



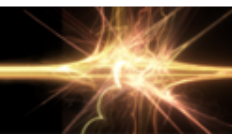
Turkish Accelerator Center

Teoman Soygul

# CONTROL SYSTEMS TECHNICAL DESIGN

# SCOPE

1. Control Systems Overview
2. Distributed Control Architecture
3. Control Network Infrastructure
4. Software Systems Architecture
5. **Live: Beam Control & Guidance Simulation**
6. Opt: IT Systems & Collaboration Web Site
7. Opt: Other Points of Concern
8. Conclusion and Future Projections



# 1

## CONTROL SYSTEMS OVERVIEW

Quick overview of the control systems used in T.A.C. IR-FEL & Brems. Facility

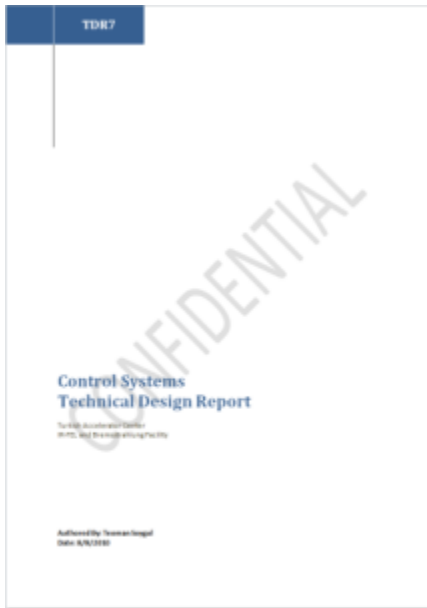
# Overview

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- The complete control architecture is implemented as a soft real-time distributed control system based on EPICS.
- Control hardware ranges from IPCs, PACs, to PLCs.
- Backbone of the control network is fiber optic 10 Gigabit Ethernet.
- When completed, the project will mark a milestone for future nuclear research laboratories in terms of the industrial grade reliability and IT level of technology of its control system.



# Project Documentation

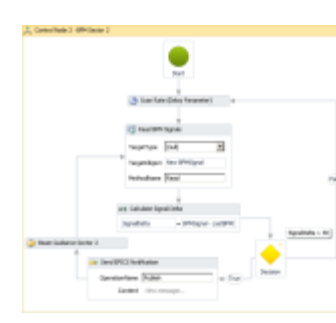
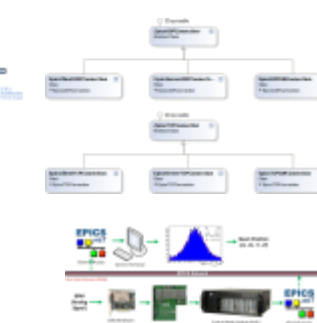
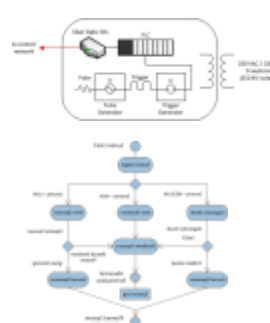
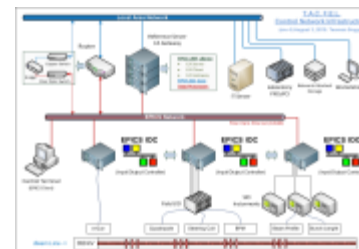
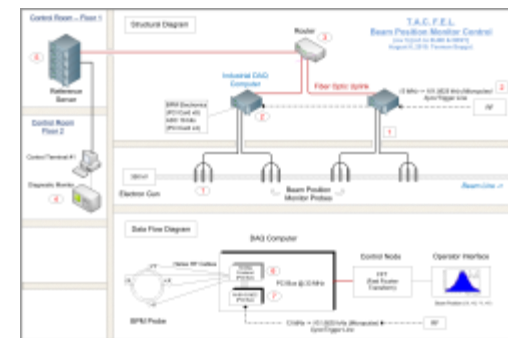
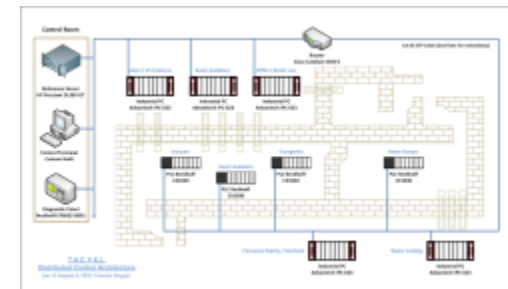


Separate design report for control systems, and always kept up to date.



MSDN style project documentation accessible via the collaboration web site.

Schematics, schematics, and more schematics. All accessible at the document library within the collaboration web site.





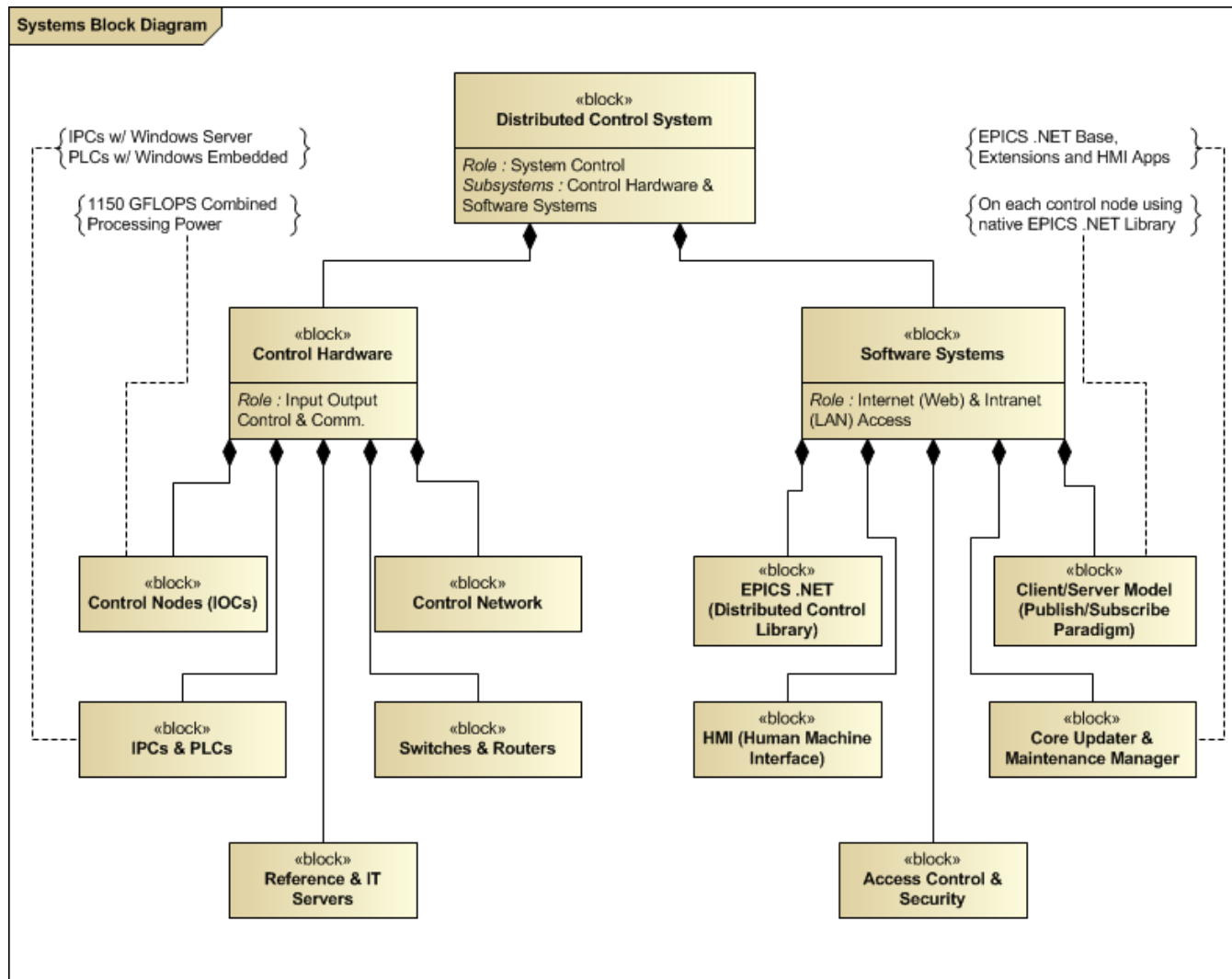
# 2

## **DISTRIBUTED CONTROL ARCHITECTURE**

Analysis of distributed architecture, IOCs, and DAQ hardware



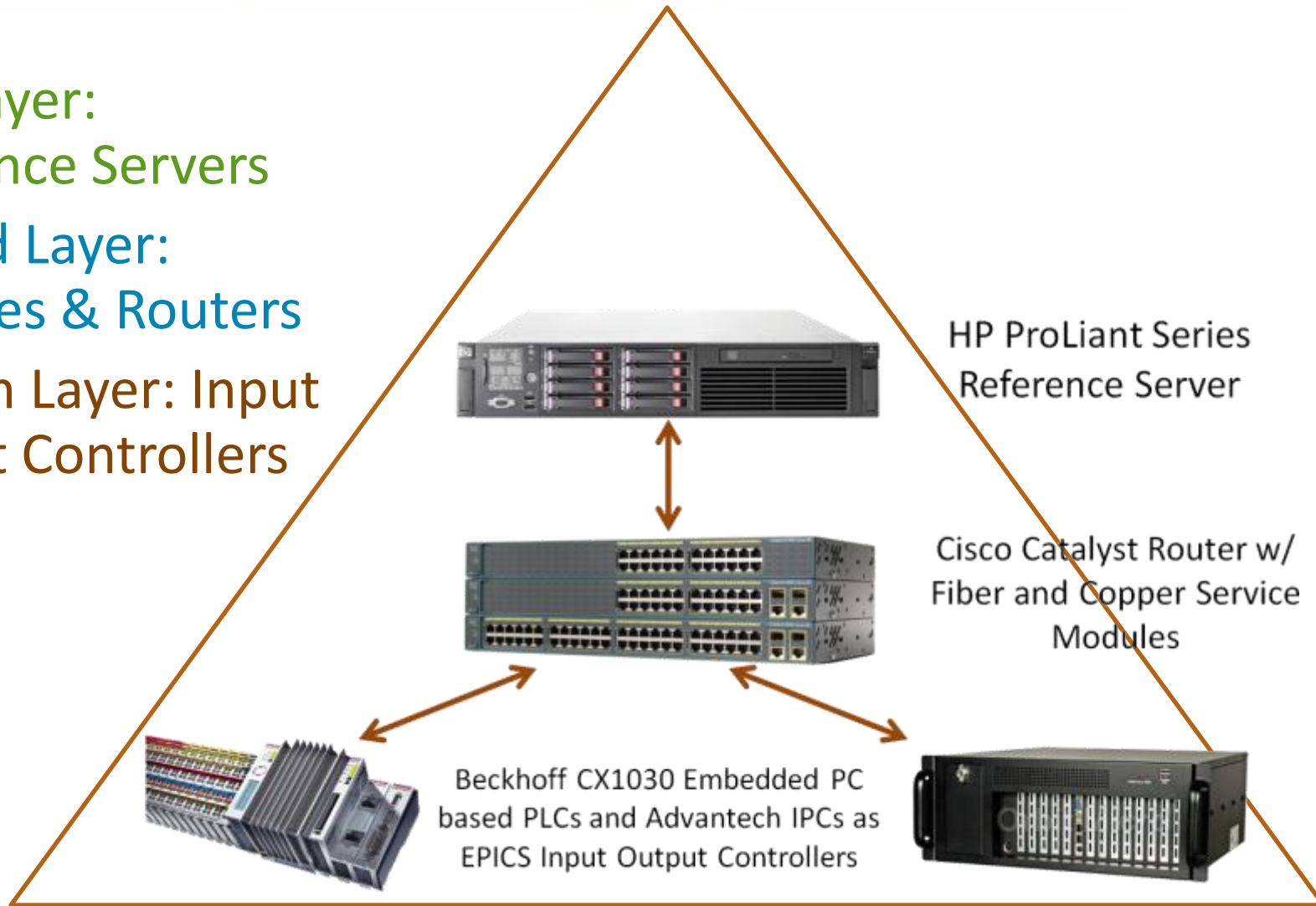
# Reference Server and Core Router



Systems req  
(functional and  
technical) then  
block diagram  
merging to big  
components of  
the system  
(hardware-  
software)

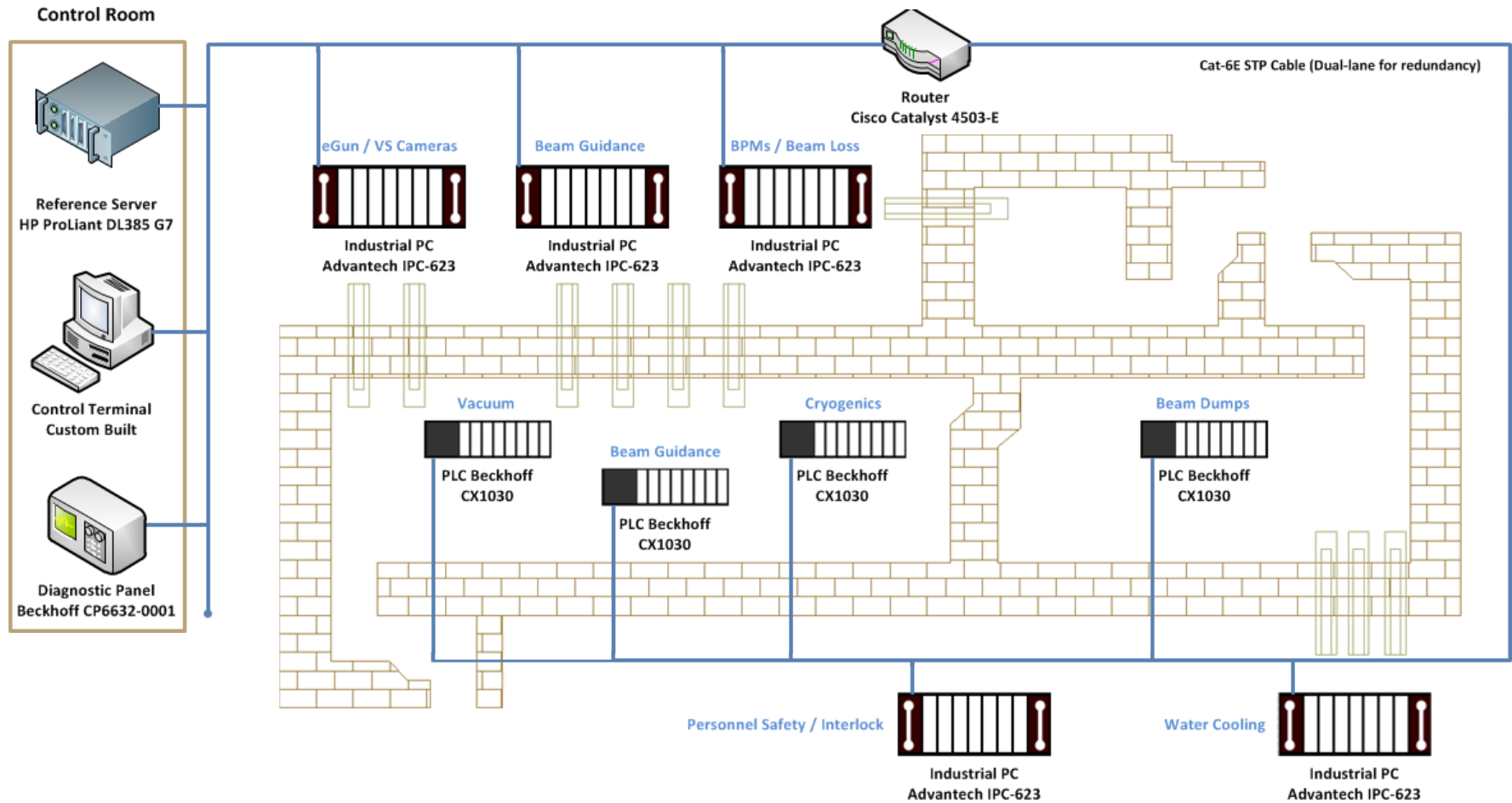
# Architectural Overview

- First Layer:  
Reference Servers
- Second Layer:  
Switches & Routers
- Bottom Layer: Input  
Output Controllers





# Installation Plan



# Core Router and the Reference Server



Cisco Catalyst 4503-E  
(Representation)



HP ProLiant DL385 G7



Cisco Catalyst 2940  
Copper switch with fiber-optic uplink  
Suitable for grid control and other high voltage / high  
radiation areas.

# Input Output Controllers: PLCs



## Beckhoff Embedded-PC PLC With CX1030 CPU Module

Intel® Pentium® M, 1.8 GHz clock frequency

1 GB Max

8 GB Compact Flash

2 x RJ 45 (Ethernet, internal switch), 10/100 Mbit/s

1 x power, 2 x LAN link/activity, TC status, 1 x flash access

1 x Compact Flash type I+II insert with eject mechanism

Microsoft Windows Embedded Standard

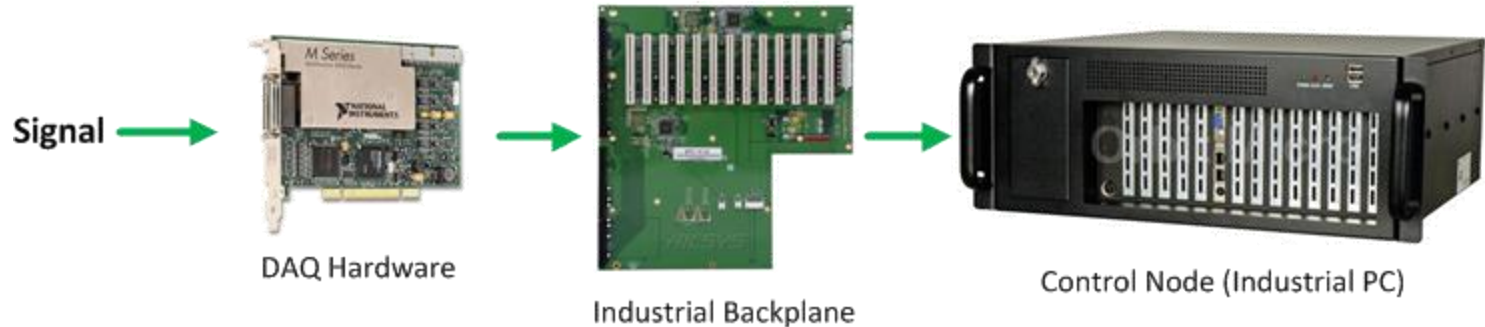
~2000\$

50\$ to 300\$

Animation: Beckhoff PLC with CPU module and I/O modules in a DIN rail



# Input Output Controllers: IPCs



## Advantech IPC-623 Chassis

BPX6806   PICMG 1.3   20-Slot PCI Express Backplane
MCXT-E   PICMG 1.3 System Host Board (SHB)
Two Quad-Core Intel® Xeon® Processors - 5400 series with 1333MHz FSB, 2x6MB L2 cache
8 GB four-channel Fully Buffered DIMM (FBDIMM) DDR2-667
Intel® 82563EB Ethernet controller - Two 10/100/1000Base-T
Intel® 82563E Ethernet controller - One 10/100/1000Base-T
2x Western Digital Enterprise 1 TB in RAID II Configuration
2x Redundant 750W
Emulex OneConnect OCe10102-N 10GbE NIC
2000\$ to 3000\$



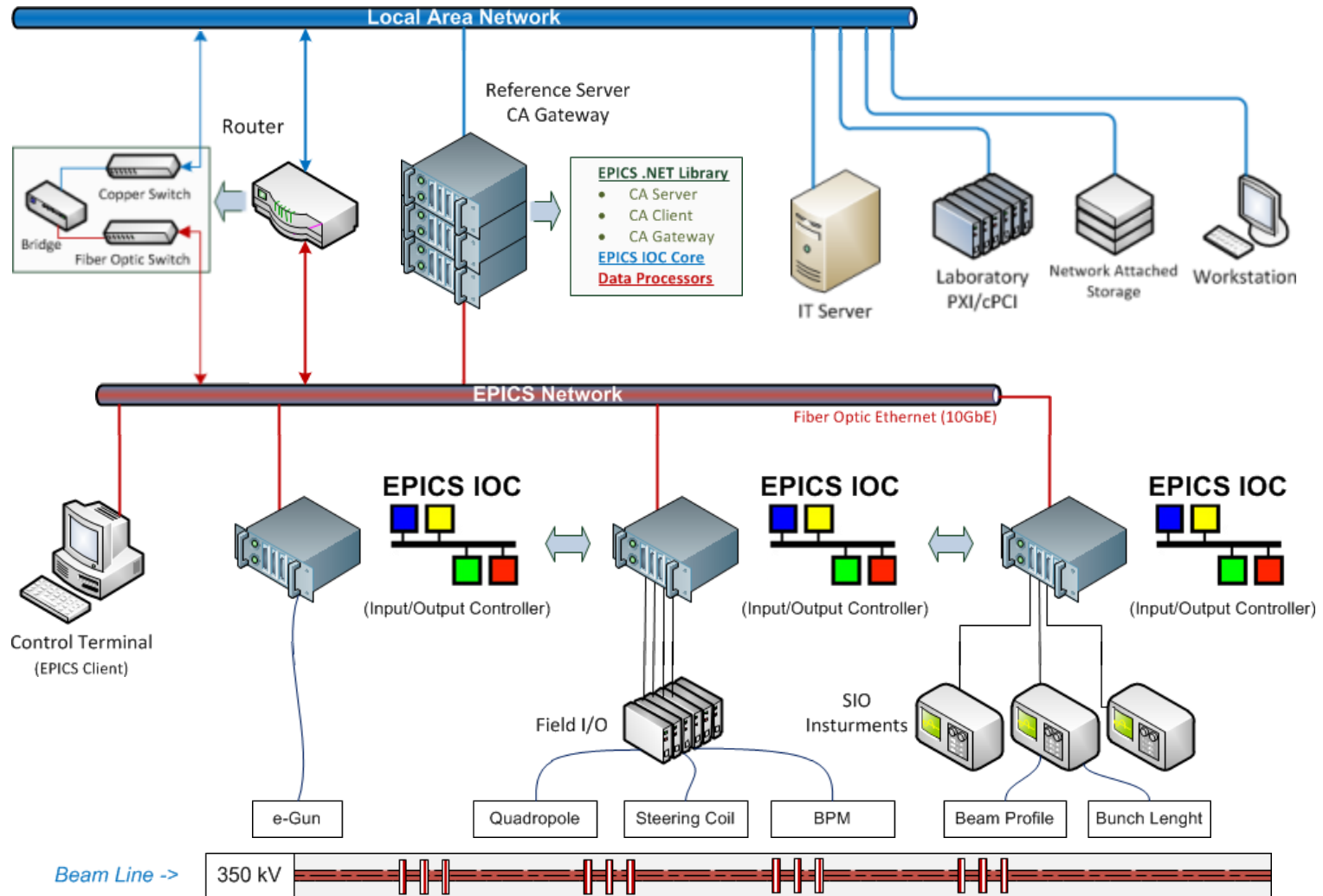
SHB (System Host Board) with two Xeon Processors and up to 32GB of ram. “Brain” of the industrial pc.



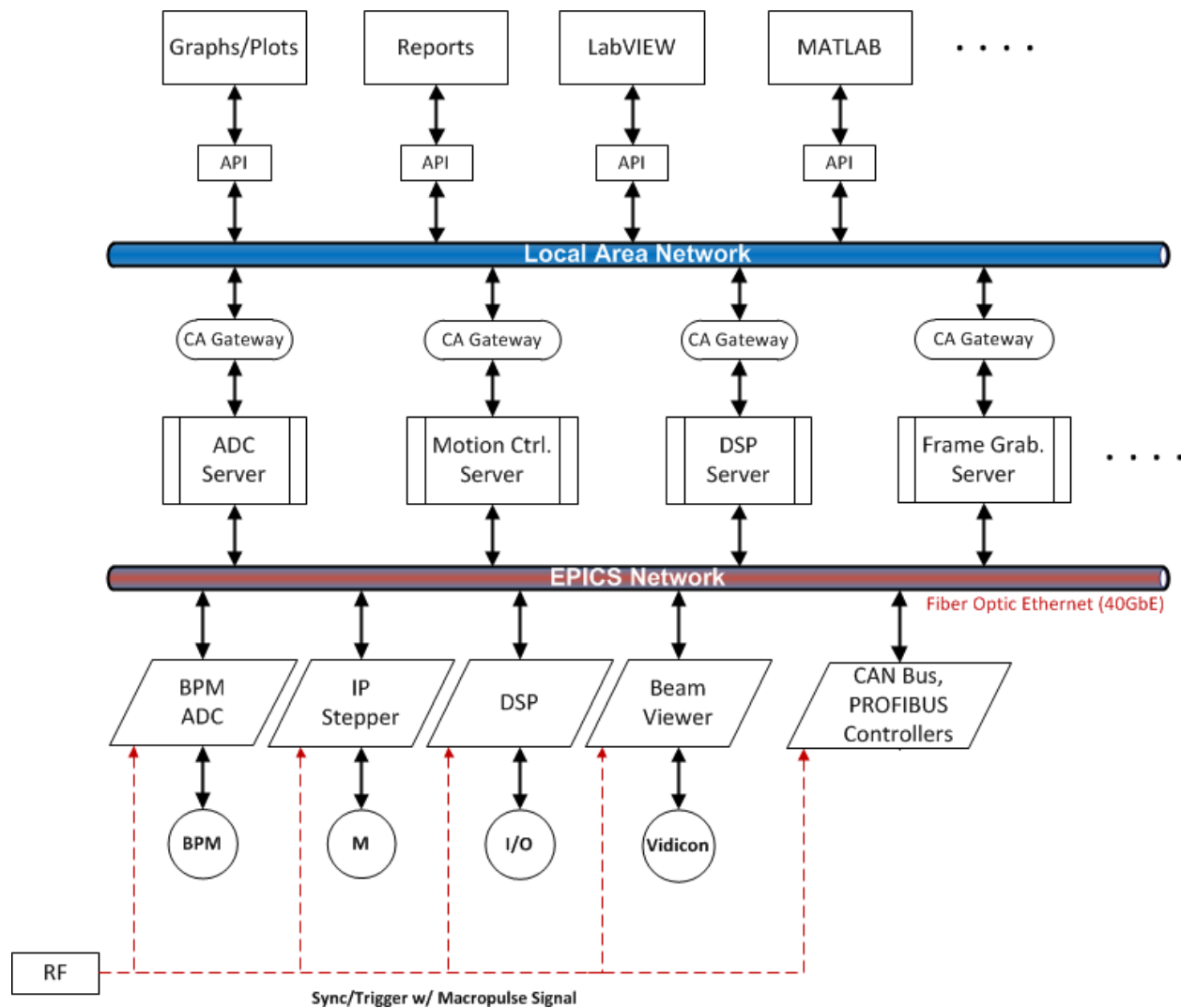
## **CONTROL NETWORK INFRASTRUCTURE**

The design of the control network with all the bells and whistles

# Control Network Infrastructure



# Software Communications and Protocols





# 4

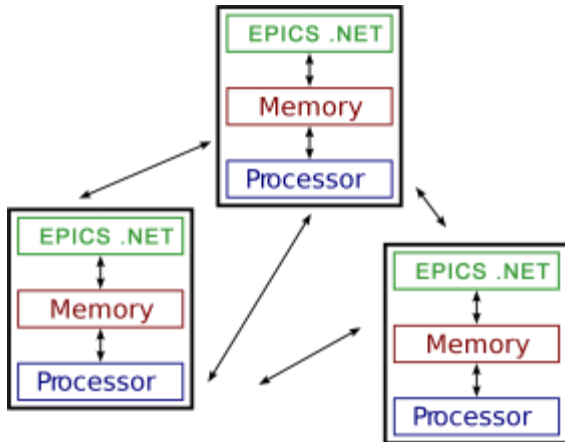
## SOFTWARE SYSTEMS OVERVIEW

Final step into completing the distributed control architecture





# EPICS .NET Library



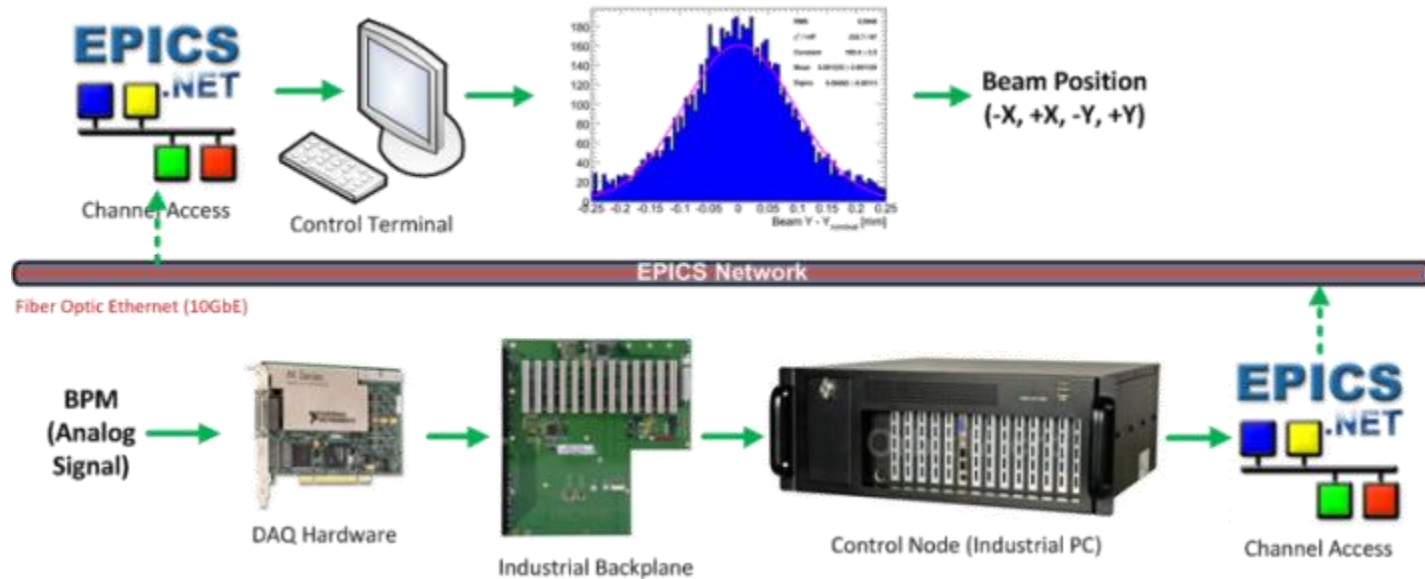
Whenever necessary, custom control software is developed and deployed using native EPICS .NET Library. Thus software architecture is standardized on a typical client-server model on each node, backed up with publish/subscribe messaging paradigm throughout the control network.



```
var localClient = new EpicsClient();
var memoryUsageResource = localClient.CreateChannel<int>("MyIOCNODE:MemoryUsage");
Console.WriteLine(memoryUsageResource.Get());
```

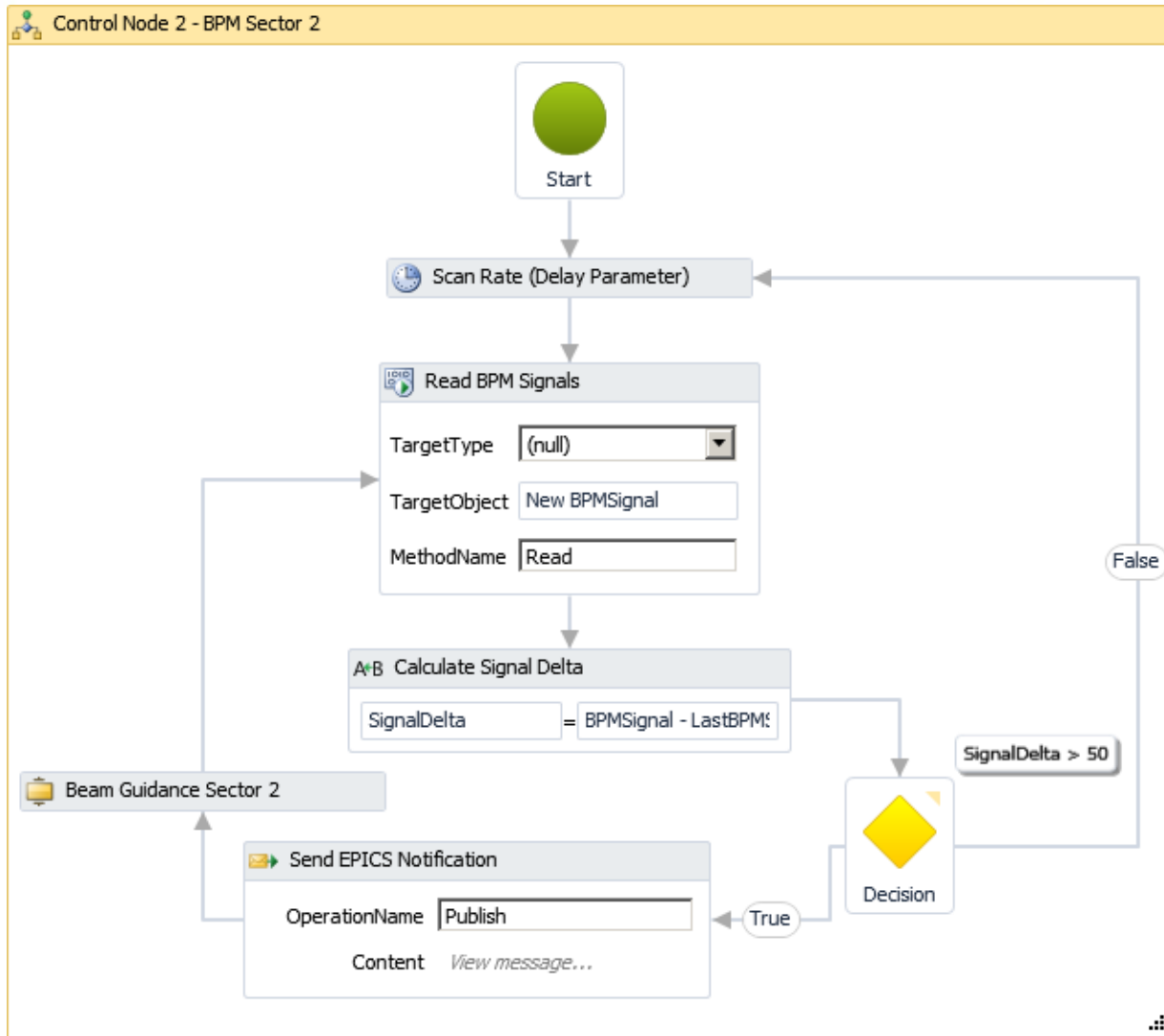
```
var myIOCNODE = new EpicsServer();
var memoryUsage = myIOCNODE.GetEpicsRecord<int>("MyIOCNODE:MemoryUsage");
memoryUsage.VAL = System.Diagnostics.PerformanceCounter("Memory", "Available MBytes");
```

# Node-to-node Communications Using EPICS



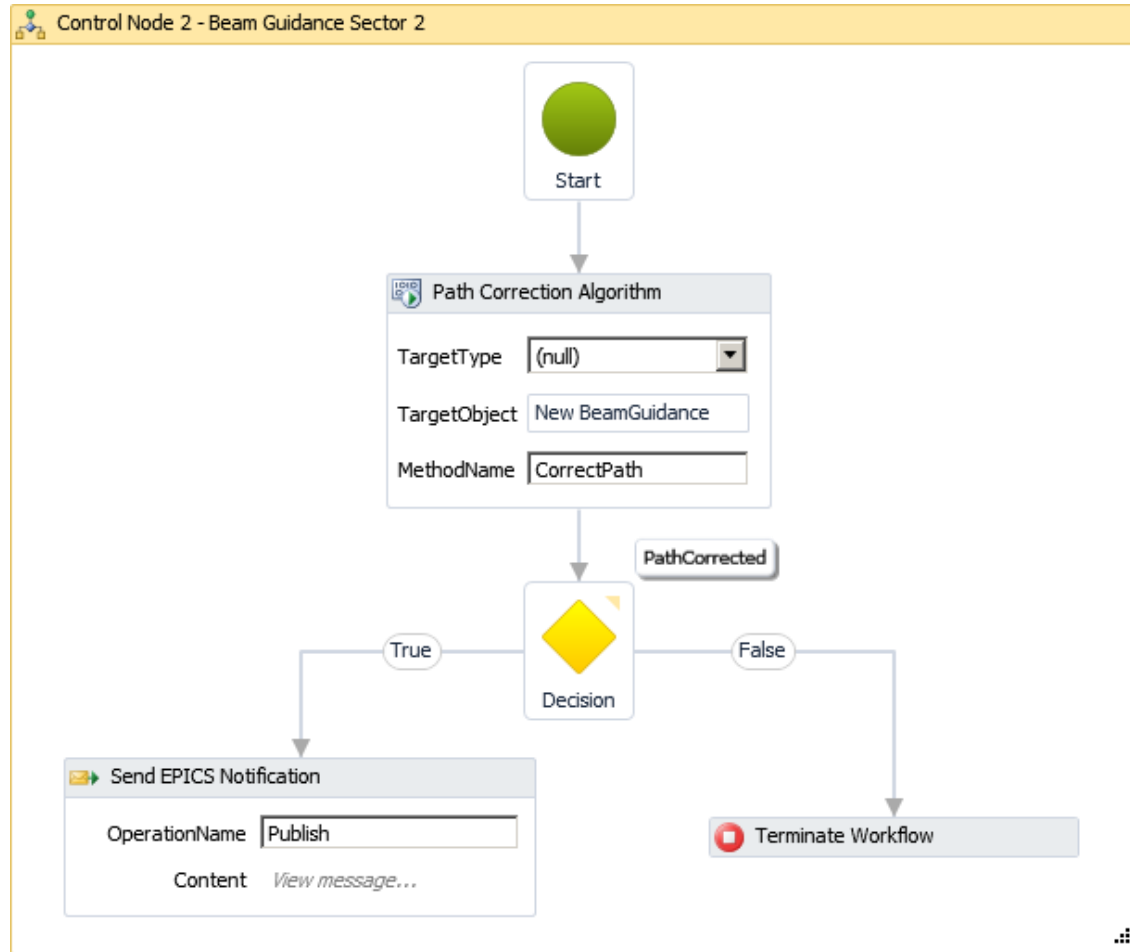
EPICS .NET Library makes node-to-node communications a breeze. Any control node can publish information, or subscribe to it over the control network using the library.

# Internal Control Workflow Using .NET Framework WF 4.0



Remember those six lines of codes? That was how it was easy to make node-to-node communications. And this is how easy it is to program the internal control logic and data flow using .NET Framework, Workflow Foundation 4.0

# Internal Control Workflow Using .NET Framework WF 4.0



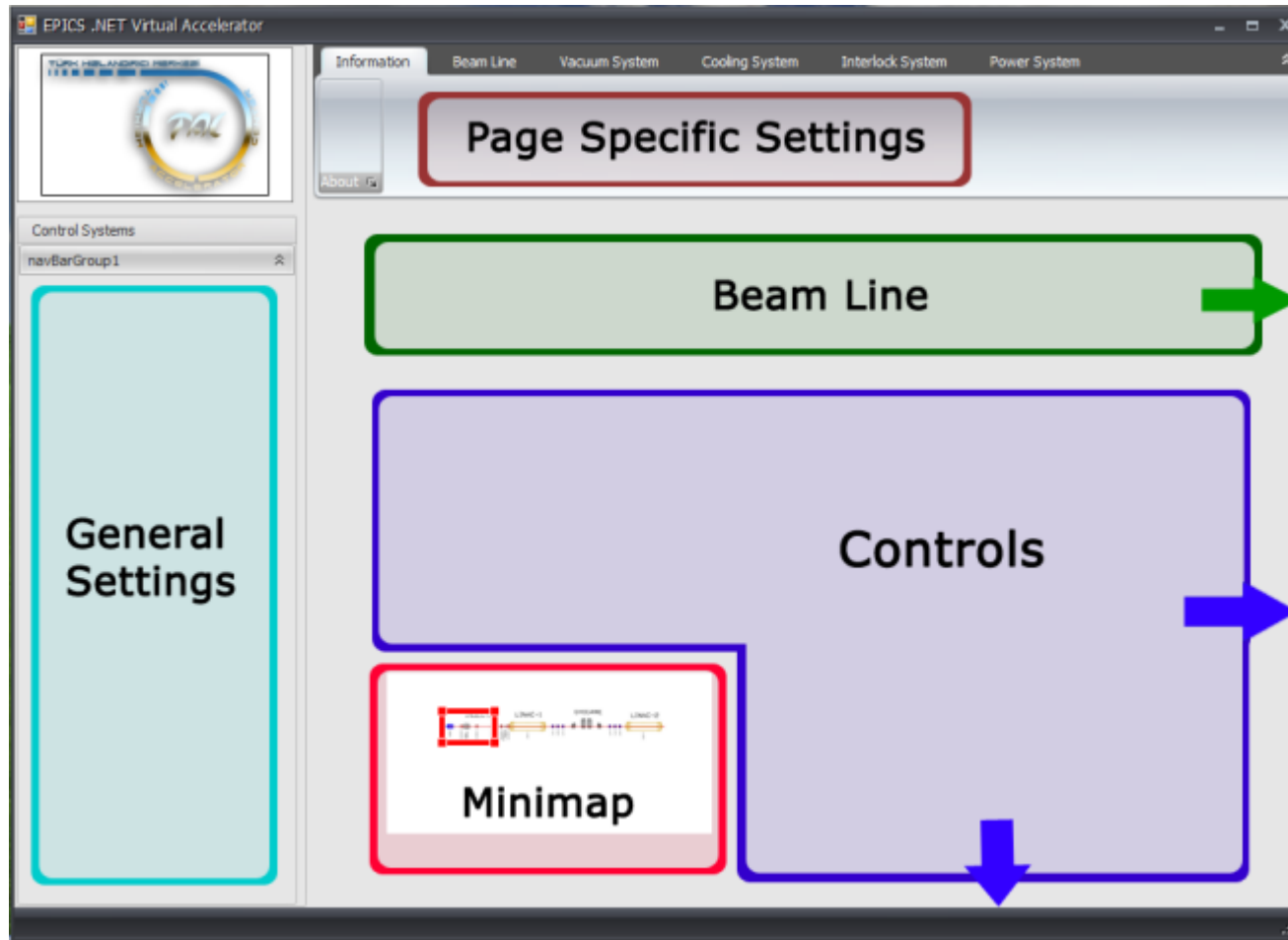
Note that these diagrams are not just pretty illustrations, they are the actual control code, which is created all graphically.

Here the beam guidance is done using custom written path correction algorithm. Note how easy it is to correct the orbit of the electron beams using workflow diagrams.

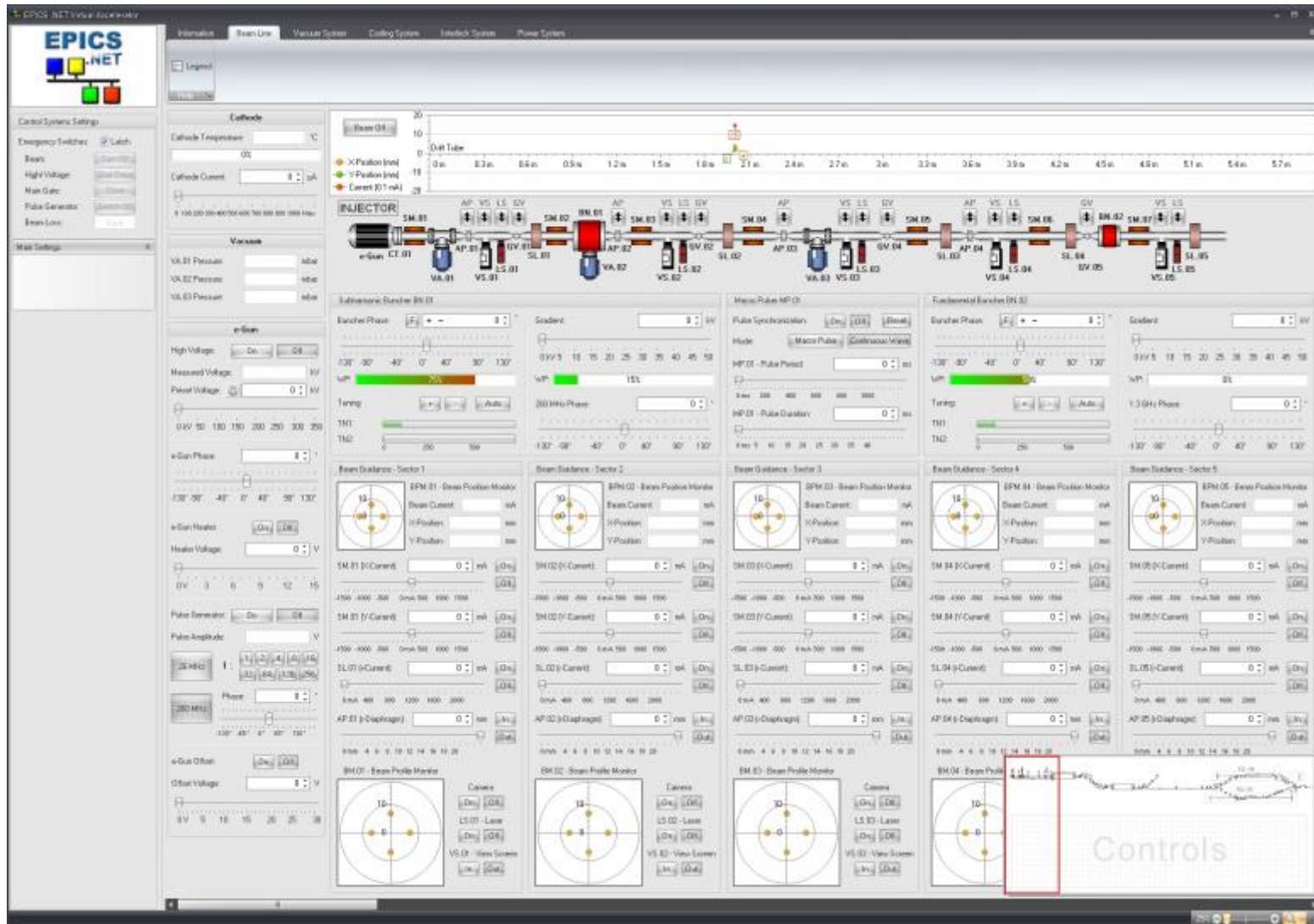
# HMI (Human Machine Interface) Software – Splash Screen



# Original HMI Design

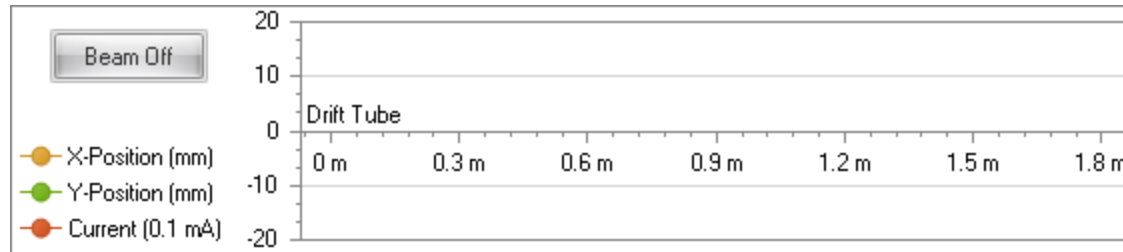


# Implemented HMI: The Beamline Control Screen

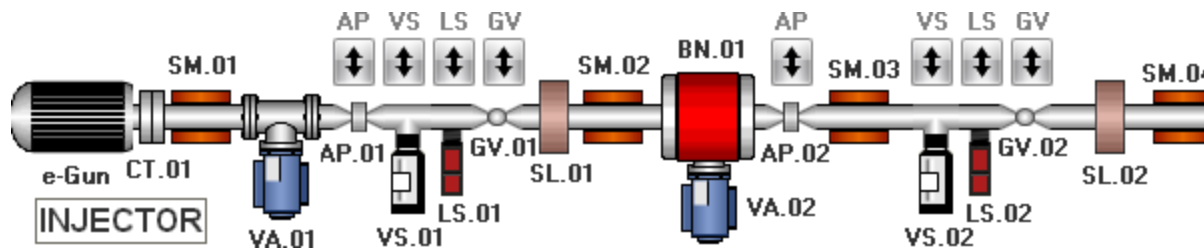




# Beamline and Process Visualization



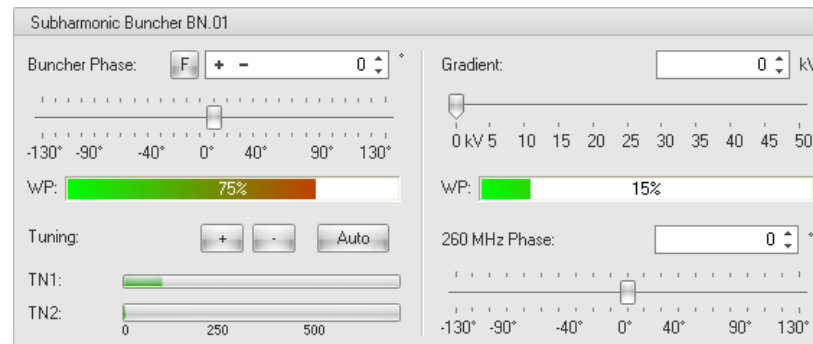
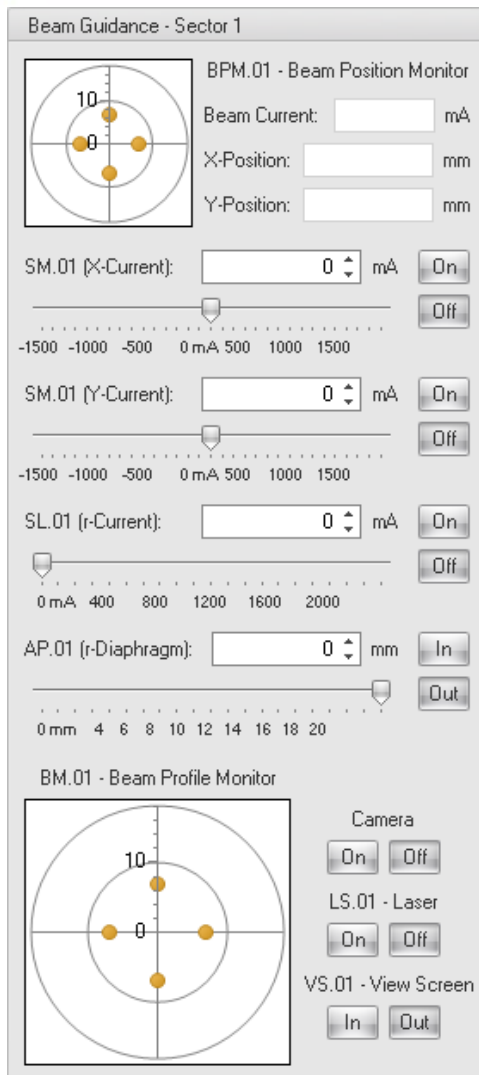
Beam position and current is displayed on the provided line charts which provides constant feedback while correcting beam patch manually.



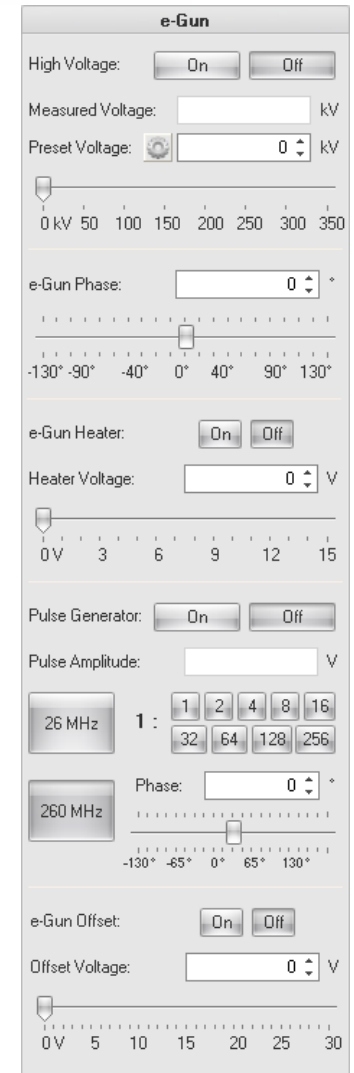
Drift-tube and electron flow is visualized vividly to provide a crystal-clear software interface, which aids the operator in making operational decisions.



# HMI Control Panels



Vivid graphics on the control panels make most of usability, providing operators with easy-to-follow information schema.





# BEAM CONTROL & GUIDANCE SIMULATION (LIVE)

## IT SYSTEMS & COLLABORATION WEB SITE

# Project Collaboration Web Site

Tuesday, 17 August 2010 Webmaster | Sitemap | Login



## T.A.R.L.A. COLLABORATION SITE

Turkish Accelerator and Radiation Laboratory at Ankara

[Home](#)[Project Progress](#)[Project Management](#)[Events](#)[Documents](#)[About](#)

### Upcoming Events

- [Regular Technical Committee Meeting](#)  
August 19, 2010 (13:00 - 14:00)  
(Technical Committee)
- [Regular Technical Committee Meeting](#)  
August 26, 2010 (13:00 - 14:00)  
(Technical Committee)
- [IMAC-II Meeting](#)  
September 02, 2010 (All Day)  
(General)

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### Logbook



(June 25, 2010) Our Microsoft Project Server is partially active now. Cost, resource, task, and schedule management will be a lot... [Read more](#)



(June 21, 2010) Our project collaboration web site has been updated with all the intended features (logbook, Microsoft Project integration, events,... [Read more](#)

### Reports

[Weekly Technical Report, June 24, 2010](#)



24 Jun 2010, Teoman Soygöl

### Project News

NEW

#### EPICS Application Developer's Guide



As you may well know, TAC IR-FEL & Brems. project control system is totally based on Experimental Physics and Industrial Control System (EPICS) software. For an experienced programmer... [Read more](#)

29 Jun 2010, Teoman Soygöl

#### Upcoming Technical Design Report & IMAC



Submission Technical Design Report's first draft is due August 15. Following the submission of TDR drafts, final draft will be put up for International Machine Advisory Committee for... [Read more](#)

24 Jun 2010, Teoman Soygöl



### Notifications

#### Reminder to All New Users

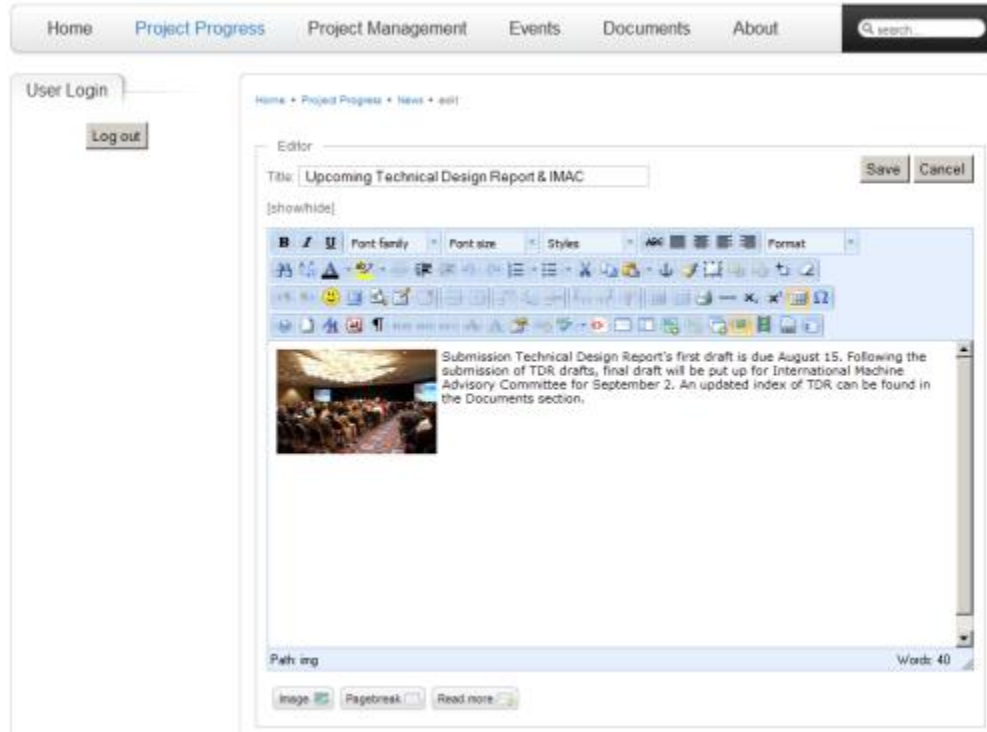


All new users should remember to change their default password on the first login. Also note that you can always have your username and password sent to your e-mail, if... [Read more](#)

24 Jun 2010, Teoman Soygöl



# In-page-editing and Other Features



## Mailing Lists

### Weekly Technical Reports

Weekly technical report with selected items for technical committee from: Weekly project news, notifications, technical documents, presentations, blog posts, and upcoming events.


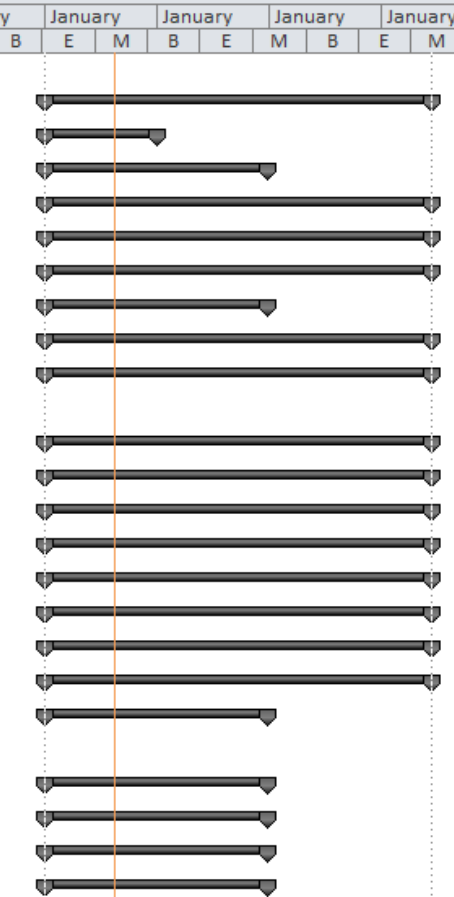






















### Monthly Progress Reports

Monthly progress reports intended for technical committee and project managers. Basic cost analysis and resource usage - task distribution compiled from our Microsoft Project Server. Also includes major news, and selected items from weekly technical reports.

### Quarterly Financial Reports

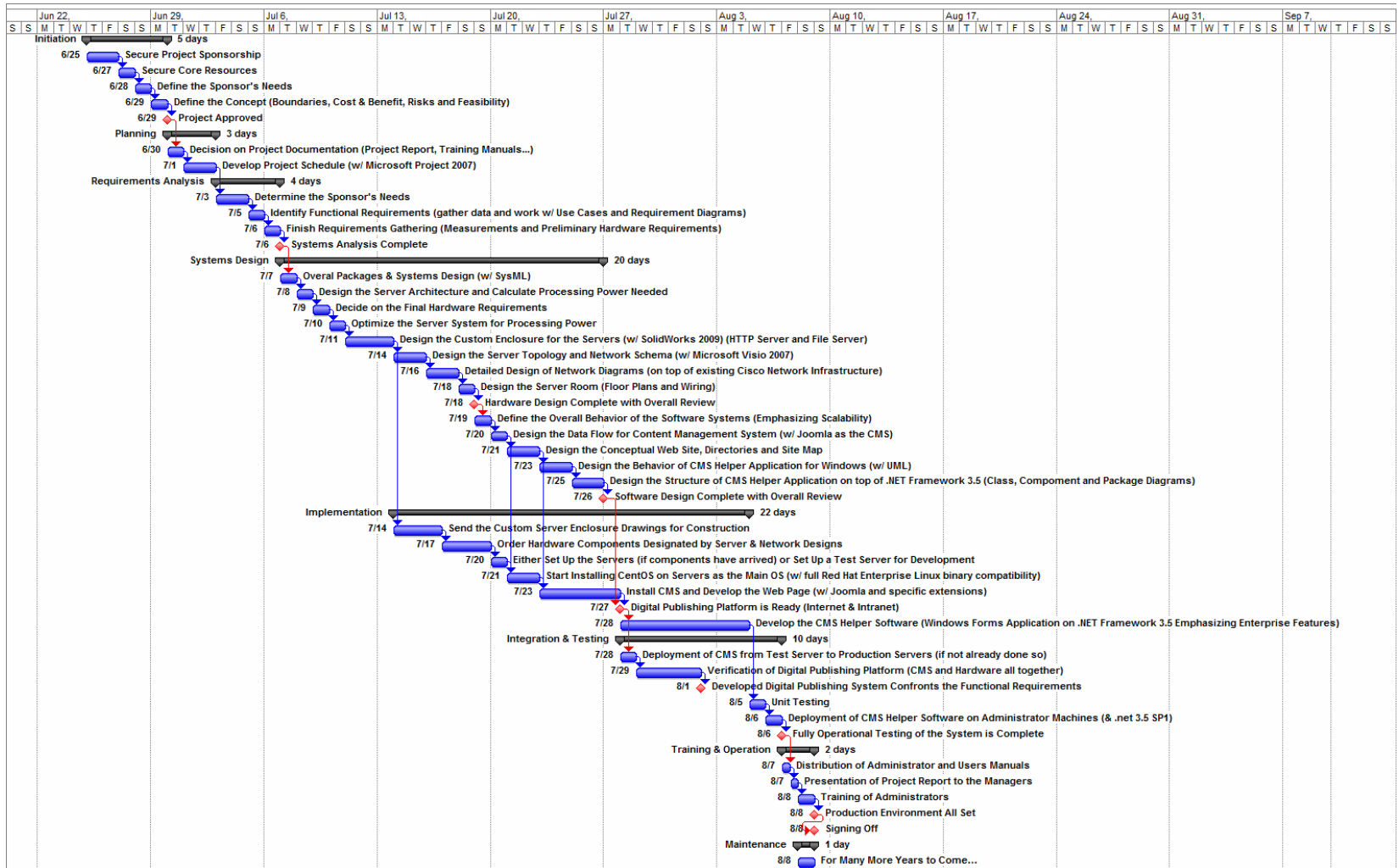
Quarterly financial reports intended only for project managers. Detailed cost and resource usage analysis with information compiled from our Microsoft Project Server.

# Project Management System

		Task Mode ▾	Task Name ▾	Duration ▾	Start ▾	Finish ▾													
							ry	January			January			January			January		
							B	E	M	B	E	M	B	E	M	B	E	M	
1																			
2			[-] Components	900 days	Fri 1/1/10	Thu 6/13/13													
3			[+] Laboratory Building	260 days	Fri 1/1/10	Thu 12/30/10													
5			[+] Injector	520 days	Fri 1/1/10	Thu 12/29/11													
28			[+] Superconducting Linear Accelerators	900 days	Fri 1/1/10	Thu 6/13/13													
41			[+] Free Electron Laser	900 days	Fri 1/1/10	Thu 6/13/13													
54			[+] Beam Transport	900 days	Fri 1/1/10	Thu 6/13/13													
60			[+] Beam Dumps	520 days	Fri 1/1/10	Thu 12/29/11													
66			[+] Bremstrahlung	900 days	Fri 1/1/10	Thu 6/13/13													
72			[+] Experimental Stations	900 days	Fri 1/1/10	Thu 6/13/13													
78																			
79			[-] Systems	900 days	Fri 1/1/10	Thu 6/13/13													
80			[+] Diagnostic Systems	900 days	Fri 1/1/10	Thu 6/13/13													
93			[+] Cryogenics (Helium Cooling)	900 days	Fri 1/1/10	Thu 6/13/13													
99			[+] Electrical Power Systems	900 days	Fri 1/1/10	Thu 6/13/13													
105			[+] Cooling Systems	900 days	Fri 1/1/10	Thu 6/13/13													
118			[+] Vacuum System	900 days	Fri 1/1/10	Thu 6/13/13													
124			[+] RF System	900 days	Fri 1/1/10	Thu 6/13/13													
137			[+] Safety Systems	900 days	Fri 1/1/10	Thu 6/13/13													
143			[+] Control System	520 days	Fri 1/1/10	Thu 12/29/11													
149																			
150			[-] IT	520 days	Fri 1/1/10	Thu 12/29/11													
151			[+] Project Mangement System	520 days	Fri 1/1/10	Thu 12/29/11													
164			[+] Data Storage and Processing	520 days	Fri 1/1/10	Thu 12/29/11													
170			[+] Project Promotion	520 days	Fri 1/1/10	Thu 12/29/11													



# Gantt-Chart for Control Systems in PM





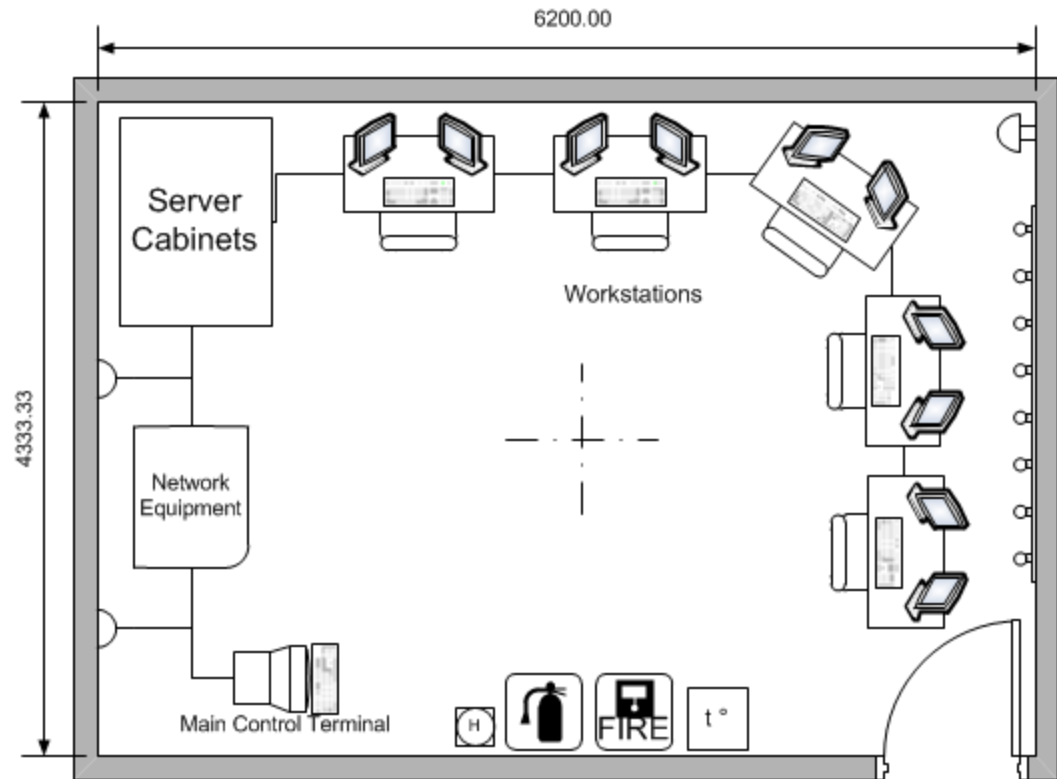
## OTHER POINTS OF CONCERN

Various other important points of concern



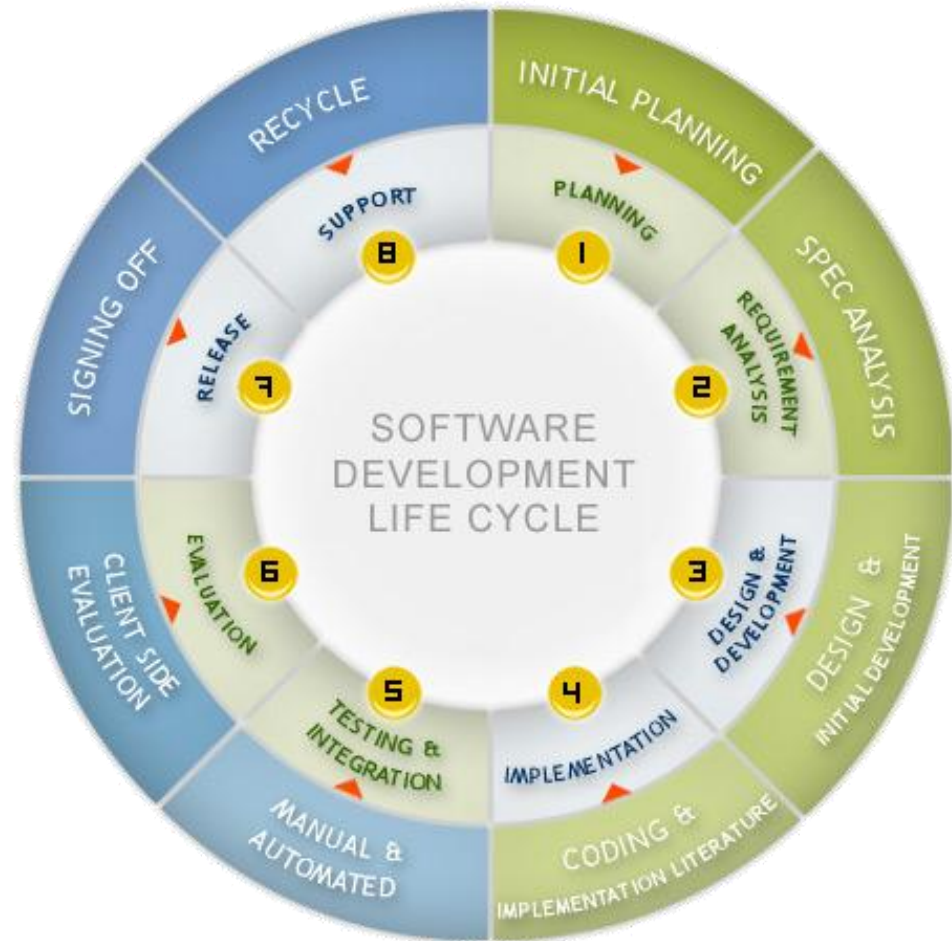
# Control Room Floor Plan

To the right is the floor plan for the control room. It is intended to be a 24/7 operation center. Currently lacking in comfort but top-notch at reliability.



# In-house Software Development Life Cycle

Software developed in-house is not left *as-is*. It is maintained, documented, tested, released, then supported. If necessary, re-development is always an option as long as the system requirements are always satisfied.





## **CONCLUSION AND FUTURE PROJECTIONS**

# Conclusions

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- With the first draft of the Control TDR, design of the control systems for IR-FEL facility is complete.
- On software side, partial implementation has begun. On the other hand, acquiring control hardware is the next-up task.
- The implementation of the control system for the bremsstrahlung room, machine and human protection, and interlock systems will be delayed until those sub-projects are complete.



# Future Projections

---

- Near future objective of the project is to extend the current implementation of the distributed control systems to include remaining portions of the facility.
- With the integration of all the subsystems, the project is expected to deliver exceptional performance, scalability, and reliability in less than twelve months' time.

