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CONTROL SYSTEMS**

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**EDITOR**  
Hamid Shoaee  
Stanford Linear Accelerator Center

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## PREFACE

ICALEPCS'2001, the 8th biennial International Conference on Accelerator and Large Experimental Physics Control Systems was held at the Fairmont Hotel in San Jose, California November 27–30, 2001. The conference was organized by the Stanford Linear Accelerator Center (SLAC) and co-organized by Stanford University and the European Physical Society Interdivisional Group on Experimental Physics Control System. The Conference Chair was Rusty Humphrey (SLAC) and the Program Chair was Hamid Shoaee (SLAC).

It was during the late preparation stages of this conference that the terrorist attacks of September 11, 2001 took place. The conference organizers were faced with the alternatives of canceling the conference, postponing it, or holding it on the original dates but with the prospects of reduced participation. Following a poll of the largest participating institutions we decided to stay with the published dates. The overwhelming support of a number of laboratories from around the world ultimately resulted in a scientifically and financially successful conference. ICALEPCS'2001 brought together 270 control specialists from 24 different nations covering Africa, America, Asia and Europe and representing 62 laboratories and 7 corporations. The attendance was lower than that of both ICALEPCS'99 (Trieste; 400 participants, 32 nations, 116 organizations) and ICALEPCS'97 (Beijing; 437 participants, 26 nations, over 100 organizations), and was a direct consequence of the September 11 tragic events. There were around 120 participants at the three workshops on Databases, EPICS, and Automated Beam Steering.

The 2001 EPCS prize was awarded to Mark Plesko (Jozef Stefan Institute, Ljubljana).

### ***Scope***

As usual, ICALEPCS'2001 covered the fields of control and operation of particle accelerators, detectors, telescopes, fusion devices, nuclear reactors and other large experimental facilities. Both hardware and software aspects of control systems were addressed. The conference was complemented by three workshops:

- International Accelerator Data Base Group (IADBG) Workshop (1 December 2001), organized by Roland Müller (BESSY),
- Automated Beam Steering and Shaping (ABS) Workshop (3–4 December 2001), organized by Greg White (SLAC),
- Experimental Physics and Industrial Control Systems (EPICS) Workshop (3–4 December 2001), organized by Bob Dalesio (LANL).

### ***General Impression***

A wide breadth of topics was covered. Oral papers often terminated with a list of references to other related presentations (oral or poster).

There was an increased number of contributions (many of them first-time) from non-accelerator facilities:

- Fusion: NIF (National Ignition Facility), NSTX (National Spherical Torus Experiment),

- Astronomy: ESO's VLT (Very Large Telescope), CEA's VISIR Instrument, Gemini-South telescope, OAS (Osservatorio Astronomico di Capodimonte),
- Interferometers: ALMA (Atacama Large Millimeter Array), LIGO (Laser Interferometer Gravitational Wave Observatory),
- Experiments: ATLAS and CMS (CERN), BABAR (SLAC), D0 and CDF (FNAL), H1 (DESY), KLOE (DAΦNE).

Noteworthy was the increased level of collaboration across different controls projects: e.g. SNS (Spallation Neutron Source), SLS (Swiss Light Source), VIMOS (Visible Multi-Object Spectrograph), NSTX (National Spherical Torus Experiment), etc. These collaborations incorporate a common development environment and emphasize the reuse of packages, modules, designs, experience, etc.

There were very few papers on commercial controls. Examples that were presented include ATLAS (Argonne Tandem Linear Accelerator System) using VSystem with PC distributed I/O, CMS (CERN) and H1 (DESY) both using PVSS II and DAFNE using LabVIEW. CERN, a pioneer in the use of commercial control systems, contributed only marginally to this conference (an aftermath of September 11, 2001).

## **Status Reports**

### **Examples of successful control systems currently in operation:**

General *credo*: control systems are no longer high-risk systems for a project; experienced and trained people, tools, equipment and bandwidth are available.

- The SLS (PSI) Control System comprises 100,000 data channels, 150 VME crates running EPICS, and the use of CDEV with CORBA (Common Object Request Broker Architecture). It is highly reliable, in part thanks to software engineering and the use of a relational database for all system configurations. Most hardware I/O channels are directly connected to VME input/output cards (no field bus). External companies delivered turnkey systems with EPICS based controls as part of the contract.
- The RHIC (BNL) Control System incorporates commercial hardware, software written in C++ and TCL, and presents many automation features: ramp control, sequencing, tune feedback, post-mortem dumps, etc.
- NSTX achieved first plasma in February 1999; its Control System uses legacy CAMAC and EPICS.
- D0 (FNAL) uses EPICS for the experiment's control system. This experiment solved the problem of "mismatch" between Oracle's database format and EPICS's flat ASCII files.
- The H1 (DESY) Detector Control and Monitoring (H1DCM) control system, based on PVSS II, successfully completed its final test phase with the delivery of a prototype for control of a CAEN based HV system, the super conducting solenoid, and the luminosity system of H1.
- The BABAR (SLAC) on-line detector system team reported on the use of Objectivity/DB, an object-oriented DBMS.

**Several very large systems are well along in the construction phase:**

- NIF (a 2.5 Billion USD project at LLNL) with its 192 laser beams delivering 1.8 Megajoules is similar to the French Megajoule project. The strategy used to develop NIF's Integrated Computer Control System (ICCS) calls for incremental cycles of construction and formal testing to deliver a predicted total of 1 million lines of code. There is a well-defined development process which involves defined roles and responsibilities, productivity measures, extensive documentation, regular assessment, design and code reviews, etc. NIF's commitment to formal testing (with an independent testing team and facility) is exciting. It requires management commitment and money, but is expected to pay off with the availability of systems that meet the "real" functional requirements and have fewer bugs.
- SNS (ORNL) discussed how the project addresses the issues of organization, communication, standardization, and integration inherent to this widely distributed project (6 collaborating laboratories).
- LIGO requires many Multiple Input Multiple Output (MIMO) control loops. The control system integrates project-designed data acquisition, commercial controls, and EPICS.
- LHC (CERN) Experiments, e.g. ATLAS, CMS, are based on a commercial SCADA (PVSS).
- CMS (CERN) gave an example of integrating Oracle in a SCADA (Supervisory Control and Data Acquisition) to store the large amount of calibration data and Front-End electronic configuration data.
- ALMA will consist of 64 12-meter sub-millimeter antennas, with baselines up to 10 km, located at an altitude of 5000m in the Chilean Atacama desert. The control system incorporates the JAVA language and CORBA tools, and was developed for the prototype in the "guerrilla" project management style of ANKA (ANGstroemquelle KARlsruhe), a style that utilizes an enthusiastic student staff under the leadership of an experienced and similarly enthusiastic architect and project manager.

***Trends***

**Project Engineering and Management:**

- Global Accelerator Network: "Can be accomplished with today's technology, but the socio-logical and management issues are more difficult."
- Geographically Distributed Development Teams are a requirement for large collaborations. Although feasible, they still require a lot of travel on the part of the coordination team (SNS experience), and the involvement of project management to resolve the effect of competing designs.

**EPICS (Experimental Physics and Industrial Control System):**

The explosive growth of EPICS continues, expanding well beyond the United States, and beyond accelerators.

**Operating Systems:**

- What are the alternatives to VxWorks: L4-Linux, RTEMS (Real Time Executive for Multiprocessor Systems)?
- Linux seems to be everybody's choice for servers, in particular Linux Redhat.

**Ethernet:**

- Ethernet is ubiquitous and an alternative to field busses (e.g. NIF and SNS).
- Lots of bandwidth is currently available and more is coming. Spring-8 gave interesting performance measurements of gigabit Ethernet including its latency and redundancy.
- CISCO announced 10 Gbps Ethernet in 2002. Price per Mbps will drop to 4 USD by 2005. Beyond the 10 Gbps: 40 and 80 Gbps are coming.

**Databases:**

Oracle is used almost everywhere for storing configuration data, archived data, and slow real-time data. Its performance keeps getting better.

**WWW:**

The Web is ubiquitous and part of the software design process.

**Java:**

Java is increasingly investigated as an alternative to C++.

**CORBA:**

CORBA offers a software architecture that provides a commercial (or freeware) interface and management of connections between software entities (objects).

- There are enough CORBA projects (e.g., ALMA prototype, NIF, RIKEN, SLS) to demonstrate the viability of the approach. However, CORBA is complicated and there are multiple implementations and many ways to use CORBA (Application Layer to Utilities, Application Layers to Devices, etc.).
- As NIF points out, system performance with CORBA may be a problem as it is strongly dependent on the network design (e.g., the need for TCP/IP tuning).

**Software and Hardware Engineering:**

There are more development tools and techniques to attack hard, complex problems, thanks to the availability of still more computing and communications bandwidth and memory.

Software Engineers presently lead system architecture design. But Hardware Engineers are coming back. There are many smart, complex device designs, incorporating significant computing and communications capabilities (e.g., INP at Moscow State University). How will network and system architectures evolve when there are many such devices, each one a network object?

**Feedback and Special Innovative Solutions:**

There is creative use of sophisticated hardware and software tools to solve very specific and complex problems, e.g.:

- Accelerator orbit feedback at the APS,
- Beam feedback at KEK,
- Wave front control at the NIF,
- Wave length and frequency sensing and control at LIGO.

#### **PLC's and Industrial Controls:**

PLC's and industrial controls are tools/components that are being used and in many different control systems. They work and we can integrate them. Interestingly, SLS reported that they were successful in getting industry to deliver turnkey systems incorporating the SLS control system (EPICS) (SNS is also doing this.).

#### ***Thank You***

This was a large effort, greatly complicated by the events of September 11, 2001. We want to thank our fellow members of the local organizing committee, who provided the focus for coordination. The professional staff of Centennial Conferences, Inc., led by their CEO, Paula Pair, provided invaluable services during the planning and negotiation phases, as well as energetic and experienced management and services during the conference itself. The SLAC Publications Services team deserves a special acknowledgment and appreciation for developing a wonderful manuscript processing system and for their tireless and round the clock effort to ensure a smooth and timely publication process. They were a professional and vigorous contributor throughout the whole process, starting with the Web site and conference poster, through abstract and manuscript processing, and now with these proceedings. We are grateful to the staff of the SLAC Electronics and Software Engineering Department and the SLAC Computing Services Department for their support of the Conference's on-site computing and communication support.

We thank SLAC and Stanford University for their support of this Conference.

We acknowledge the contribution of the session chairs to the success of the program.

We would like to greatly acknowledge the generous contributions made by the Brocade Corporation, CISCO Corporation and Siemens.

Finally, we want to thank the attendees and the people and organizations mentioned for the firm support of this conference in the wake of the events of September 11, 2001. It was the people who wanted to report their work and to meet with their colleagues, and the people and organizations that organized and supported the conference who made this a success. This success is a tribute to the vitality of the field and it has been an honor to work with all of you.

#### ***ICALEPCS'2003***

The community looks forward with enthusiasm to ICALEPCS'2003, which will be hosted by Professor In Soo Ko, (POSTECH) in Gyeongju, South Korea, 13-17 October 2003. Co-Chairpersons will be Professor Ko and Dr. Axel Daneels.

Rusty Humphrey  
Hamid Shoaee

