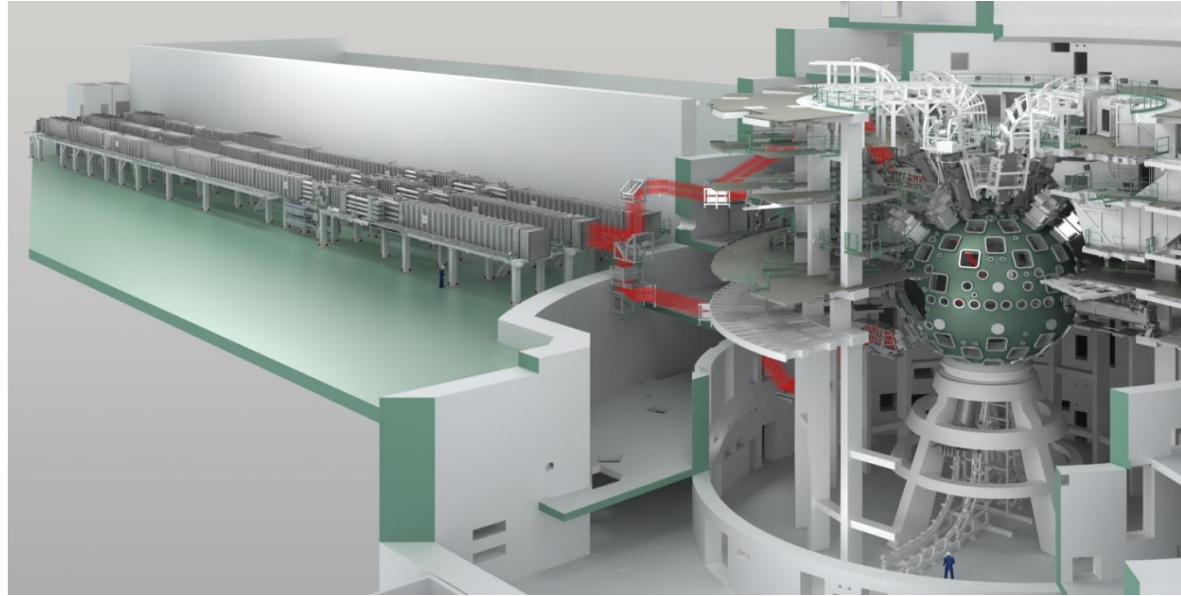


DE LA RECHERCHE À L'INDUSTRIE



www.cea.fr

LASER MEGAJOULE TARGET DIAGNOSTIC CONTROL COMMAND SYSTEM



Presented by S. Perez

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What is LMJ, What are Target Diagnostics ?

The LMJ Control Command architecture

Layer 0 for Target Diagnostics Control Command

Camera Drivers Modular Architecture and Vacuum System

Maintenance and Qualification Tools

Real and Virtual Modes

Layer 1 for Target Diagnostics Control Command

Managing Contractors

Conclusion

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How could we achieve Life Expectancy, Modularity, Heterogeneity ?

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The Laser Megajoule (LMJ)

LMJ is a large research instrument used to condition a very small quantity of matter at extrem temperature and pressure

Heavy and Hot Plasma studies and understanding

- Found in Thermonuclear Devices
- Found deep inside Stars

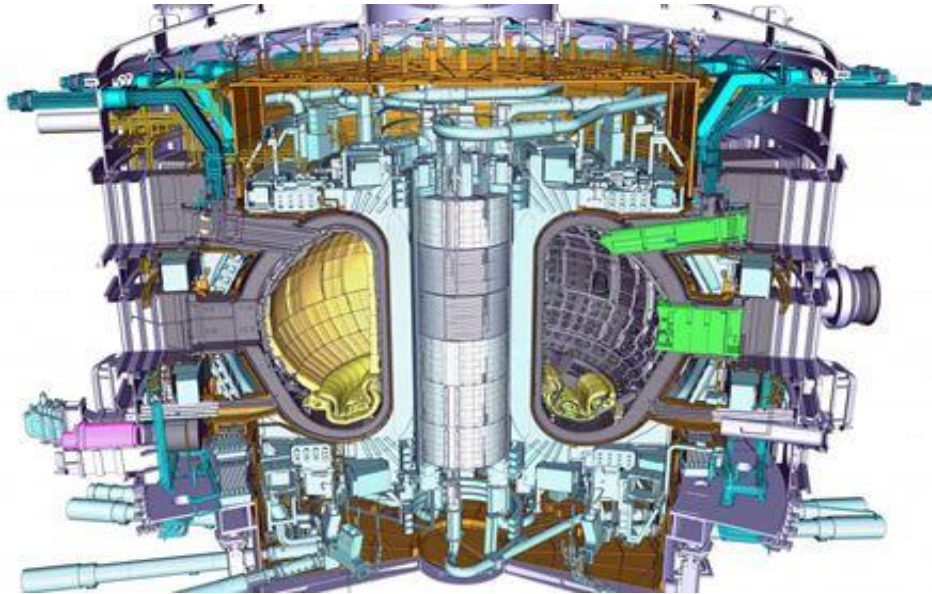
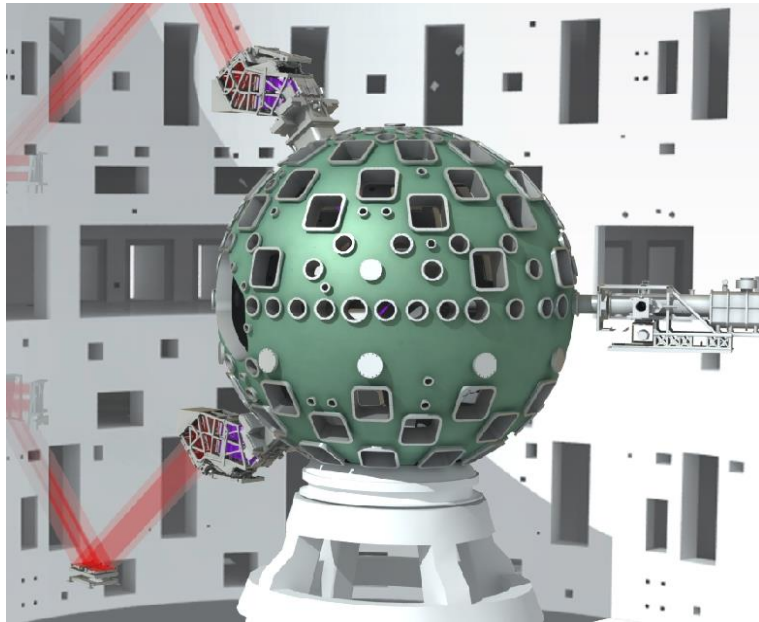
LMJ : A fundamental key in
CEA's **Simulation**
Program

LMJ : An instrument for
Astrophysics and
Fundamental Research

LMJ : One step forward a
new kind of **energy source**,
Inertial Fusion

Inertial vs Magnetic Fusion

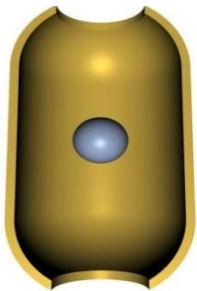
LMJ will concentrate 10^{25} atoms/cm³ during 10 ps



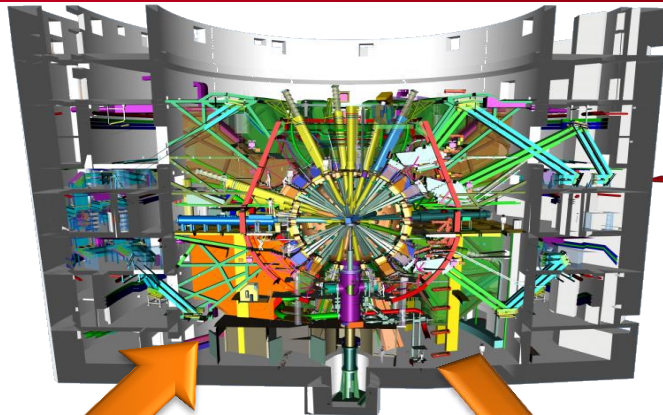
ITER will heat a 10^{13} atoms/cm³ gaz during 10 s

Same ratio than between 2 days and the age of the Universe

From the Target to the Facility



Target \varnothing 2 mm



Experiment Room
 \varnothing 60 m / 50 m High

Laser Megajoule
150 m x 300 m
35 m High



Experiment Chamber \varnothing 10 m





What are Target Diagnostics ?

- **Hard and Soft X-ray imaging systems** (30 eV to 15 keV range) with a 15 to 150 μm spatial resolution and a 30 to 100 ps time resolution, providing 30 imaging channels,
- Diagnostic set for **Hohlraum temperature measurements** including an absolutely calibrated broadband X-ray Spectrometer, a Gating Spectrometer, a time resolved Imaging System of the emitting area,
- Optical diagnostic set dedicated to EOS measurements including 2 VISAR (**V**elocity **I**nterferometer System for any reflector), 2 SBO (**S**hock **B**reak **O**ut), a **Pyrometer** and a **Reflectivity Measurement**,
- **Full Aperture Backscatter System**,
- **Near Backscatter Imager** to measure the power, spectrum, and angular distribution of backscatter light to determine the energy balance.
- **Neutron Detectors**

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Various and Different Equipments

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We will focus on a typical X-ray Imaging System

Various and Different Equipments

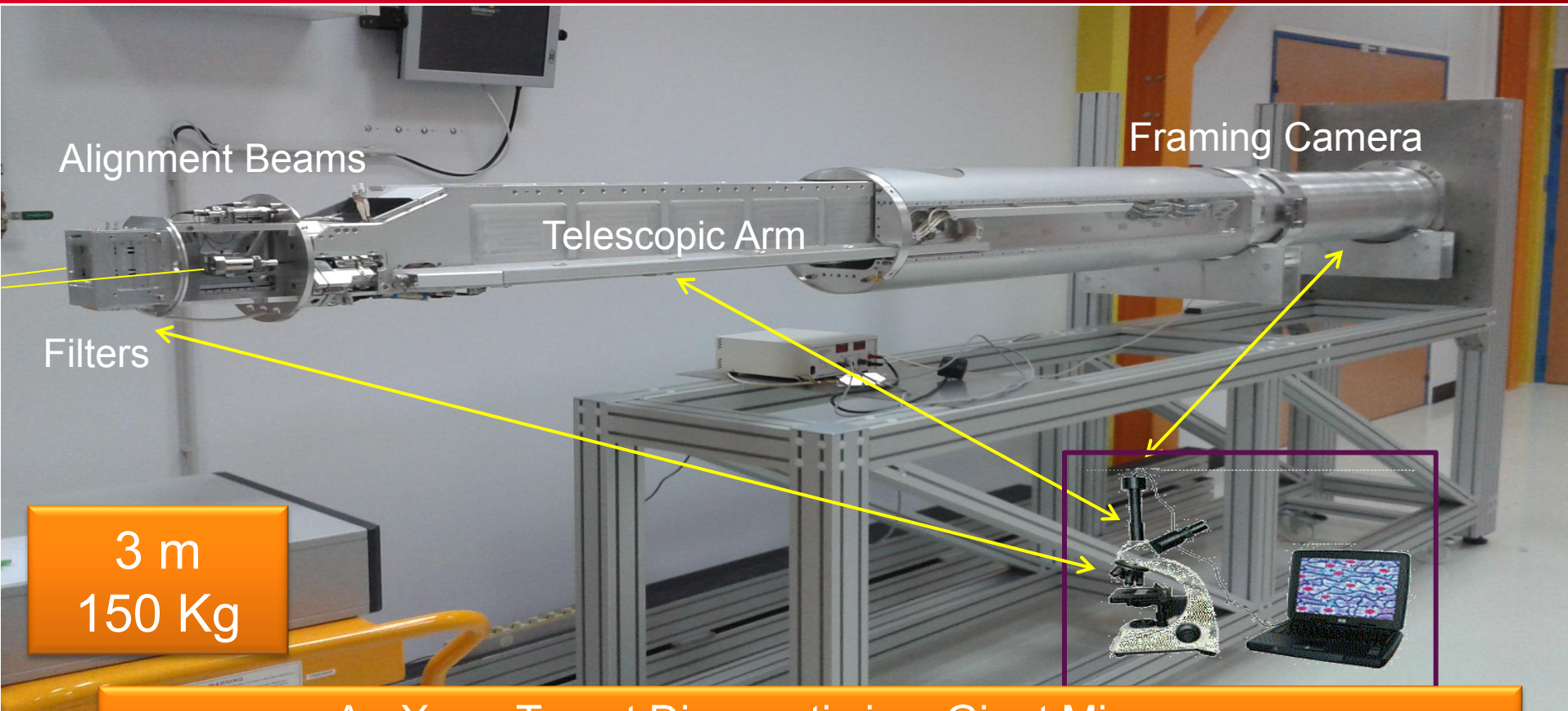
What are Target Diagnostics ?

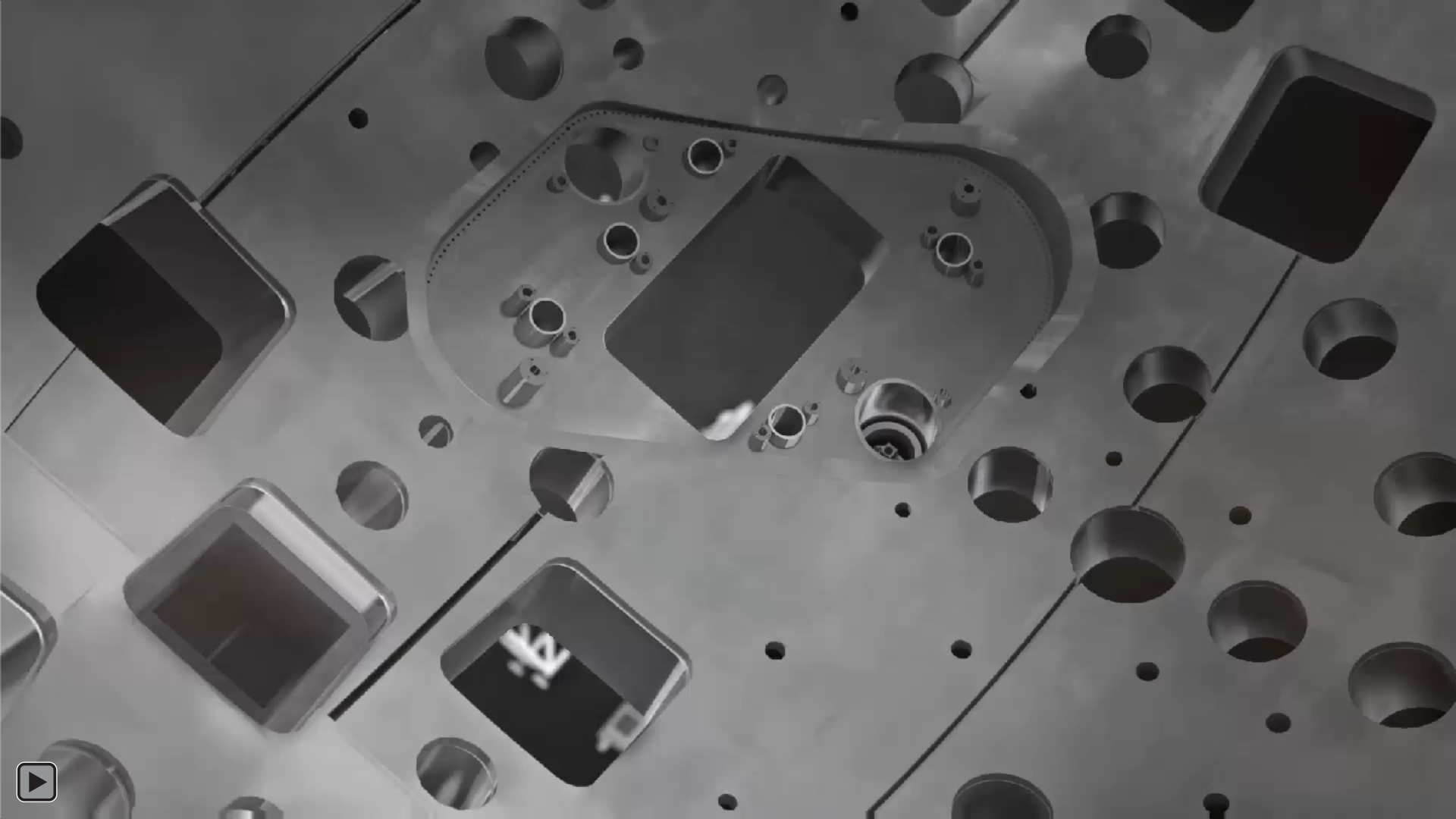
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Various and Different Equipments

From a Microscope to a LMJ Diagnostic







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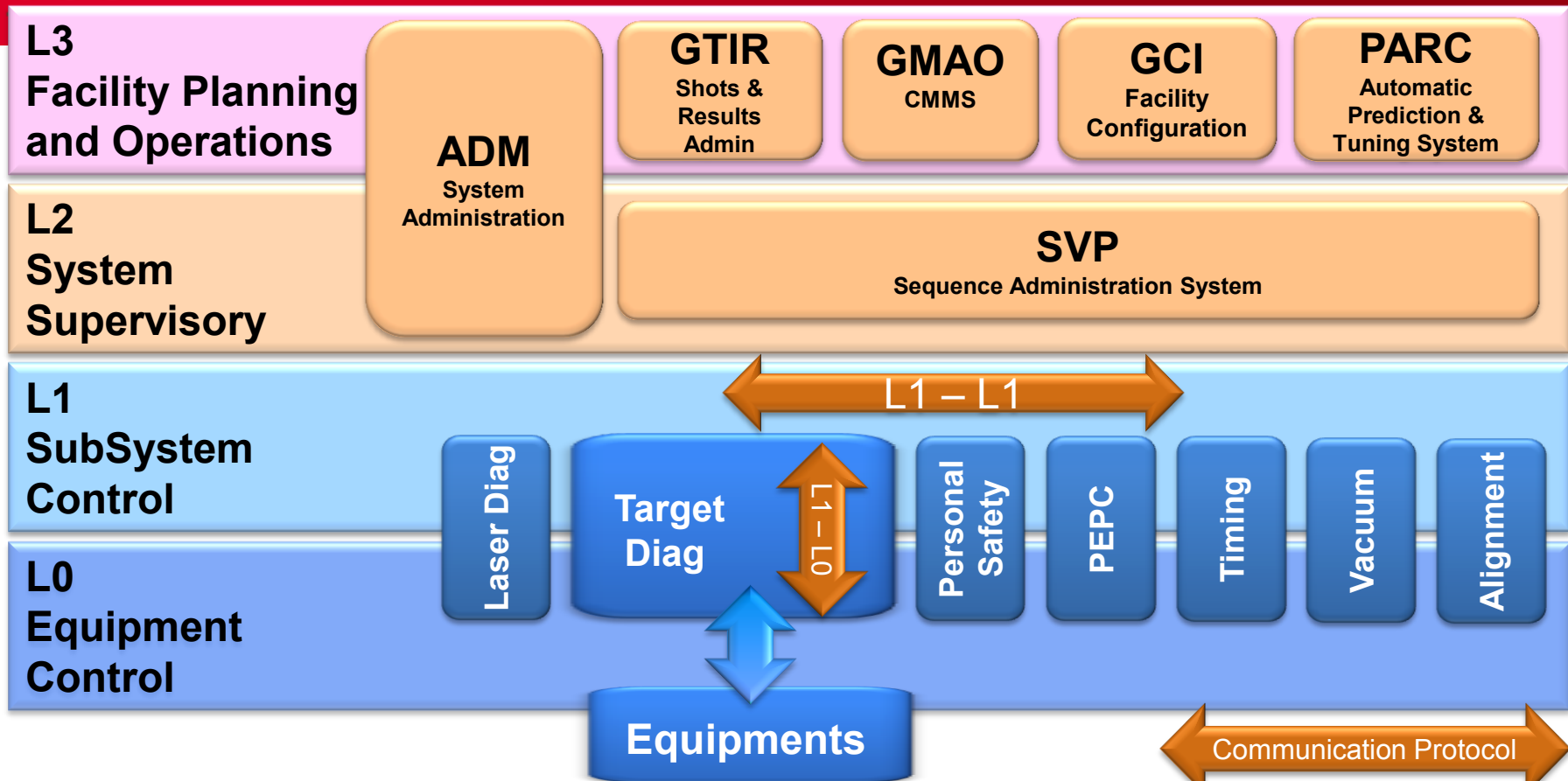
Real and Virtual Modes

Layer 1 for Target Diagnostics Control Command

Managing Contractors

Conclusion

Purdue Model of the LMJ CC



LMJ Control Command Development Constraints

For **LMJ** :

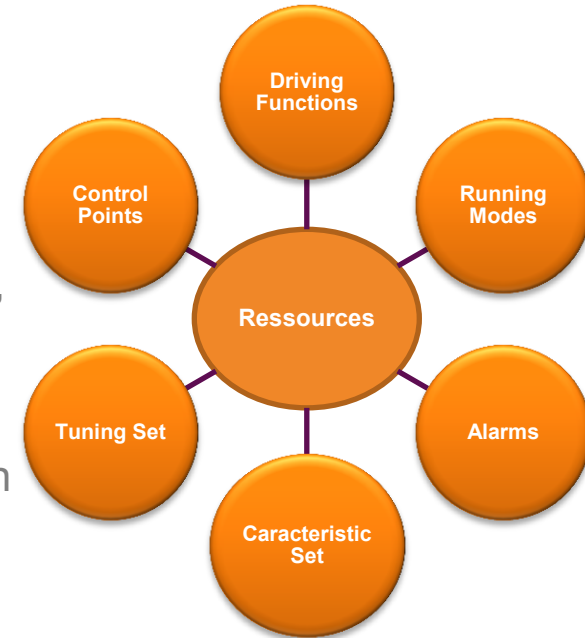
- Windows 7 64 bits,
- Panorama E² for the CCN1 SCADA,
- Equipments as LMJ Ressources.

For **Target Diagnostics**, be able to :

- Handle hundreds of various Equipments,
- Add (and develop) new Target Diagnostics during several years,
- Insure software Maintainability during dozen of years.

Leads to :

- A stable and open source language, easy to understand (Python for Scientists),
- An open source framework for drivers (Tango),
- Specific GUI for maintenance, developed in QT,
- As possible, the use of Ethernet TCP interface for Equipments.



Life expectancy : Open Source, Ethernet / Heterogeneity : TANGO

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The Old Stuff

Drive E: = Driver MSCD000 unit 0

C:\>mem

Memory Type	Total	=	Used	+	Free
Conventional	640K		16K		624K
Upper	123K		86K		37K
Reserved	0K		0K		0K
Extended (XMS)*	129,861		84,853K		45,008K
Total memory	130,624		84,955K		45,669K
Total under 1 MB	763K		102K		661K
Total Expanded (EMS)					33,152 (33,947)
Free Expanded (EMS)*					32,768 (33,554)



Game / 3D Software

DirectX

OpenGL

Device Driver

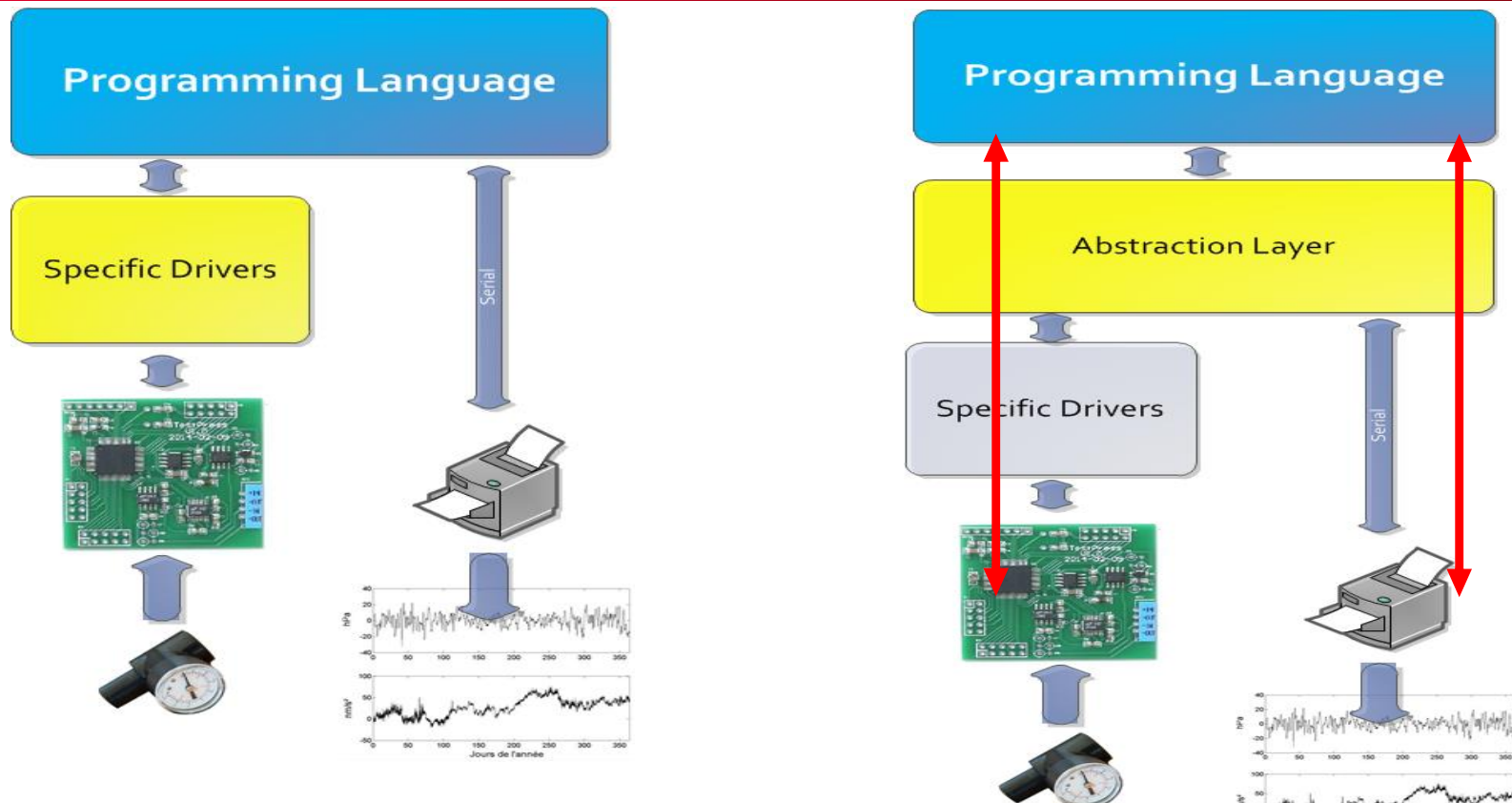
Hardware Abstraction
Layer (HAL)

Graphics Card / Chipset



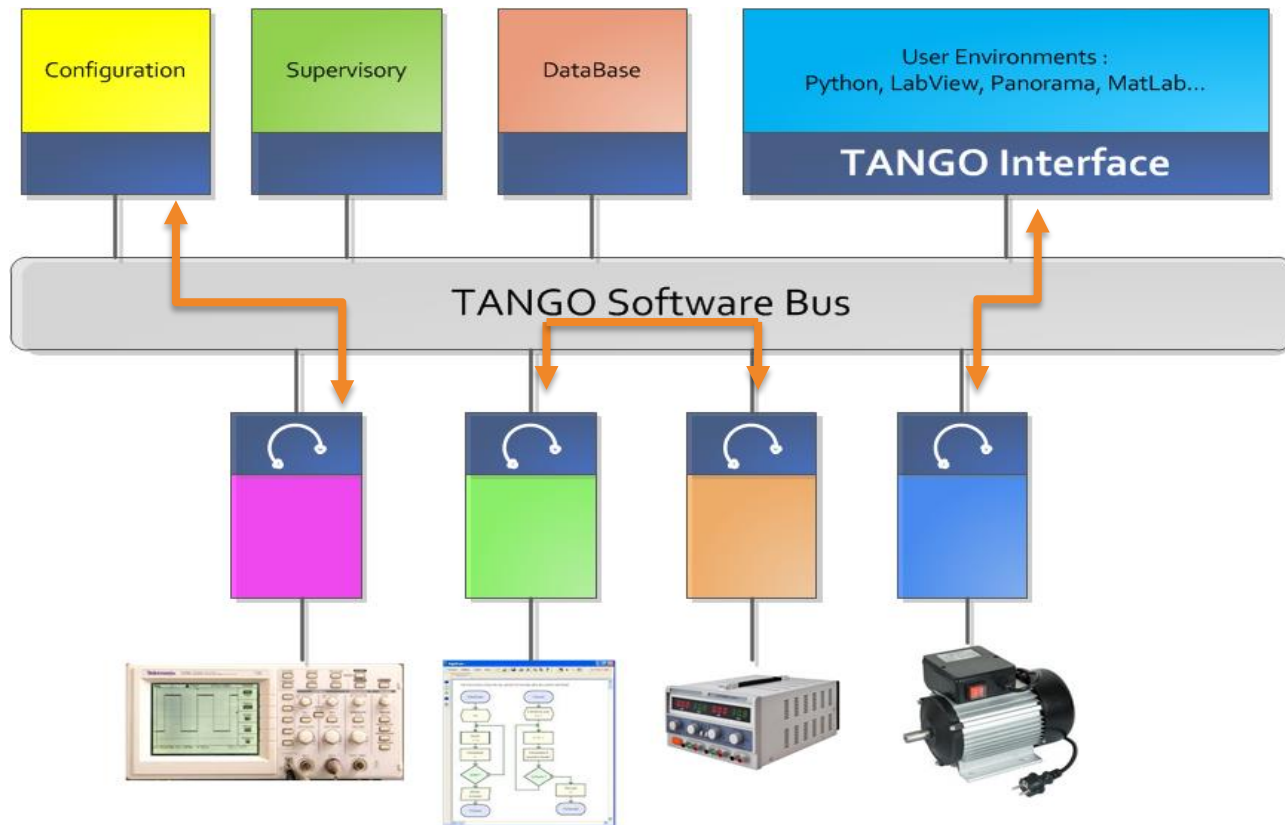
Wasted time, but... meaningful Experience !

Abstraction Layer for Life Expectancy



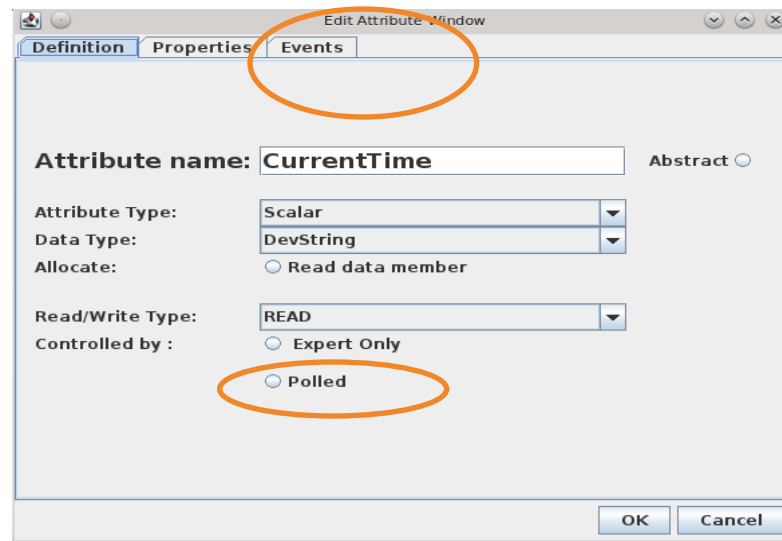
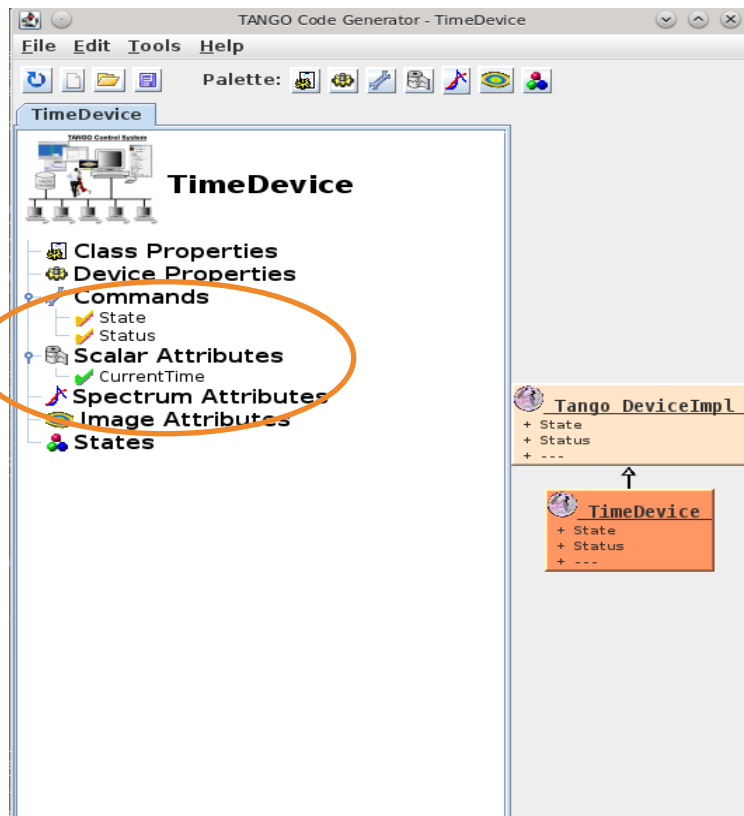
Abstraction Layer : THE solution for Life Expectancy and Heterogeneity ?

The TANGO Framework



TANGO : a nice Abstraction Layer Architecture

POGO (1)



POGO : a code generator for Drivers

POGO (2)

Class Definition Window

Class Name : TimeDevice

Language : ☒ Cpp ☐ Java ☐ Python

Project Title : TimeProvider

Class Description:

Device Class Identification [Help](#)

Contact email * : ael.koep@softwareschneiderei.de

Class family * : System

Platform * : All Platforms

Bus * : Not Applicable

Manufacturer : Softwareschneiderei GmbH

Product Reference :

Tango DeviceImpl

- + State
- + Status
- + ---

↑

TimeDevice

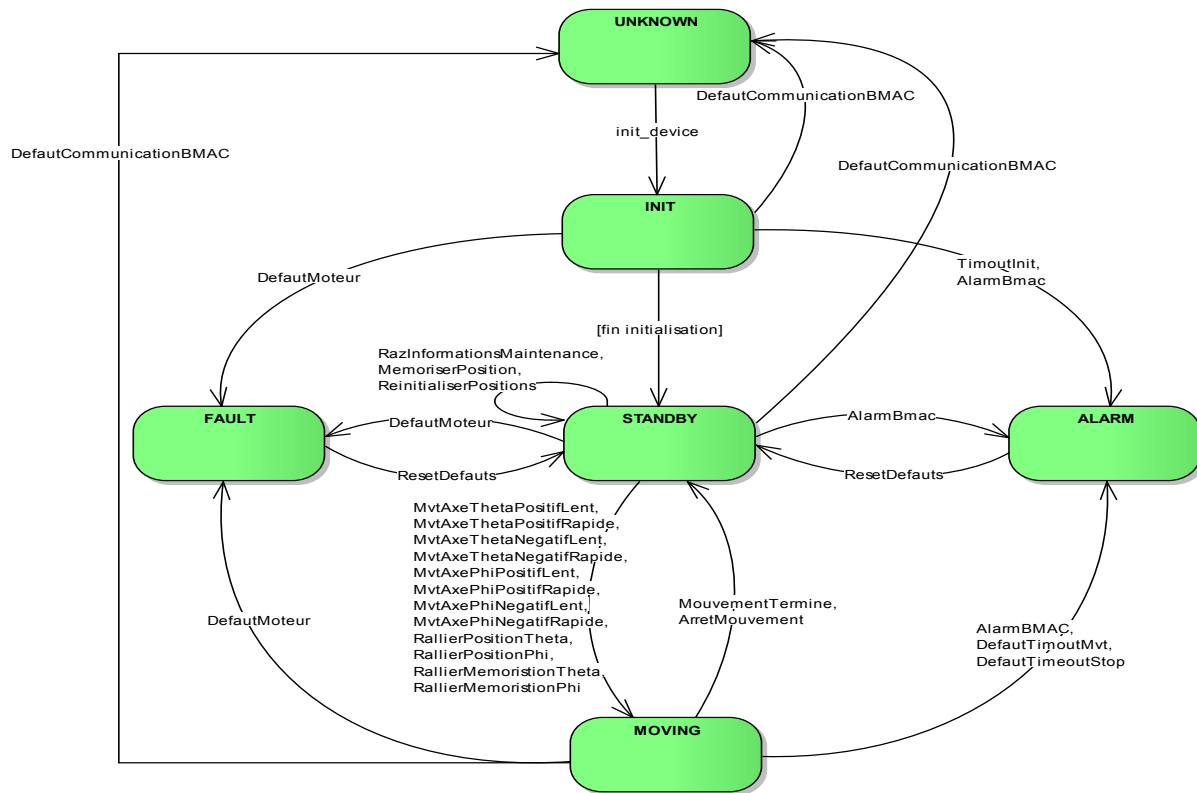
- + State
- + Status
- + ---

OK Cancel

You can choose between 3 languages

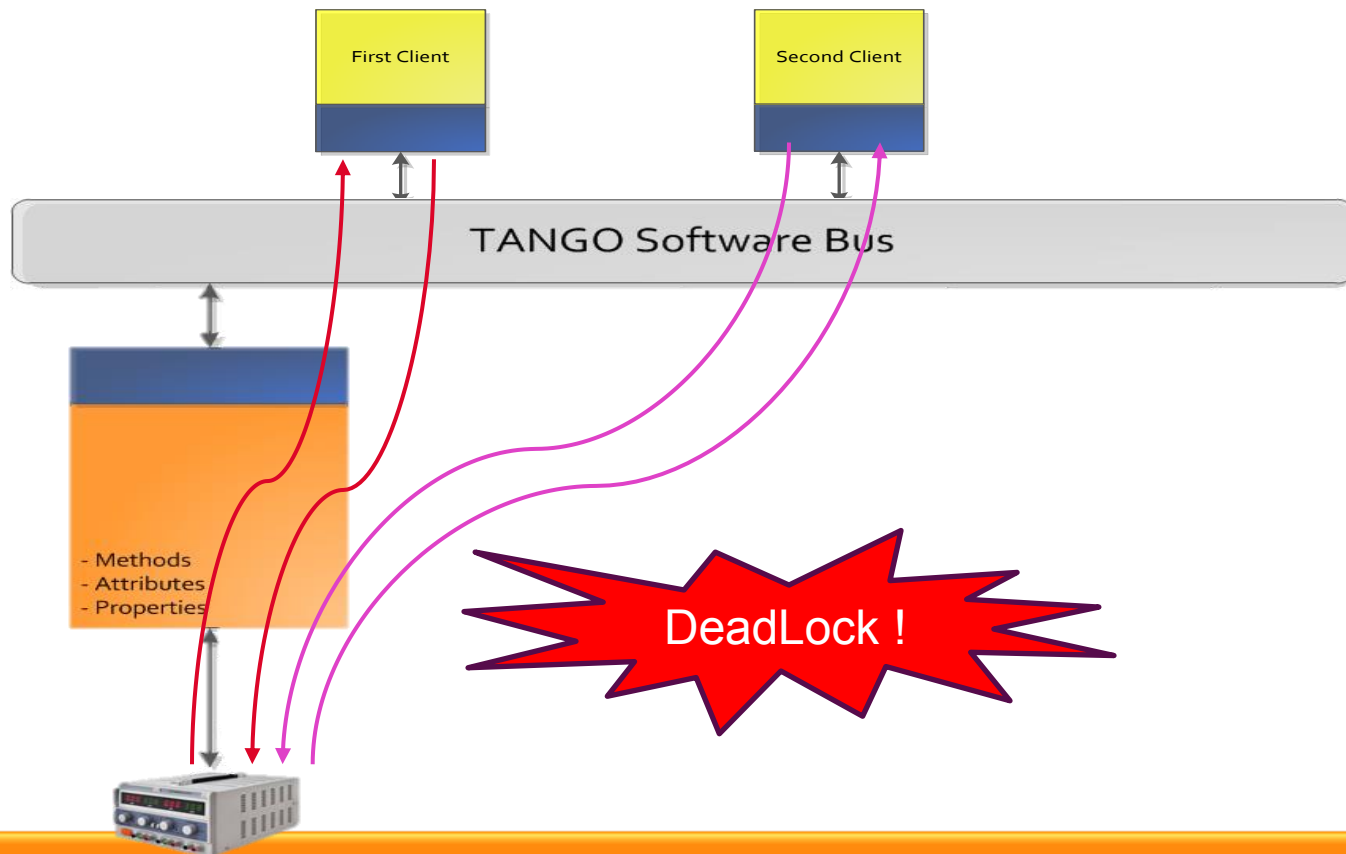
The 14 TANGO States

- UNKNOWN
- INIT
- STANDBY
- ON
- OFF
- OPEN
- CLOSE
- RUNNING
- ALARM
- FAULT
- INSERT
- EXTRACT
- MOVING
- DISABLE



State Machine protection for all Devices Commands

TANGO Polling



Deadlock can occurs with multiple clients and some hardwares

TANGO Polling

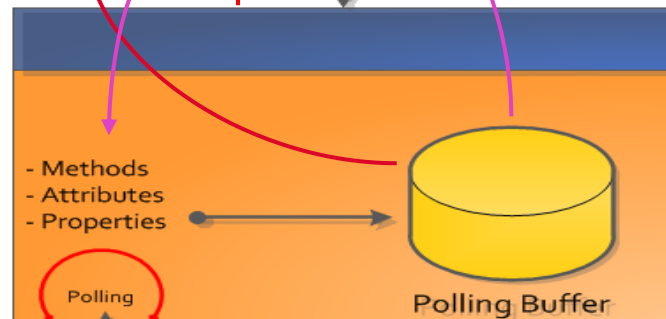
Client 1 :

Notifications on Change,
Ranging... value of
attributes



Client 2 :

Using Methods/Attributes



Values are read inside the buffer



TANGO Polling

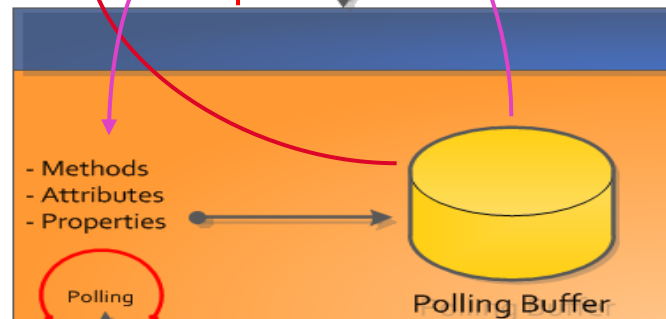
Client 1 :

Notifications on Change,
Ranging... value of
attributes



Client 2 :

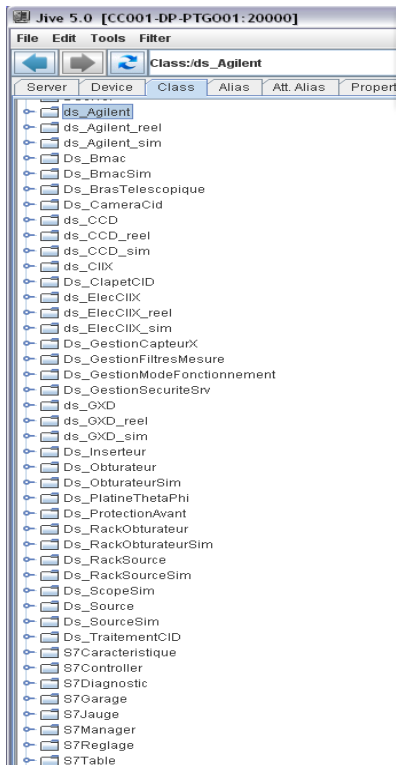
Using Methods/Attributes



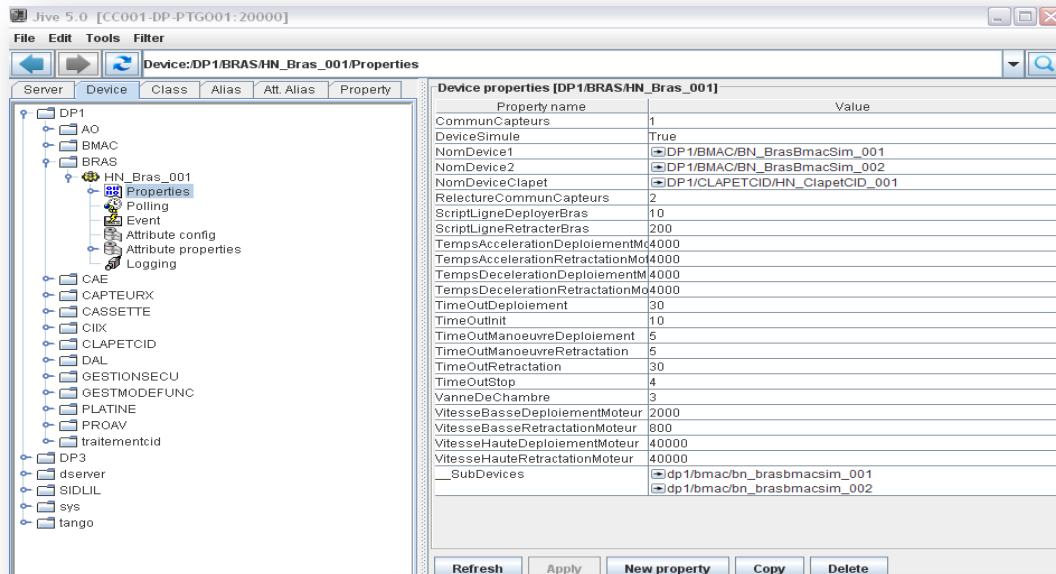
Values are read inside the buffer

Polling can also be used for Computer Power Configuration or Full Driver testing

Jive : a low level TANGO Tool



All the drivers in a Class Window



Equipments in a Device Window

Jive is a usefull tool for the very low level debugging

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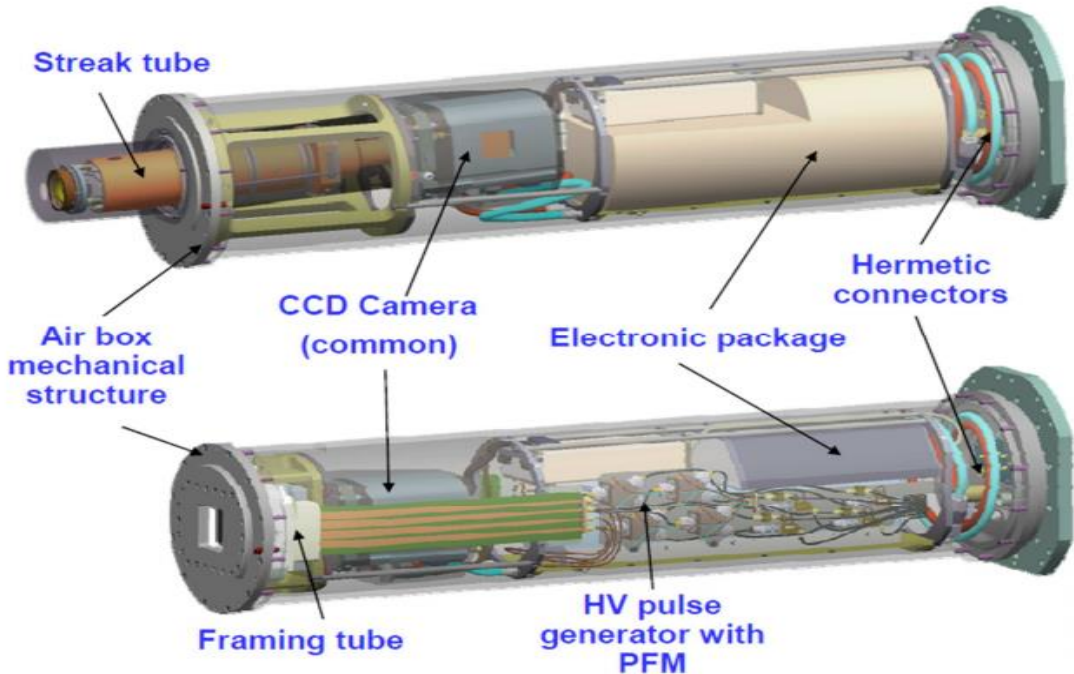
Optical Analyzers

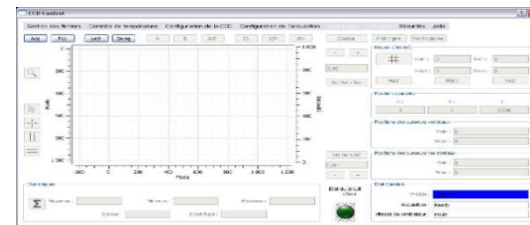
■ 1D Streak Camera :

- Electronic Board 1
- Agilent PS
- CCD Camera

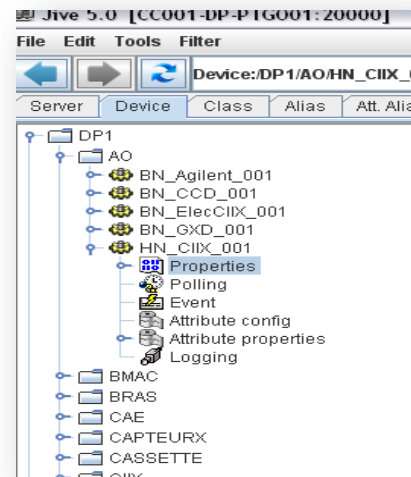
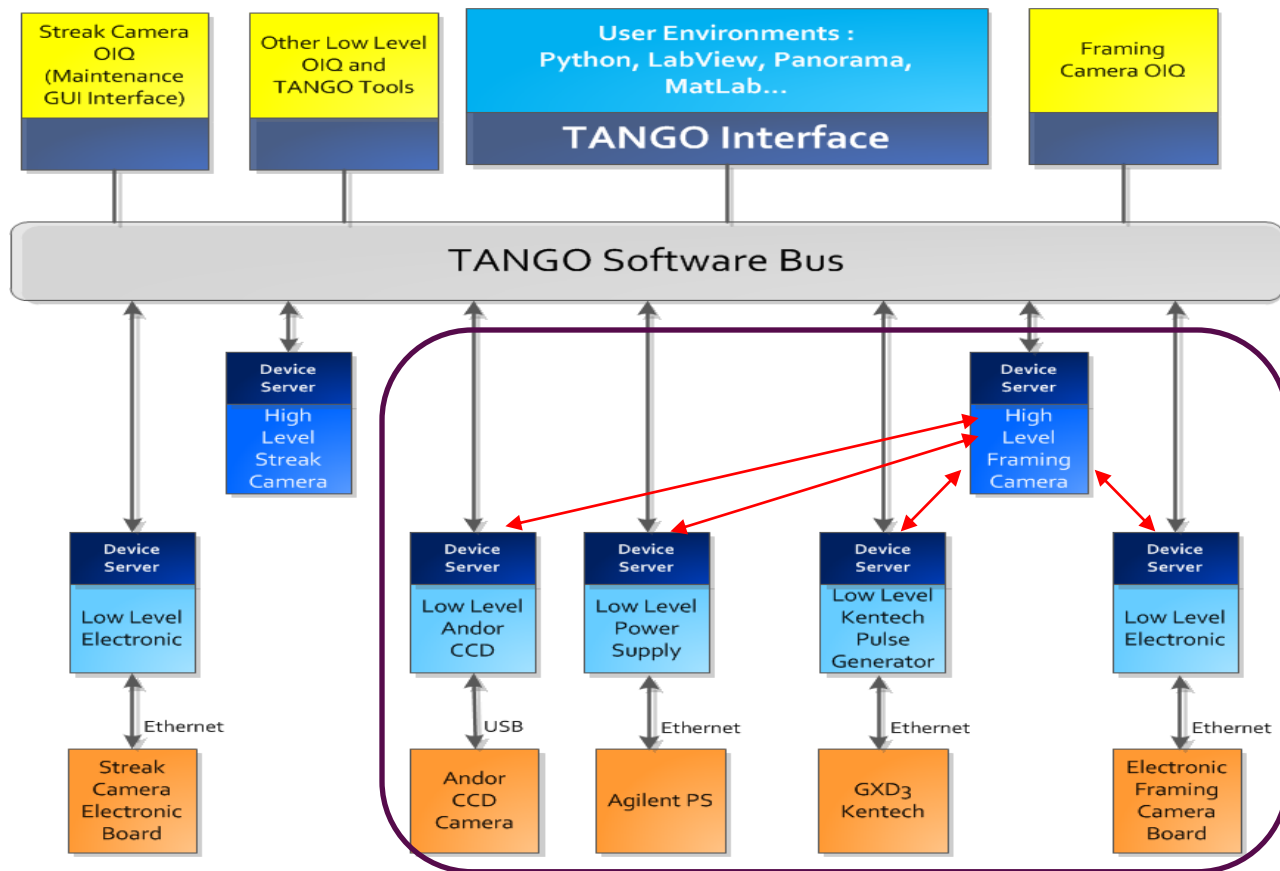
■ 2D Framing Camera :

- Electronic Board 2
- Agilent PS
- CCD Camera
- HV Pulse Generator

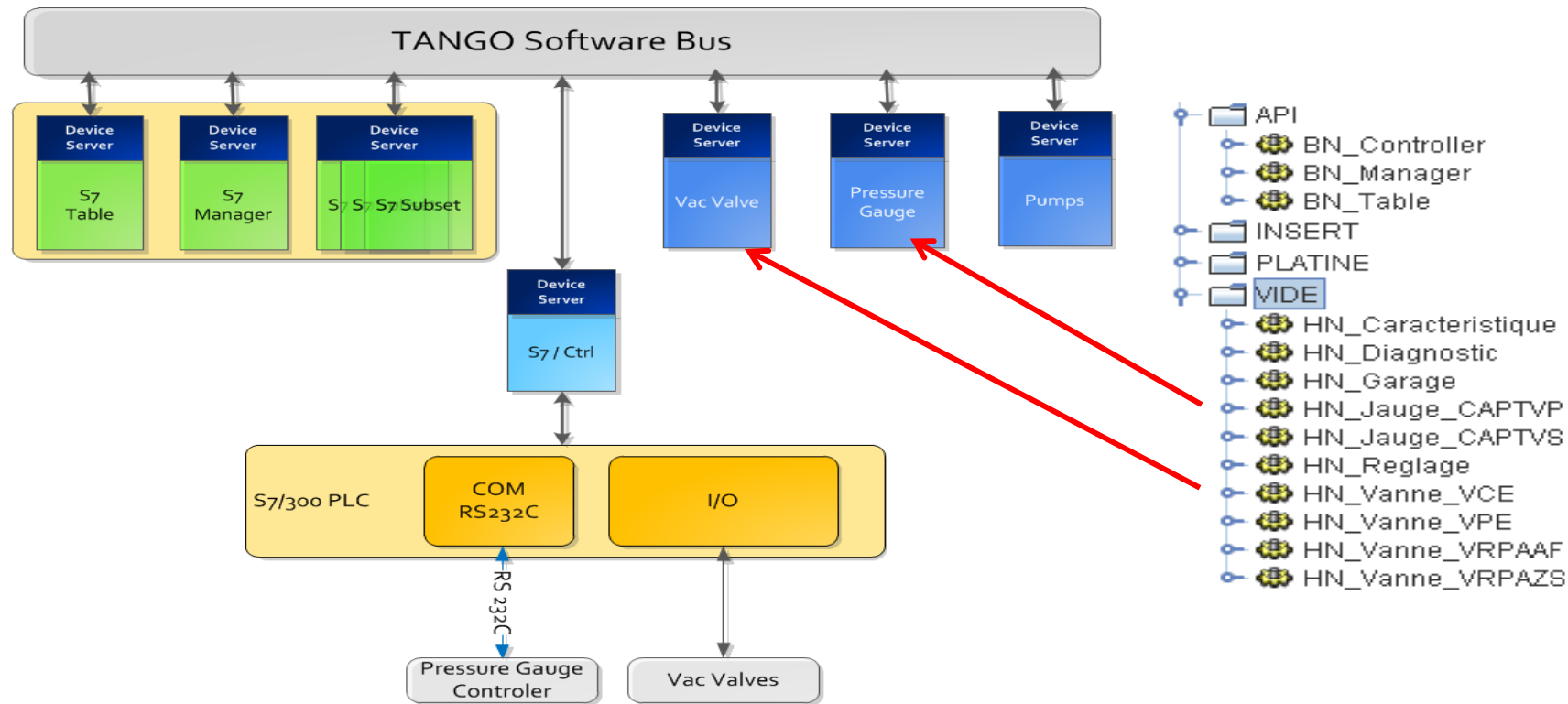




TANGO Device Servers Architecture for Optical Analyzers

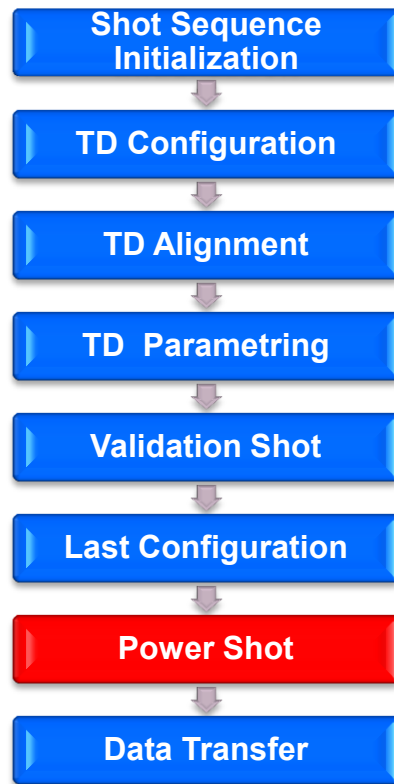
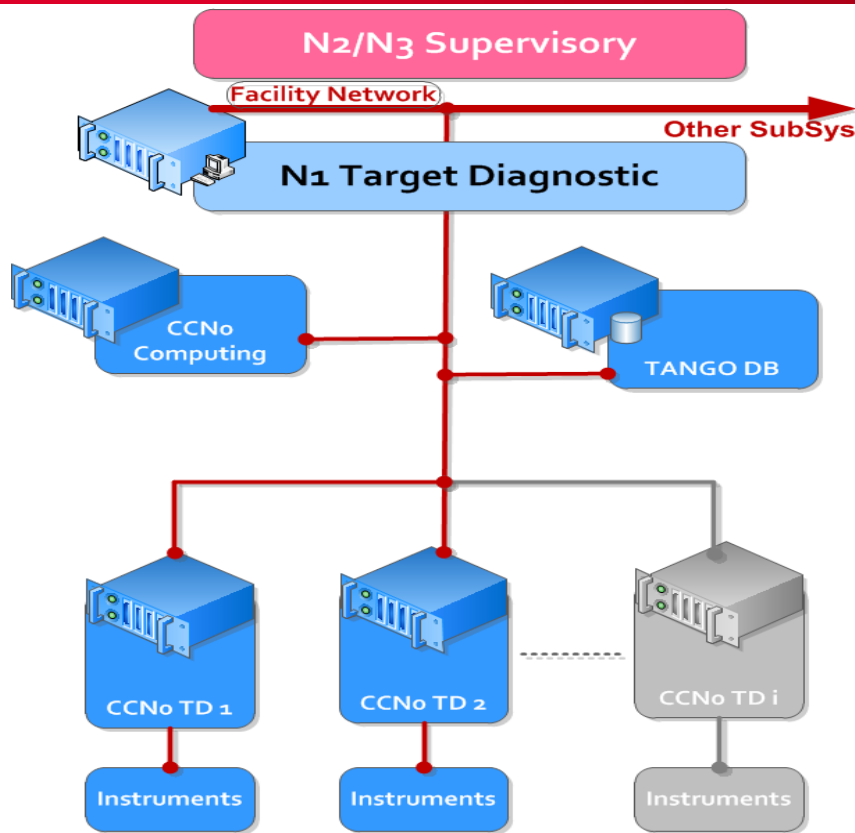


High and Low Level Device Servers for PLCs



PLC DS : Access to all low level Equipments (Gauges, Valves, Pump...)

Architecture and Sequence



Shot Sequence

No Real Time → Configuration, Arming, Waiting, Getting results

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Main GUI for Maintenance

Supervision Imageurs X EQUINOX
IXDCM2t - Maintenance

Bras Télésopique
TIR EFFECTUÉ
Rafraîchissement

Bras Télésopique
Équipement
Etat du device: N° série
Nom Ds: 1/BRAS/HN_Bras_001
Nom Ds Clapet: D/HN_ClapetCID_001
Référence
Caractéristiques Propres: astelescopique/bras_propV01_01.xml
Statut: Bras en attente - Reinitialise Position Retracte
Commandes
Sélection du moteur: Moteur 1 (selected), Moteur 2
Déployer le bras, Rétracter le bras
Reset Defaults, Pilotage Expert Moteur
Arrêt Mouvement

Points de contrôle
Position Bras: [Progress Bar]

Alarmes
Détails Défauts Capteurs
Défaut Timeout Déploiement, Défaut Capteurs, Déployé n°1, Déployé n°2, Avancement, Rétracté n°1, Rétracté n°2
Synthèse des défauts du bras, Défaut Communication, Défaut Moteur 1, Défaut Moteur 2



Moteurs
Mode Simulé
Moteur 1 (simulé)
Nom Ds: DP1/BRAC/BN_BrasBmacSim_001
Adresse IP: 192.168.0.30, Port: 10003
Caract. Propres: e/bmac1/bmacV01_01.xml
Etat du device: The device is in STANDBY state.
Moteur 2 (simulé)
Nom Ds: DP1/BRAC/BN_BrasBmacSim_002
Adresse IP: 192.168.0.30, Port: 10004
Caract. Propres: e/bmac2/bmacV01_01.xml
Etat du device: The device is in STANDBY state.

Devices Log Viewer
Level: INFO
From: DP1/BRAC/BN_BaniletBmacSim_001 successfully registered
Message: Logging Widget
From: DP1/BRAC/BN_BaniletBmacSim_002 successfully registered
Message: Logging Widget
From: DP1/CLAPETCID/HN_ClapetCID_001 successfully registered
Message: Logging Widget

Alarm Viewer
Date: 2014-06-16 17:13:30.60/2000
Source: TongoAttribute(DP1/CAPTEURX/HN_CapteurX_001/DefaultCommunicationSim)
Type: ATTR_ALARM
Valeur: 1

OIQ GUI gives access to « Mid Level » TD commands

Filters Selection Interface

Supervision Imageurs X EQUINOX

IXDCM2t - Maintenance

TIR EFFECTUÉ

Protection Avant
 Rafraîchissement

Arrêt Logiciel

Gestion Séquence

Pilotage Manuel

Gestion Configuration

Mode de Fonctionnement

Protection Avant

Bloc Optique

Dispositif Align.

Alignement Interne

Bras Télésopique

Filtres Mesure

Analyseur Optique

CID

Analyseur Electrique

Editeur Blocs

Maintenance

Protection Avant

Commandes

Dérouler les films

Arrêt mouvement

Reset Défauts

Pilotage Expert Moteur

Rouleau Avant

N° série

Référence

Nature

Type

Film

N° série

Référence

Nature

Type

0,00 Epaisseur (µm)

0,00 Distance CC (mm)

Points de contrôles

Nombre de trs sur les films

Alarmes

Défaut Timeout

Défaut Moteur

Défaut Communication

Défaut Paramètres

Synthèse des défauts

Equipement

N° série

Référence

Nom Ds

Caract. Propres

Statut

Moteur en attente

Etat du device

Rouleau Médian

N° série

Référence

Nature

Type

Film

N° série

Référence

Nature

Type

0,00 Epaisseur (µm)

0,00 Distance CC (mm)

Moteur (simulé)

Mode Simulé

Statut

Rouleau Arrière

N° série

Référence

Nature

Type

Film

N° série

Référence

Nature

Type

0,00 Epaisseur (µm)

0,00 Distance CC (mm)

Nom Ds

Adresse IP

Port

Caract. Propres

Etat du device

Références Equipements

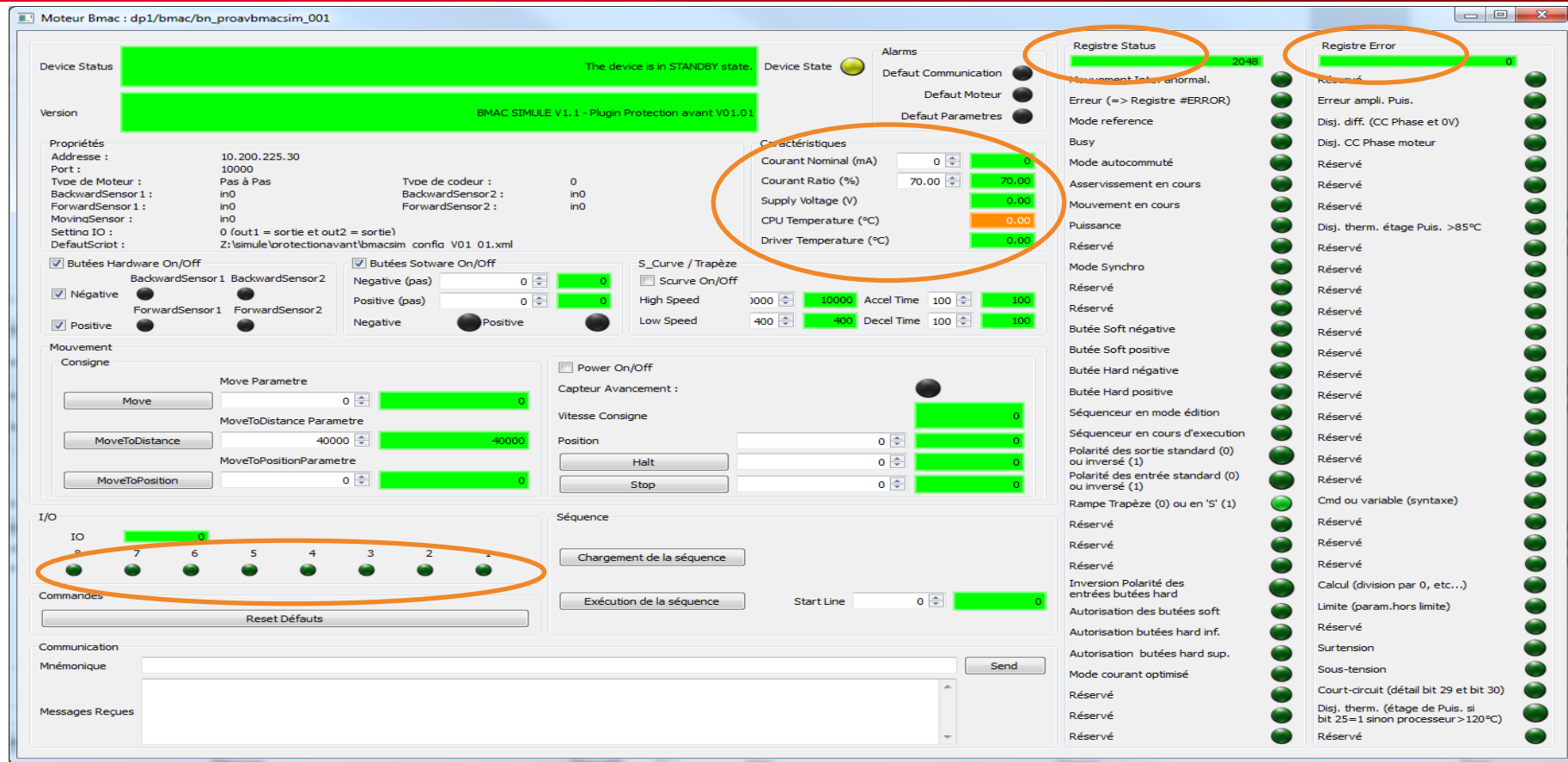
DEVICES Log Viewer

Time	Level	From	Message	ThreadID
2014-06-10 10:11...	INFO	Logging Widget	DP1/CLAPE/CID/HN_Clapet_U01 successfully registered	MainThread
2014-06-16 16:11...	INFO	Logging Widget	DP1/BMAC/BN_ClapetCIDBmacSim_001 successfully registered	MainThread
2014-06-16 16:11...	INFO	Logging Widget	DP1/traitementcid/BN_CameraCID_001 successfully registered	MainThread
2014-06-16 16:3...	ERROR	dp1/capteur/hn_capteur_001	MAX ALARM for attribute DefautCommunicationAlim	@1e08 [8]

Alarm Viewer

Date	Source	Type	Valeur
------	--------	------	--------

Motor Expert Mode gives access to a specific Motor Controller Interface



The Back Alignment Interface

Supervision Imageurs X EQUINOX
IXDCM2t - Maintenance

Alignement CID

Commandes

Lancer Acquisition

Stopper Acquisition

Prendre Image Noir

Enregistrer Image Alignement

Enregistrer Image Mesure

Reset

☒ SoustraireImageNoir

Traitement CID

Nom Ds : mentoid/HN_TraitementCID_001

Nom Ds CID : atementoid/BN_CameraCID_001

ROI Alignement

Indice colonne : 0 Indice ligne : 0

Nb colonnes : 270 Nb lignes : 600

Traitement : **En attente**

Camera : **The device is in UNKNOWN state.**

Alignement Interne

Clapet CID

Nom Ds : LAPETCID/HN_ClapetCID_001

Ouvert ☒ Fermé ☐

Crayon CID

Nom Ds : 1/DAL/HN_SourceSim_004

Allumé ☒ Éteint ☐

Valeur Flux : 1

Allumer Crayon

Eteindre Crayon

Barycentre X Y

Platine θ φ

Commandes

Axe θ

Axe φ

Arrêt Mouvement

Reset Défauts

Réinitialiser les positions de référence

Equipement

N° série : a

Référence : b

Nom Ds : DP1/PLATINE/HN_ThetaPhi_001

Caract. Propres : e/platine_prop.xml

Etat du device : **Platine en attente**

Statut : **Platine en attente**

Points de contrôles

Coordonnée θ : 1000

Coordonnée φ : 1000

Fin de course

min θ max θ

min φ max φ

Moteurs

☒ Mode Simulé

Moteur φ (simulé)

Nom Ds : DP1/BMAC/BN_ThetabMacSim_001

Adresse IP : 192.168.0.30 Port : 10001

Caract. Propres : rule/platine/bmacphi/bmac.xml

Etat du device : **The device is in STANDBY state.**

Statut : **The device is in STANDBY state.**

Moteur θ (simulé)

Nom Ds : DP1/BMAC/BN_PhiBmacSim_001

Adresse IP : 192.168.0.30 Port : 10002

Caract. Propres : e/platine/bmactheta/bmac.xml

Etat du device : **The device is in STANDBY state.**

Statut : **The device is in STANDBY state.**

Alarms (Défauts)

Moteur θ

Moteur φ

Timeout

Capteur min θ

Capteur min φ

Paramètres

Capteur max θ

Capteur max φ

Communication

Synthèse

Devices Log Viewer

Time	Level	From	Message	ThreadID
2014-06-16 17:11:00	INFO	Logging widget	DP1/BMAC/BN_bariletmacsim_001 successfully registered	mainThread
2014-06-16 17:11:00	INFO	Logging widget	DP1/BMAC/BN_bariletmacsim_001 successfully registered	MainThread
2014-06-16 17:11:00	INFO	Logging widget	DP1/BMAC/BN_bariletmacsim_002 successfully registered	MainThread
2014-06-16 17:11:00	INFO	Logging widget	DP1/CLAPETCID/HN_ClapetCID_001 successfully registered	MainThread

Alarm Viewer

Date	Source	Type	Valeur
2014-06-16 17:13:30.802000	TangoAttribute(DPI/CAPTEURX/HN_CapteurX_001/DefaultCommunicationAlarm)	ATTR_ALARM	1

...and many others Maintenance Interfaces...

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Conclusion

The Integration Platform (PFI)

3 steps for the integration of the control system

- **Step 1 : Contractor acceptance tests**

- Acceptance tests for equipment
- Acceptance tests for control system
 - With real equipment (Representativeness)
 - With simulators (CS Robustness)

**In
Factory**

- **Step 2 : Integration Platform tests (PFI)**

- Global tests for N3-N2 supervisory
- Global tests for all subsystems control systems :
between each other and with N3-N2 supervisory

*For each
subsystem*

**On
Integration
Platform**

- **Step 3 : Functional integration (Integration Room)**

- Contractor tests for each subsystem
- Global tests with the N2-N3 supervisory

*For each
bundle*

In LMJ

Real and Virtual Driver Modes

Real Mode

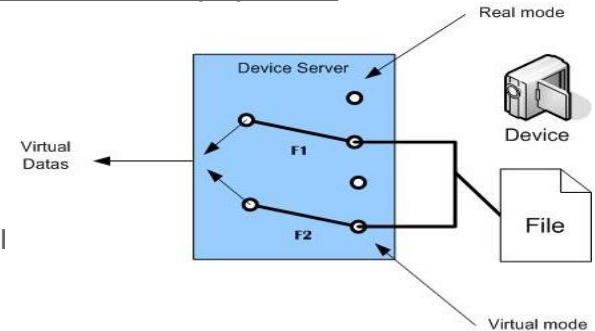
- **Directly** drive the equipment
- Gets datas from the **Physical** equipment,
- The **Main** using mode inside the Facility.

Virtual Mode

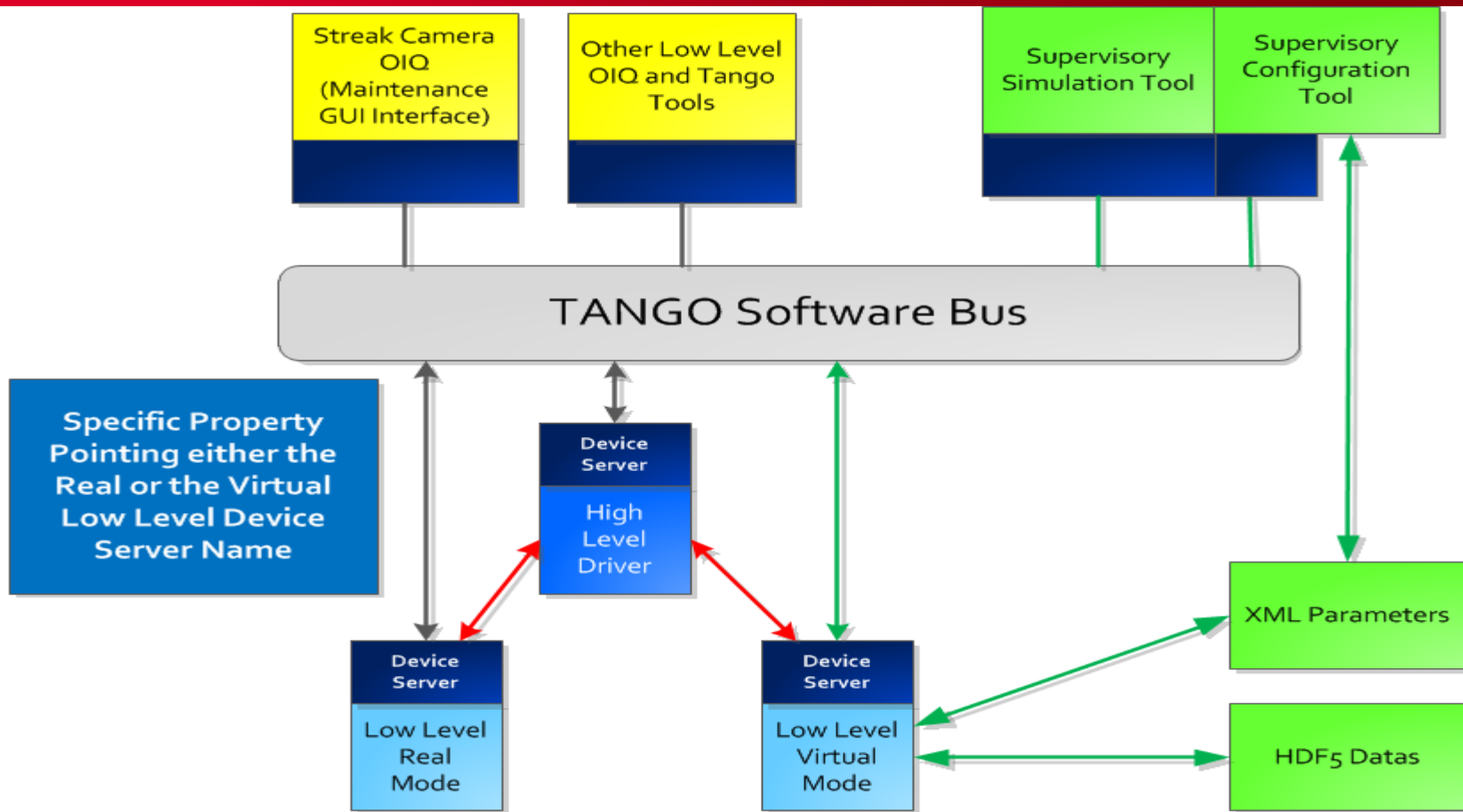
- Gets Equipment Datas thru an **External File**
- Can be used to **test** the high level Device Server without the need of the real equipment
- Can be used to make a full « **Virtual** » **Target Diagnostic**

Implémentation :

- By using a **boolean** inside a kind of metadrivers
- First idea, mode selection for each function, now, mode selection for the full equipment
- Simulated datas in HDF5 format, configuration file in XML format,



Real and Virtual Mode Management



High and Low Level for the Telescopic Arm

Device:DP1/BRAS/HN_Bras_001/Properties

Property name	Value
CommunCapteurs	1
DeviceSimule	True
NomDevice1	DP1/BMAC/BN_BrasBmacSim_001
NomDevice2	DP1/BMAC/BN_BrasBmacSim_002
NomDeviceClapet	DP1/CLAPETCID/HN_ClapetCID_001
RefectureCommunCapteurs	2
ScriptLigneDeployerBras	10
ScriptLigneRetract	
TempsAccelerat	
TempsDecelerat	
TempsDecelerat	
TimeOutDeploy	
TimeOutInit	
TimeOutManoeuv	
TimeOutManoeuv	
TimeOutRetract	
TimeOutStop	
VanneDeChamb	
VitesseBasseDe	
VitesseBasseDe	
VitesseHauteDe	
VitesseHauteDe	
__SubDevices	

Device:DP1/BMAC/BN_BrasBmacSim_001/Properties

Property name	Value
AddressIP	192.168.0.20
AxisEncoderType	0
BackwardSensor1	7
BackwardSensor2	5
CurrentMax	50
DcConstant	5450
DcResistance	2200
DefaultScript	Z:\simulate\brastelescopique\bras_bmac1_v01_01.xml
ForwardSensor1	8
ForwardSensor2	6
MotorType	2
MovingSensor	4
Port	20004
SettingIO	0
TimeOut	10

A Versatile configuration : The High Level DS can be set to a different Driver

The BMAC Virtual Configuration Tool

Défauts BmacSim

Générateur de défauts sur BMAC Simulé

Client TCP

☒ Connecté

Hôte: MI-03066

Port: 20000

Défaut Moteur

Message personnalisé

Défaut Communication

Message personnalisé

Défaut Capteurs

IO8 IO7 IO6 IO5 IO4 IO3 IO2 IO1

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ 1 X XX0XXXX1 0

Défaut Vitesse

Alarme

Message personnalisé

Diagram:

```

graph TD
    XMLConfig[XML Config] -- "Chosen from..." --> XMLFiles[XML Files]
    XMLFiles -- "Load" --> GUI[GUI]
    GUI -- "Save" --> XMLFiles
    GUI -- "TCP Defaults Sent" --> DSCode[DS Code]
    subgraph DSCodeBox [DS Code]
        DSCode
        DSCode -- "Plug-In" --> PlugIn[Plug-In]
    end
    PlugIn -- "Plug-ins List" --> PlugInList[Plug-ins List]
  
```

What is LMJ, What are Target Diagnostics ?

The LMJ Control Command architecture

Layer 0 for Target Diagnostics Control Command

Camera Drivers Modular Architecture and Vacuum System

Maintenance and Qualification Tools

Real and Virtual Modes

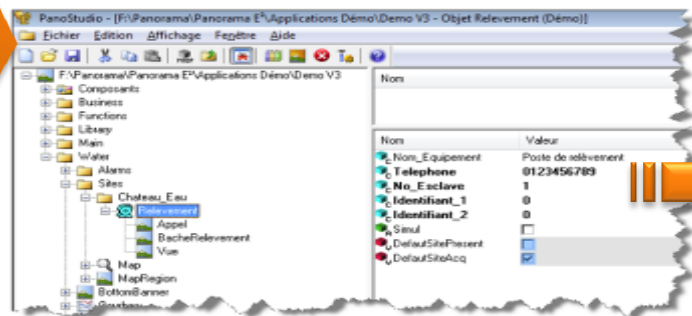
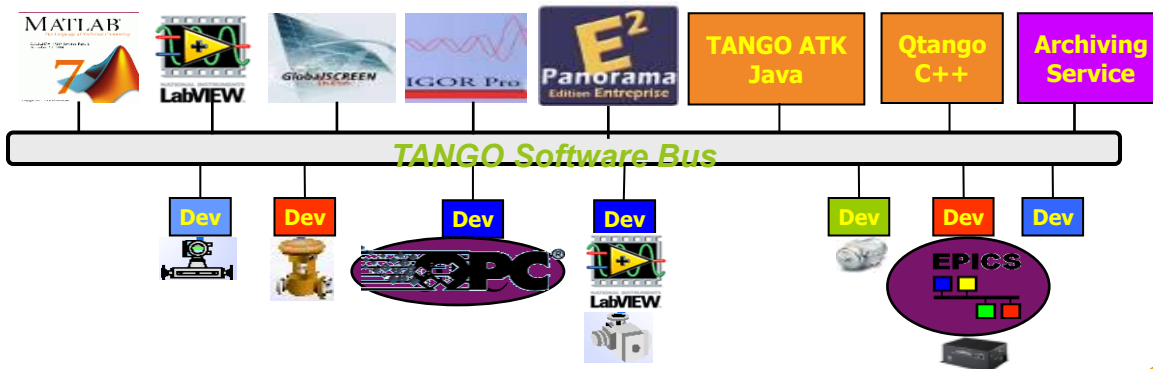
Layer 1 for Target Diagnostics Control Command

Managing Contractors

Conclusion

L0/L1 interface : TANGO/PANORAMA Binding

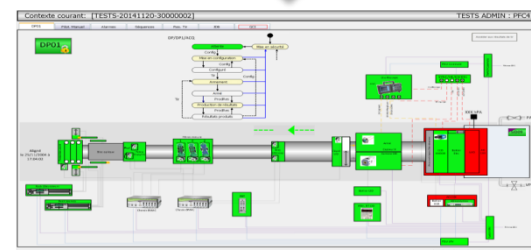
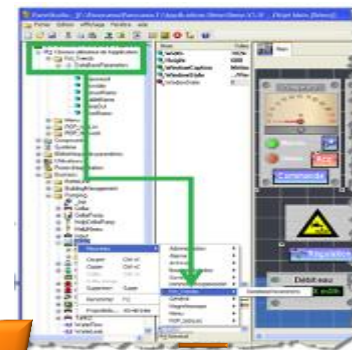
Edition graphique



Bidirectional Integration of Tango components inside
PANORAMA E² IDE



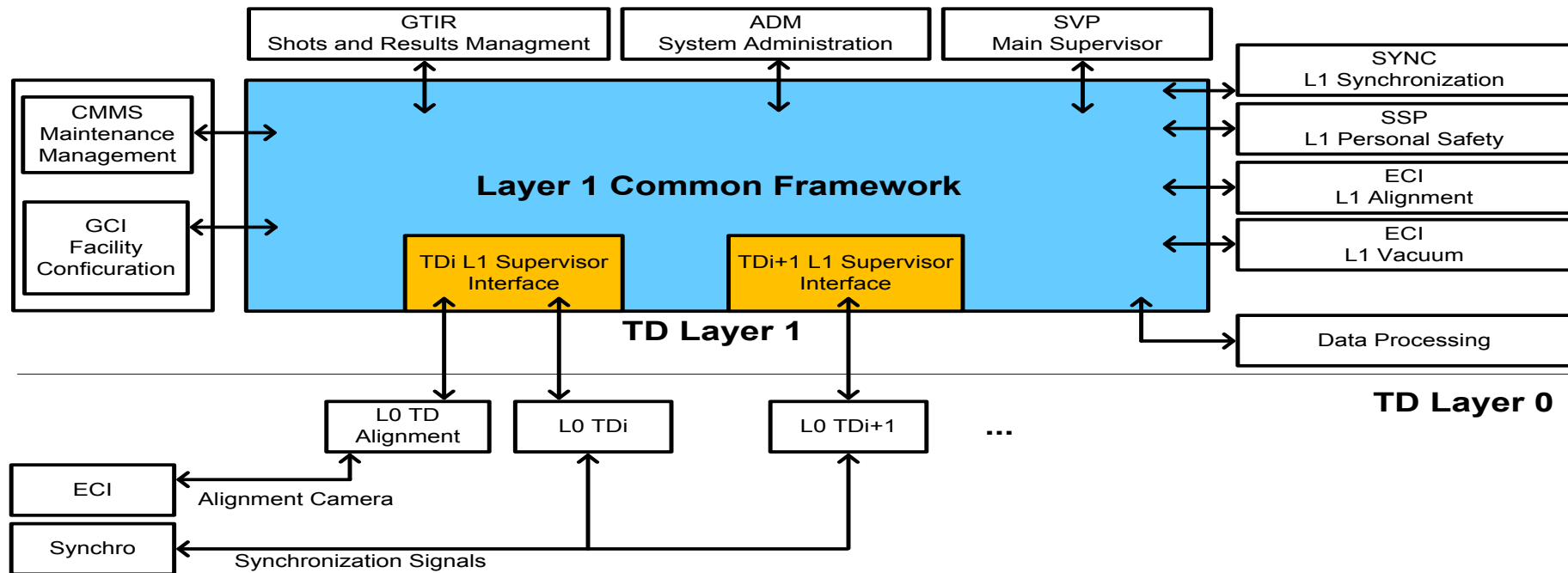
Panorama vbScript



Layer 1 GUI

ISO image available @ www.tango-controls.org

Layer 1 Architecture



A Open System with TD Interfaces as Level 1 Plugins

The screenshot displays the LMJ-DP application interface, which is divided into several functional areas:

- Top Left:** A header area containing the application name "LMJ-DP" and a section for "Application name and User Profile".
- Top Center:** A section titled "Nombre de FDS en cours : 0" with a checkbox "Griser les ressources sélectionnées" and a table with columns: "Nom FdS", "TS", "Etape", "Av/H.dém", and "H.prév".
- Top Right:** A section titled "Installation DP" containing a table with columns "DP", "SRV", and "ACQ", and a "Ressources Tree" diagram showing a hierarchy of resources like CCE, DP1, DP2, ACQ, SRV, and Vdm-1.
- Middle Left:** A section titled "Synthèses Alarmes" with a "Maj." button, a "Crit." button, and a "Non acq: 1" indicator. Below it is a "Connexion" section with buttons for "SVP", "ECI/PAL", "SRV/VHE", "SYNC", and "SSP".
- Middle Right:** A section titled "List of TD" containing a table with columns "DP", "SRV", and "ACQ", and a "Légende..." button.
- Bottom:** A section titled "Alarmes" with a "Toutes" button, a "Contextuel" button, and a "DP3" button. It also includes an "Acquitter..." button and a table with columns: "Date app.", "Heure app.", "Etat", "Origine", "Destination", and "Libellé".

Annotations on the left side of the image point to specific elements:

- "Application name and User Profile" points to the top left header.
- "Sequence in Use" points to the "Nombre de FDS en cours : 0" section.
- "Alarms" points to the "Synthèses Alarmes" section.
- "Connections" points to the "Connexion" section.
- "Alarms Details" points to the "Alarmes" table.

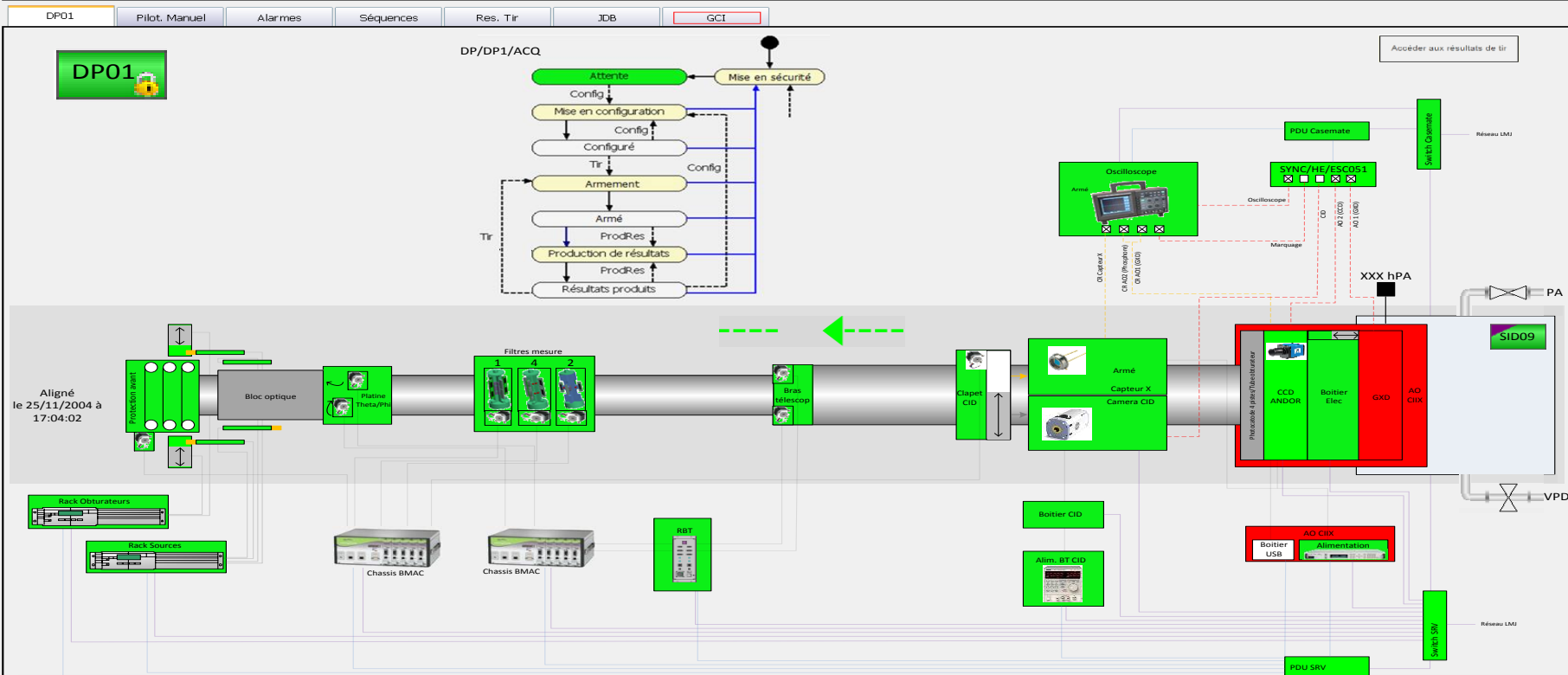
Annotations on the right side of the image point to specific elements:

- "TD Resources" points to the "Ressources Tree" diagram.
- "Ressources Tree" points to the "Ressources Tree" diagram.
- "List of TD" points to the "List of TD" table.
- "Log File Access" points to the "Contextuel" button.
- "On Line Help" points to the "DP3" button.

The X Ray TD Layer 1 Interface

Contexte courant: [TESTS-20141120-30000002]

TESTS ADMIN : PFC4



Access to Sequence, other SubSystems, Equipments and High Level States

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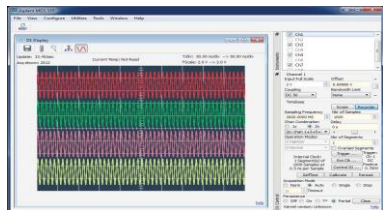
Real and Virtual Mode

Layer 1 for Target Diagnostics Control Command

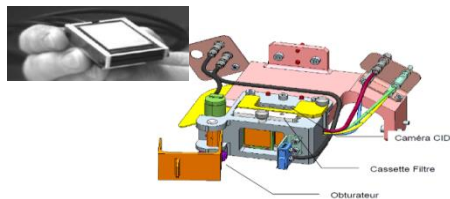
Managing Contractors

Conclusion

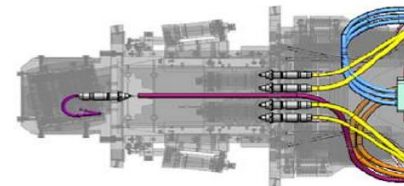
X-ray Imaging Target Diagnostics Contractors for Device Servers



Oscilloscopes drivers
(NEXEYA)

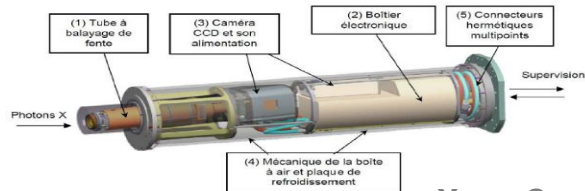
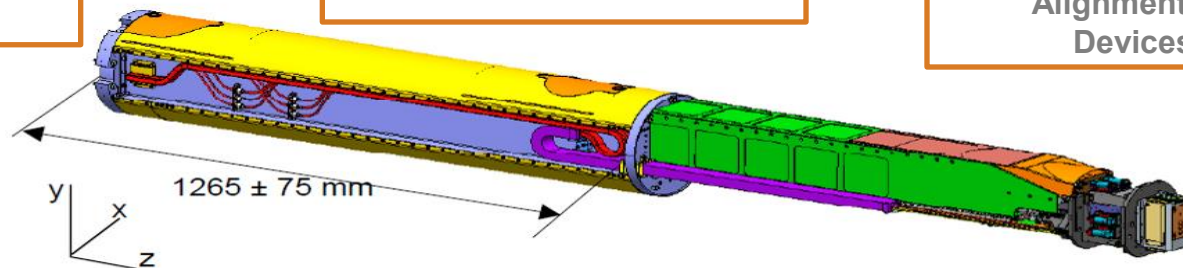


CID Camera (GFTy)

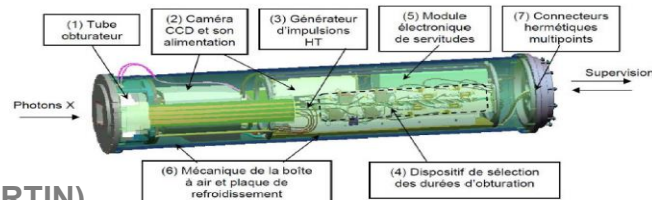


Alignment Pointing
Devices (IDIL)

Integration
(THALES)



X ray Cameras (BERTIN)



Managing Industrial Contractors

- Many Contratrors
 - Command Control,
 - Cameras,
 - Target Diagnostics Mechanics,
 - Integration.

- Majors Challenges
 - Full Outsourcing,
 - First Tango Industrial Development (after the European Synchroton Team),
 - We were using Windows (→ Tango initial development and LIMA for Linux OS),
 - Project Development Timing not easy to handle with so many interfaces.

- Experience Feedback
 - Who's in charge : Mechanics, Electronics, Optronics, Software Contractor ?
 - Who is making the Glue between Subcontractors ?
 - DS Design Guide Rules specification was written during developments...
 - It took some time to be stabilized

- Is Full Outsourcing good ?
 - Better understanding of contractors development by internalising DS prototypes.

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■ Life Expectancy :

- Tango Open Source Architecture,
- Open Source Python language, with DS code quite easy to maintain for scientists,
- Keeping (almost !) the software DS core, even if the OS changes,
- Using the same architecture running on futur computers.

■ Modularity :

- Mixing DS instantiations for several equipment (i.e. CCD, Power Supplies...),
- Dispatching DS, Tango Database in different computers.

■ Heterogeneity :

- Capability of making DS for any kind of equipment,
- Using already developed DS for futur diagnostics

■ Independency

- Using any new contractor for DS developping !

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4 Target Diagnostic @ the moment, more than 25 in preparation....

Thank you for your attention...

