Experience feedback on Tore Supra

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Outline

- The Tore Supra Tokamak
- Home made versus industrialisation: the electronic group
- Control/command and Data acquisition
- Conclusion
A point of view ...

- ... as reviewers of the ITER CODAC document (first document and recent revision)
- as Designers / Developers and users of the Tore Supra CODA systems
- with a 20 years experience of 20 years operating such systems
- as member of the data acquisition and control command team
The Tore Supra Tokamak

- Tore Supra is one of the largest superconducting Tokamak (1st plasma 1988)

- $R = 2.42\,\text{m}$, $a = 0.72\,\text{m}$, $I_p = 1.5\,\text{MA}$, $B_{\text{tor}} = 4.5\,\text{T}$

- 50 diag. and sub-systems synchronized and operated at the same time → RT acquisition and control is essential

- Devoted to long duration, high performance plasma discharge researches
Continuous acquisitions 24h a day (dt ~ 1s) Plant monitoring

Standard acquisitions (dt ~ 1ms) during the entire plasma discharge. Global analysis of the physic of the discharge

Fast acquisitions (dt ~ 1μs or less) triggered by plasma events Essential for studying fast events (plasma deep understanding)
- Total amount of data per year increased
- Average raw data volume increased by a factor 5 (#channels increases, fast acquisition increases)
• Define a set of rules and advises dedicated to the systems
  - QA
    • Standards (power, size, input / output...)
  - Technique
    • Racks, Cubicles, Cabling and wiring
  - Environments
    • Operating environment, hardware monitoring function
  - Documentation

• Advantages
  - Consistency
  - Easily implemented
  - Designed could be re-used
  - Spares
  - Updating
Signals conditioning: the industrialisation phase

**Sensors**
- Thermocouples:
  - PT100
  - U/U, U/I, ...
- Micro channel plate
- Surface-barrier detector
- Bolometer
- Photomultiplier
- Voltage probe....

**Conditioners**
- Classical

**Commercial products**
- Advantages:
  - universal
  - standardization

**Home-made**
- Advantages:
  - Dedicated
  - EMIC, Ruggedization
  - High galvanic isolation
  - Links with DAS, synchronization

The electronic group
The electronic group

- **Special function: The timing and Event Distribution Network**
  - Provides extremely accurate timing information to all the sub-systems
  - Timing values are used for time stamping (events and data samples) and for synchronization
  - Used to start the different sub-systems or actuators in the right order and at the right time (the scheduling of the pulse)
  - Distributes **deterministic** and fast synchronized triggers for data acquisition
• Historical separation of control/command and data acquisition systems
  - Different needs
  - Different operation mode
  - Domain driven by engineers vs domain driven by physicists

• Induced to solve some issues

• Today, this choice would be not justified

• Need for continuous data (physicists as well as for the device operation)

Calorimetric measurements,
Mass spectrometer...

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The control system frame

**Human interfaces:**
- 30 PC Win 2000
- SCADA → Panorama™
- Developments under the control of the operation groups.
- Standards pattern.

**Communication:**
- Fip
- Ethernet

**Control:**
- 50 Schneider electric PLC
- IEC 1131 standard
- Developments under the control of the operation groups.
- Standard pattern.
• A higher data flow rate
  – Large amount of data from new generation of diagnostics can cause some network overloading

• A Data access and "post" processing during the pulse
  – Plasma parameters must be follow throughout the discharge.
    • Recorded data are available for analysis through the pulse.
    • Continuous effort is carried out to develop real time algorithms to process data inside the front-end units.
Needs for long-duration plasma discharges (2)

- **A continuous data acquisition system**
  - Some "Pre" and "post" pulse data are of high interest
  - Continuous data recording of specific data

- **Depending on the time duration of the plasma, the control loops must be more and more sophisticated**
  - Independent feedback controllers
  - Fast real time network to share information.
  - Powerful real time algorithms and CPU power increase
- Tore Supra routinely addresses the technological and physical issues
- related to multi-megawatt steady-state plasma discharges

- Most of the developments are relevant for the new generation of fusion devices
Thank you for your attention !
Association Euratom-CEA

POLOIDAL COILS
Plasma Current Position & Shape

UV Spectroscopy
Radiated Power
IR Interferometry

PELLETS & PIEZO VALVES
Density Radiation

LINE DENSITY GAS FLOWS

MAG

REAL TIME ANALYSIS

INJECTED & REFLECTED POWER

KLYSTRONS
Power Phases

IR Camera
Polarimetry
Hard X-Rays

GAS

ICRH

INJECTED POWER COUPLING

TETRODES
Power Capacitors

Shared Memory

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Parameters and data handling

- **Descriptions are stored in a relational database**
  - diagnostic configuration, hardware, software version,
  - profiles
  - acquisition strategy ...
  - description of the data
  - Metadata

- **Flexibility**

- **Data are transferred from UA using frames**
  - enable continuous operation, real time visual feedback

- **Quality**
  - rules of consistency (database controls)
  - Certification of data
  - management of multi-occurrences for processed data, of dependencies (between processes) and replay
  - versioning for data and codes