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Australian synchrotron

OUTSOURCING, INSOURCING, AND INTEGRATION OF CONTROL SYSTEMS IN THE AUSTRALIAN SYNCHROTRON

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The Australian Synchrotron was built in less than four years and under budget with many subsystems outsourced.

The reasons for outsourcing
The approach taken
Technical issues involved
The importance of a solid engineering approach, systems design and in-house

Some suggestions for future projects

MANAGEMENT APPROACH – STRUCTURE AND TEAM

- Minimise staff;
- Maximise contracting and outsourcing;
- Meet tight deadlines;
- Defined acceptance criteria;
- Form small “Project/product teams; and
- Minimise and outsource risks.

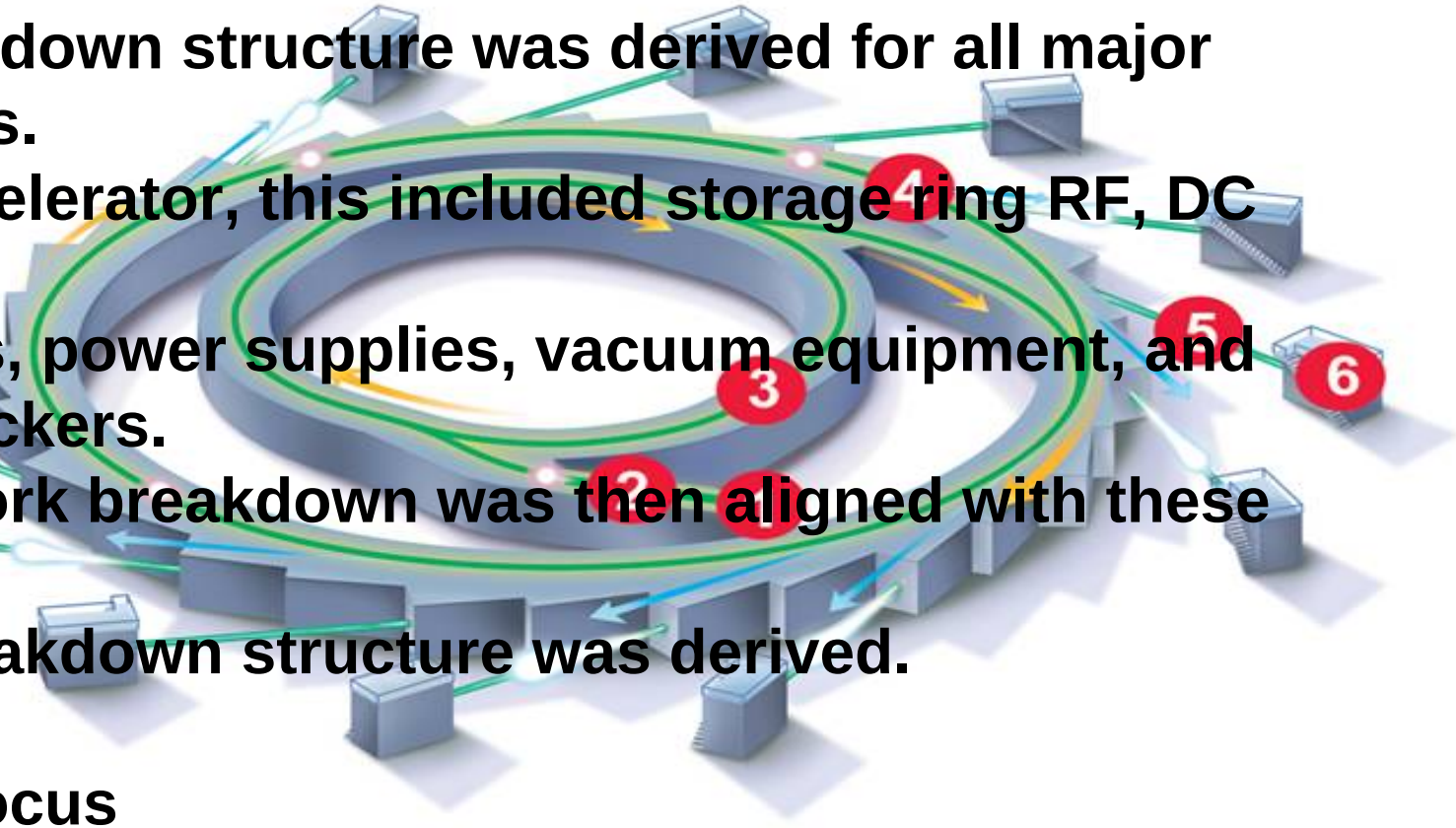
We got

- A total team of less than 50;
- The major subsystems outsourced;
- A lot of contractual support work;
- A need to integrate separate subsystems
- Low risk solutions – leading edge, not bleeding edge
- Defined but not prescriptive standards

Outsourcing
mechanical works
building
the injection systems, Linac, Booster and
RF systems were outsourced as “turn-key contracts”.
controls were included in the scope of supply.
risk for ensuring that it is actually fit for purpose

Work and system breakdown structures

Work breakdown structure was derived for all major subsystems.
For the accelerator, this included storage ring RF, DC magnets,
diagnostics, power supplies, vacuum equipment, and injection kickers.
controls work breakdown was then aligned with these systems
system breakdown structure was derived.



Controls Focus
Controls was recognized in having a special focus on integration.
Controls team for a while was the largest team on the project reaching eleven members !

Instant Friends
EPICS was chosen for the control system, collaborative nature, entrance to the existing community provided instant friends!
The Australian Synchrotron is the major EPICS user in the country, although we did discover two other smaller users

Sharing training with the turnkey contractors.
Picking your contractors wisely

GUIs
The visible part of the control system.
Standard tools were spec'd for the contractors
We are slowly replacing them.
Using a commercial MS Windows based integrated development environment (IDE)
Runs in a Linux environment using WINE. This works well response is fast,
Functionality identical across the MS Windows and Linux.

Gratuitous screen shots follow

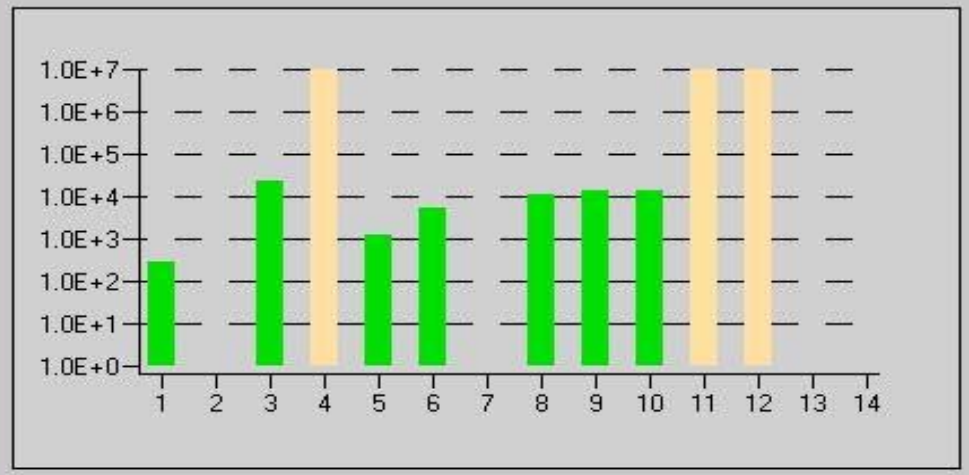
Australian Synchrotron

Beam Loss Monitor Control

Framework General Vacuum Magnets Diagnostics Timing Insertion Devices Miscellaneous

Beam Loss Monitor Control

Index	Modify	On	Off	On/Off	Counts	Sensor A	Sensor B	Mode	LOF	HIF	More
201	Modify	On	Off	ON	288	DISABLED	DISABLED				
202	Modify	On	Off	ON	0	DISABLED	DISABLED				
203	Modify	On	Off	ON	23256	DISABLED	DISABLED				
304	Modify	On	Off	ON	0	DISABLED	DISABLED				
305	Modify	On	Off	ON	1184	DISABLED	DISABLED				
406	Modify	On	Off	ON	5168	DISABLED	DISABLED				
407	Modify	On	Off	ON	0	DISABLED	DISABLED				
508	Modify	On	Off	ON	11584	DISABLED	DISABLED				
509	Modify	On	Off	ON	14320	DISABLED	DISABLED				
610	Modify	On	Off	ON	13816	DISABLED	DISABLED				
711	Modify	On	Off	ON	0	DISABLED	DISABLED				
712	Modify	On	Off	ON	0	DISABLED	DISABLED				
113	Modify	On	Off	ON	0	DISABLED	DISABLED				
114	Modify	On	Off	ON	0	DISABLED	DISABLED				



SR01BLM02

Port 2 Address 1

Sensor A Enable Disable DISABLED

Sensor B Enable Disable DISABLED

Reset Reset

Low Limit 0 +00,000,000 A

High Limit 10,000,000 +10,000,000 A

1 - Val/Min 0.056

Max/Val - 1 0.083

Temperature 30.0 degC

10 Oct 07 14:38:08

Beam Position Monitors and Corrector Strengths - 1

Framework General Vacuum Magnets Diagnostics Timing Insertion Devices Miscellaneous

Beam Position Monitors and Corrector Strengths

Primary Scale (Blue)

Mode: None / (•) Real Time / Snap-shot / RT - SS

Data: (•) Hor BPM Posn / Ver BPM Posn / Hor Correctors / Ver Correctors / SQ Correctors

Snap-shot | Save to File... | Auto Scale

Secondary Scale (Red)

Mode: None / (•) Real Time / Snap-shot / RT - SS

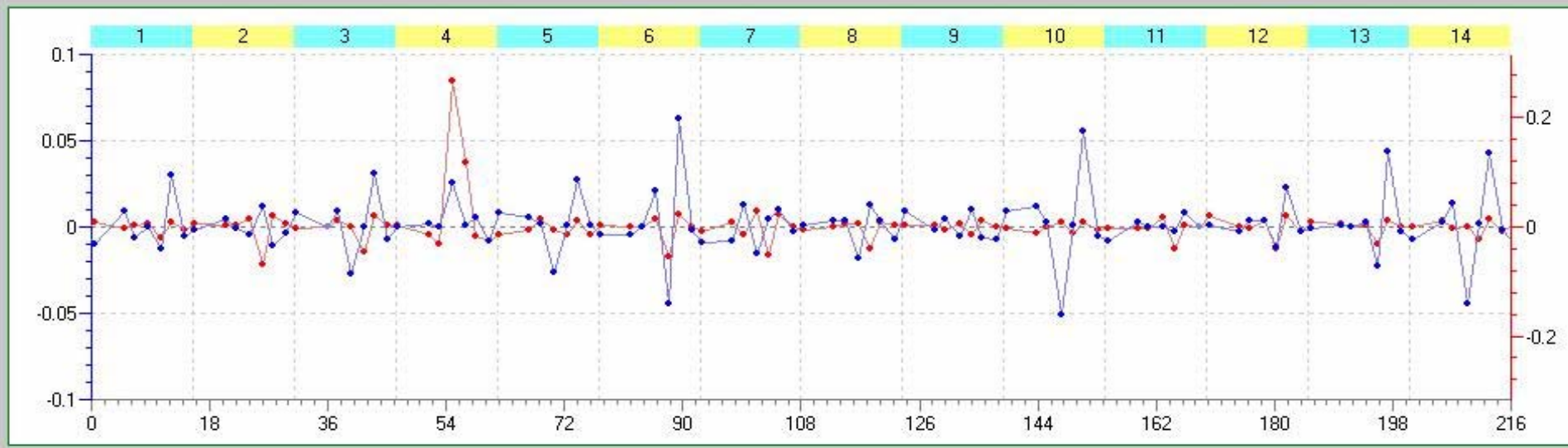
Data: Hor BPM Posn / (•) Ver BPM Posn / Hor Correctors / Ver Correctors / SQ Correctors

Snap-shot | Save to File... | Auto Scale

Misc

Beam Current: 77.748 mA

Beam Energy: 3.056 GeV



-216 -180 -144 -108 -72 -36 0 36 72 108 144 180 216

S R 0 Offset 0

1 2 3 4 5 6 7 8 9 10 11 12 13 14

S R 1.0 Scale 1.0

-1 0 1 2 3 4

S R 0.00 Primary Scale (Logarithmic) 2.00

-1 0 1 2 3 4

S R 0.00 Secondary Scale (Logarithmic) 1.50

Strip Chart - 1

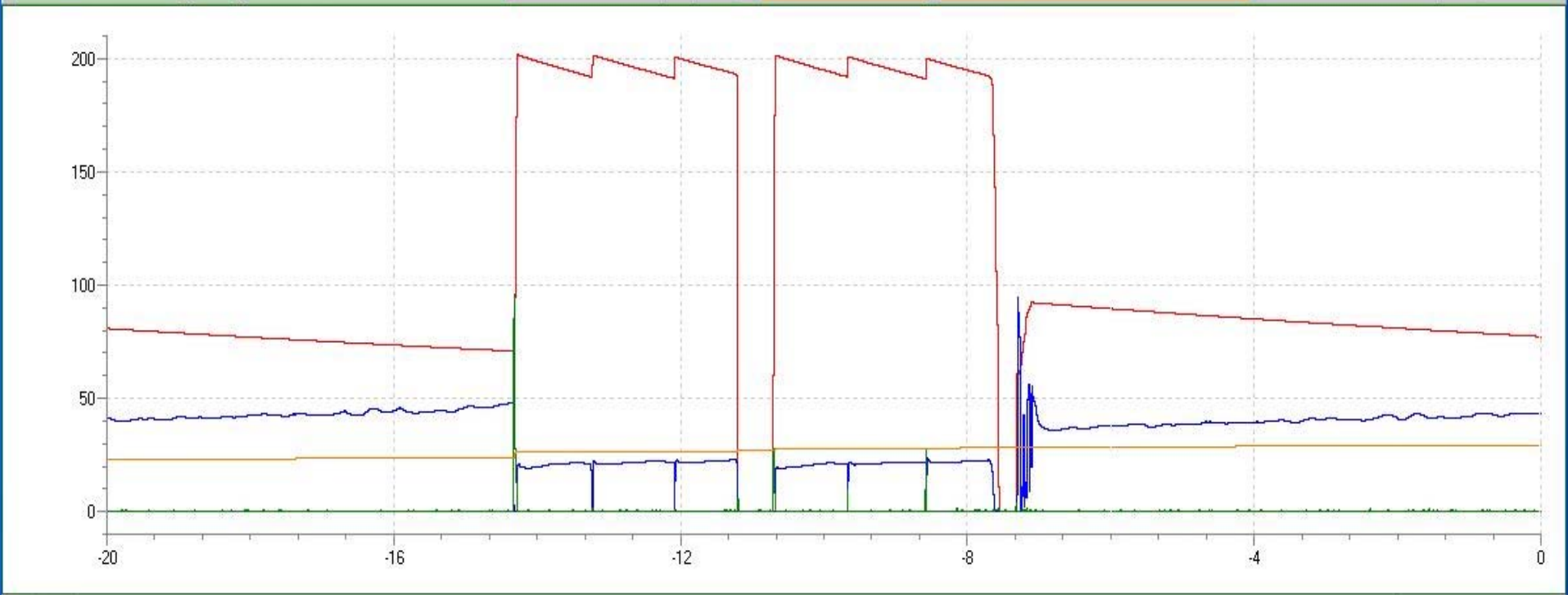
Framework General Vacuum Magnets Diagnostics Timing Insertion Devices Miscellaneous View

Strip Chart

M A N | 1m 2m 5m 10m 20m 30m 40m 1h 2h 4h 6h 10h 12h 18h 20h 24h 48h | RA | CT EST EDT UTC

Back Normal Linear Manual Scale 09 Oct 2007 19:11:29 to 10 Oct 2007 15:11:29 EST 0 20:00:00 Real Time Eastern Standard Time

SR11BCM01:CURRENT_MONITOR	+77.265 mA	SR11BCM01:LONG_LIFETIME_MONITOR	+43.2243 Hrs
SR14GRM01:DOSE_RATE_MONITOR	+0.07 µSv/Hr	SR14GRM01:DOSE_MONITOR	+29.431 µSv



Time: -0 09:28:11 Value: +82.453,987,73 10 Oct 07 15:11:31

Australian Synchrotron

Front End Schematic - 1

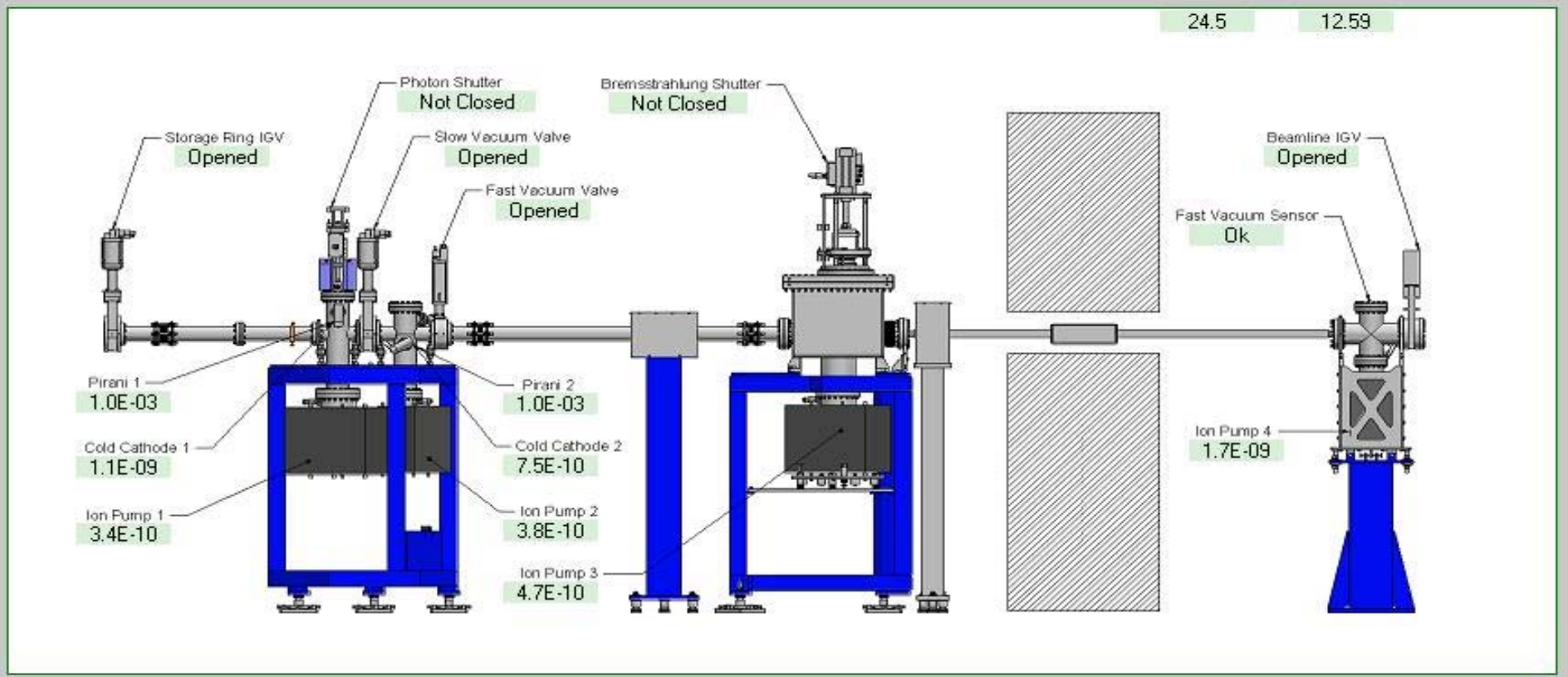
Framework General Vacuum Magnets Diagnostics Timing Insertion Devices Miscellaneous

Front End Schematic - Protein Crystallography 1

Select by Front End

1-ID	2-ID	3-ID	4-ID	5-ID	6-ID	7-ID	8-ID	9-ID	10-ID	11-ID	12-ID	13-ID	14-ID
1-BM1	2-BM1	3-BM1	4-BM1	5-BM1	6-BM1	7-BM1	8-BM1	9-BM1	10-BM1	11-BM1	12-BM1	13-BM1	14-BM1
1-BM2	2-BM2	3-BM2	4-BM2	5-BM2	6-BM2	7-BM2	8-BM2	9-BM2	10-BM2	11-BM2	12-BM2	13-BM2	14-BM2
1-IR	2-IR	3-IR											

Front End Control



10 Oct 07 15:02:31

Facility Status Monitor - build 125.03

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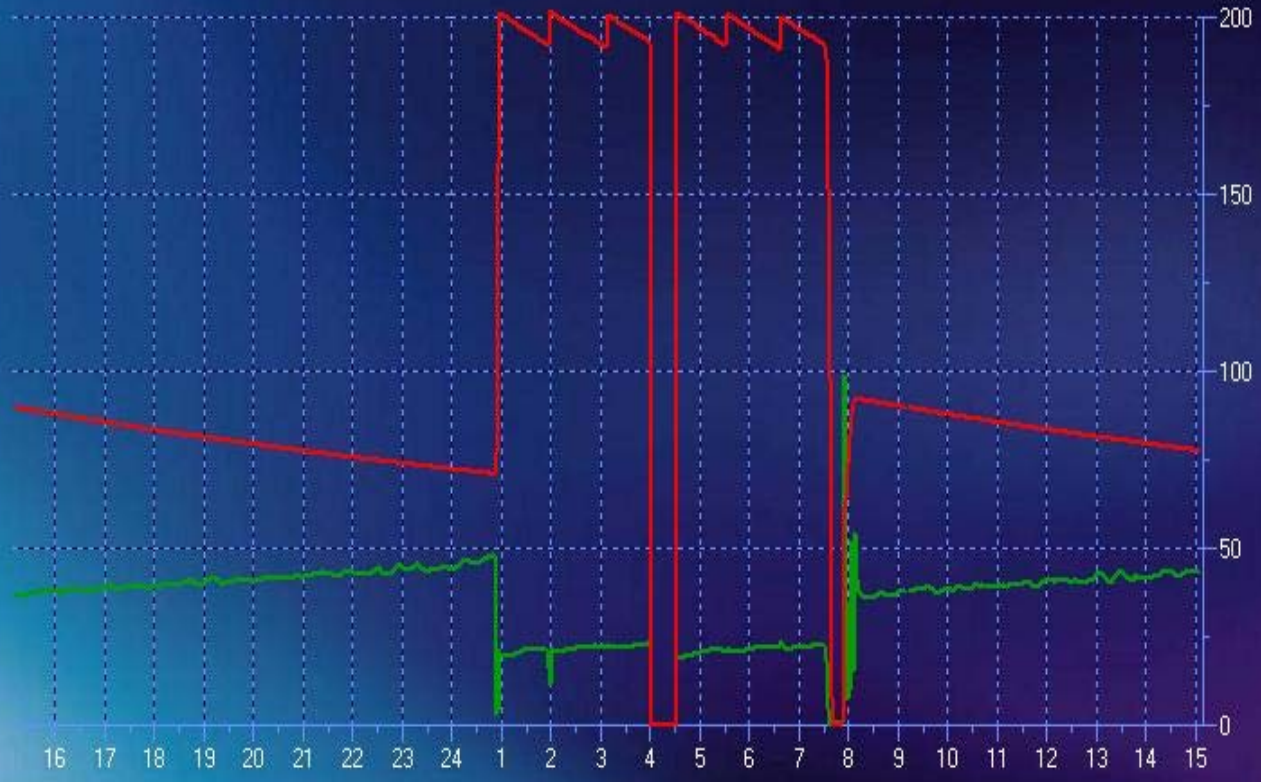
Control Room / Duty Officer Extn 123

Beam Current	Beam Lifetime	Current x Lifetime	Integrated Current
77.3 mA	46.5 Hrs	3.60 AHrs	354.2 AHrs



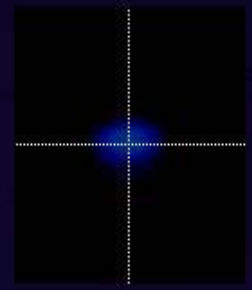
Next Injection	Next Current
16:00	200.0 mA

Position

X	-12.8 µm
Y	+11.1 µm

Size (FWHM)

X	250.0 µm
Y	137.9 µm



Beamline Status

PSS Master Shutter Enable	
Infra Red	
Protein Crystallography 2	
Protein Crystallography 1	
Microspectroscopy	
Medical Imaging	
Micro XRD/XRF	
Powder Diffraction	
X-Ray Absorption Spectroscopy	
Small/Wide Angle Scattering	
Soft X-Ray	

125.03

ailable... Stored beam available... Stored be

10 Oct 07 15:09:15

Hardware selections

EPICS for Linux was

A proper port of EPICS to a commercial real time Linux

Modbus EPICS driver for equipment and safety PLCs

PCI to VME bridge technologies

PC104 + solid state disks

Operating system selection

The use of specialist real-time operating systems can be important;

The real time work was provided by “Redhawk” propriety real time system

Later non realtime IOC’s on PC104 hardware and standard PC hardware was used.

Australian Synchrotron uses Linux operating systems for all critical data collection purposes and all user machines.

Could have avoided real time operating systems entirely.


Australian Synchrotron

Timing systems

commercial off the shelf timing systems have become available.
The master oscillator & RF distribution amplifiers.

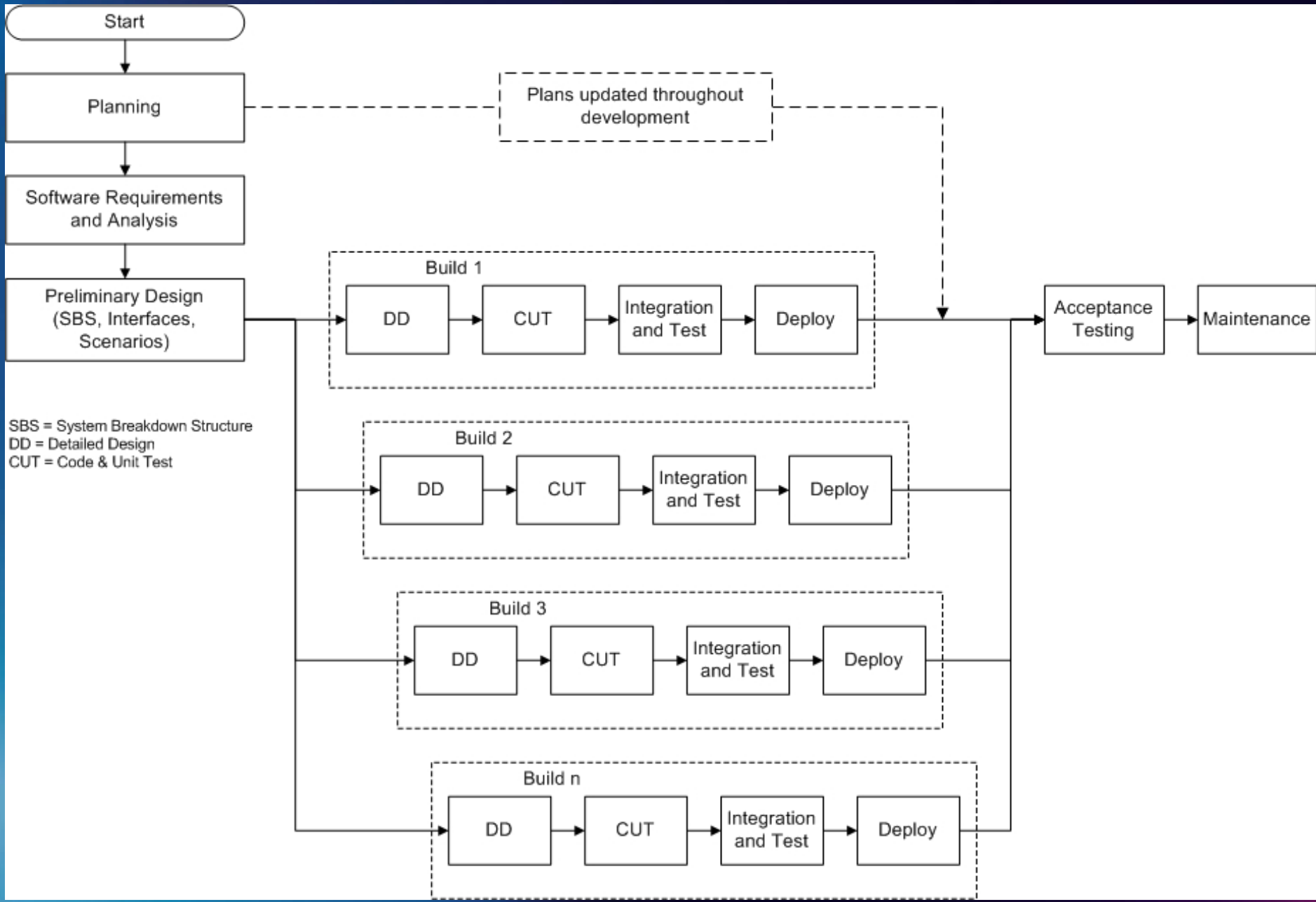
Conventional Facilities

Building controls, compressed air, HVAC systems, cooling water
effort required to pass data to the EPICS accelerator systems has been substantial.

External Peer Reviews
There were several external peer reviews
assure management that the controls successful.
provide minor corrections and good direction,

Engineering Approach

A standard systems engineering approach,
identifying the functional requirements,
sorting our the interfaces,
producing design documents,
creating the code
sourcing the hardware,
testing against the requirements
An incremental delivery approach
block interface diagrams, sequence diagrams,
collaboration diagrams, use cases and flow charts.


Start
Planning
Plans updated throughout development
Software Requirements and Analysis
Preliminary Design (SBS, Interfaces, Scenarios)
Build 1
DD
CUT
Integration and Test
Deploy
Acceptance Testing
Maintenance
SBS = System Breakdown Structure
DD = Detailed Design
CUT = Code & Unit Test
Build 2
DD
CUT
Integration and Test
Deploy
Build 3
DD
CUT
Integration and Test
Deploy
Build n
DD
CUT
Integration and Test
Deploy

Formal internal peer reviews

formal peer reviews for the design of each system.
“Pack” of information distributed amongst reviewers

The build system and source control
“Build” for the accelerator.
control very tightly exactly what software is deployed.
all EPICS code base, but also extends to PLC code.
useful when delivering incrementally,
deployed over 125 builds to the accelerator

LONG TERM OPERATIONS

operation for over twelve months beamlines for over six months.

machine has achieved over 95% uptime over the last six months.

Insourcing

e importance of having all source code in our configuration repositories

Bringing the various outsourced systems into a common environment

common components will decrease the spares count

increase the ability of staff

Source and configuration controls

Perforce a commercial but free for Open source developers

Bugzilla as the source control and bug/enhancement tracking tools respectively.

SUGGESTIONS FOR FUTURE PROJECTS

The following suggestions are made for future projects

- Get controls in early as you can,
- Get conventional facilities as part of the systems
- Standardise before any contracts
- Copy instead of reinventing where possible
- Don’t take too many risks, and manage those you do.
- Set realistic, milestones and goals
- See what works elsewhere
- Get good people and let them free.

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Farnsworth Law of control systems

Finally, a statement of some experience on the way:

“Controls gets squeezed most as time runs out.”

Australian Synchrotron site from the air, June 2006

Victoria
The Place To Be

Aerial view of the Australian Synchrotron with Melbourne CBD skyline

Community Open Day 20 March 2005 and again in August 2006