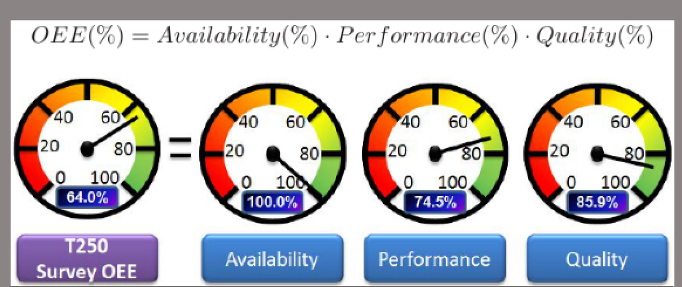
OCS's Software & Harware modules

CIA & OEE

CEFCA engineering team has designed the OAJ control system as a global concept to manage, monitor, control and maintain all the observatory systems including not only astronomical subsystems but also infrastructure and other facilities. In order to provide quality, reliability and efficiency, the OAJ control system (OCS) design is based on CIA (Control Integrated Architecture) and OEE (Overall Equipment Effectiveness) as a key to improve day and night operation processes.



Control Integrated Architecture (CIA)



Overall Equipment Effectiveness (OEE)