Availability and Controls

Tom Himel
SLAC

Controls GG meeting January 20, 2006

Contents

- The unavailability budget
- Major tools:
  - Hot swappability
  - Redundancy
- Helping other systems diagnose their problems

Availability Design Philosophy

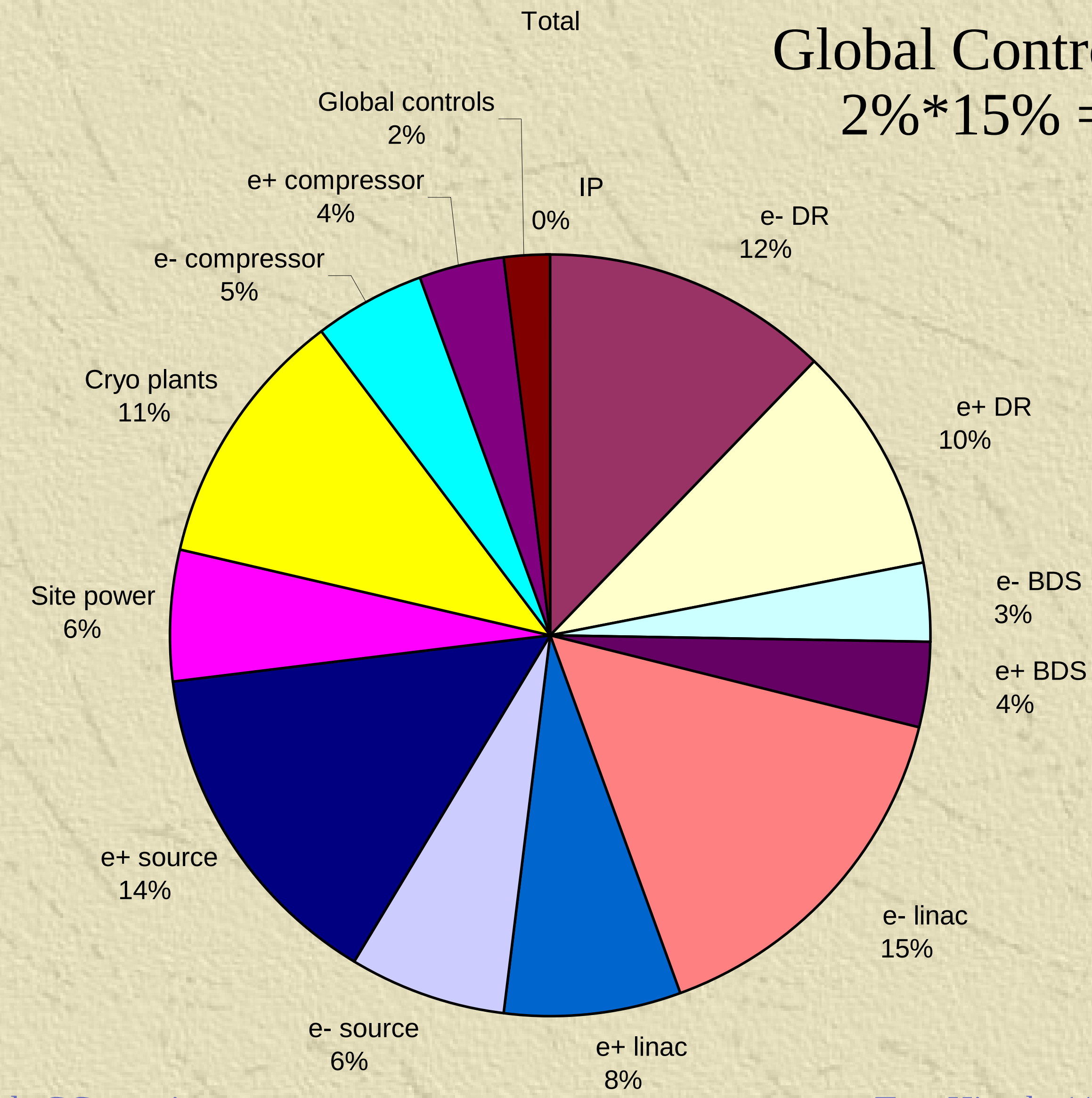
- Design it in up front.
- Budget 15% downtime total. Keep an extra 10% as contingency.
- Try to get the high availability for the minimum cost.
- First stab given here.
- Will need to iterate as design progresses.
  - Quantities are not final
  - Engineering studies may show that the cost minimum would be attained by moving some of the unavailability budget from one item to another.
  - This means some MTBFs may be allowed to go down, but others will have to go up.

Will Need Improvement Program

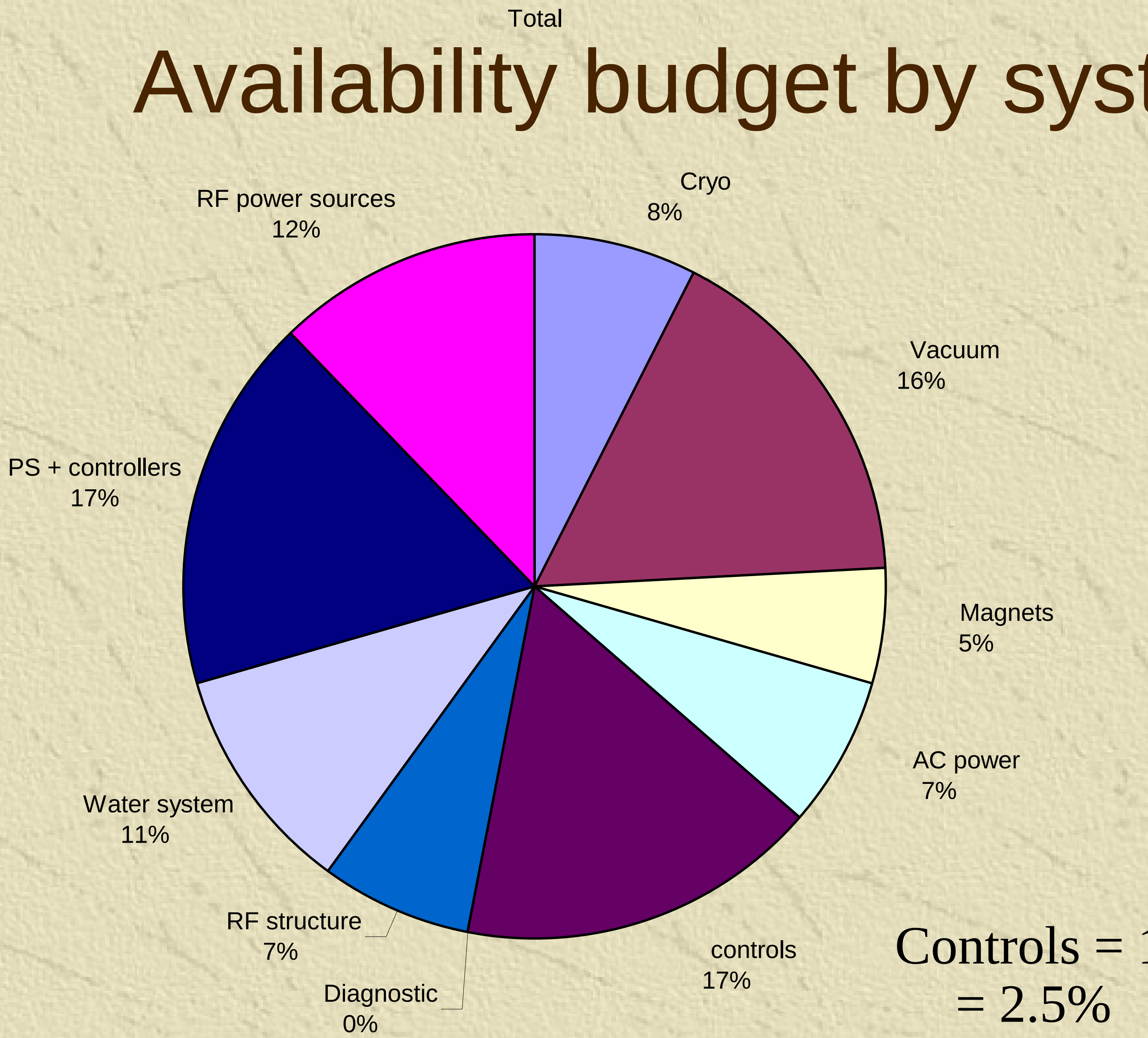
- Must design to meet the budget on the first pass.
- Assume we are only partly successful and unavailability will be too high when we turn on.
- Will need operations budget and engineering to make the necessary improvements.

Unavailability budget by region

Global Controls =
2%*15% = 0.3%



Availability budget by system



Controls = 17%*15%
= 2.5%

MTBF/MTTR requirements

Device	Improvement factor **A** that gives 17% downtime for 2 tunnel undulator e+ source	Downtime (%) due to these devices for 2 tunnel undulator e+ source with strong keep_alive	Nominal MTBF (hours)	Nominal MTTR (hours)
magnets - water cooled	**20**	0.4	1,000,000	8
power supply controllers	**10**	0.6	100,000	1
flow switches	**10**	0.5	250,000	1
water instrumention near pump	**10**	0.2	30,000	2
power supplies	**5**	0.2	200,000	2
kicker pulser	**5**	0.3	100,000	2
coupler interlock sensors	**5**	0.2	1,000,000	1
collimators and beam stoppers	**5**	0.3	100,000	8
all electronics modules	**3**	1.0	100,000	1
AC breakers < 500 kW		0.8	360,000	2
vacuum valve controllers		1.1	190,000	2
regional MPS system		1.1	5,000	1
power supply - corrector		0.9	400,000	1
vacuum valves		0.8	1,000,000	4
water pumps		0.4	120,000	4
modulator		0.4	50,000	4
klystron - linac		0.8	40,000	8
coupler interlock electronics		0.4	1,000,000	1
vacuum pumps		0.9	10,000,000	4
controls backbone		0.8	300,000	1

Hot-swappability

- Definition: An item is hot-swappable if it can be replaced without making anything else temporarily not work.
- If 1 channel of a 16 channel ADC is dead, and it requires a full module replacement to fix the bad channel, then it is not hot-swappable.
- Tried to make reasonable assumptions about what was hot-swappable.
- Both hardware and software need to support hot-swapping.

Parts spreadsheet
(double click to view)

This sheet gives a list of parts and their characteristics. It is used by all the sheets

component name subsys/segment	system	problem name	parameter effected	add/mult	degradation	MTTR	Still broken after repair	access needed?	n repair people	Starting MTBF	all in 1 tunnel, no robots	TESLA	all in 1 tunnel, robots	2 tunnels, access only with RF off
Bends beamline	Magnets	broken	luminosity	mult	0.00	8		1	2	2.0E+07	1	1	1	1
BPMs diagnostic	Diagnostic	broken	luminosity	mult	[illegible]	1		1	1	[illegible]	1	1	-1	0
Cavities cavity	RF structu	broken	energy overhead e+ sour	add	-31.14	[illegible]		1	2	[illegible]	1	1	1	1
Cavity piezo tuner cavity	RF structu	broken	energy overhead e+ sour	add	[illegible]	[illegible]		1	2	[illegible]	1	1	1	1
Cavity tuner cavity	RF structu	broken	energy overhead e+ sour	add	-31.14	672		1	2	1.0E+06	1	1	1	1
controls backbone sector	controls	broken	luminosity	mult	0.00	1		1	1	3.0E+05	1	**0**	**0**	0
Controls PPS region	controls	broken	luminosity	mult	0.00	1		1	1	3.0E+05	1	**0**	**0**	0
Corrs - can't tune around beamline	Magnets	broken	luminosity	mult	0.00	2		1	2	1.0E+07	1	1	1	1
Corrs - can tune around beamline	Magnets	broken	luminosity	mult	0.00	0.5	quad or co	-1	2	1.0E+07	-1	-1	-1	-1
coupler interlock electronics coupler	RF structu	broken	energy overhead e+ sour	add	-747.36	1		1	1	1.0E+06	1	1	**-1**	0
coupler interlock sensors coupler	RF structu	broken	energy overhead e+ sour	add	-747.36	1		1	1	5.0E+06	1	1	1	1
cryo JT valve cryo string	Cryo	broken	energy overhead e+ sour	add	-2491.20	2		1	2	3.0E+05	1	1	1	1
cryo vac enclosure cryo module	Cryo	broken	energy overhead e+ sour	add	-2491.20	8		1	2	1.0E+07	1	1	1	1
cryo vac enclosure cryo segment	Cryo	broken	luminosity	mult	0.00	8		1	2	1.0E+07	1	1	1	1
Electrical - .05<<0.5 beamline	AC power	broken	luminosity	mult	0.00	2		1	2	3.6E+05	1	1	1	0
Electrical - .05<<0.5 klystron	AC power	broken	energy overhead e+ sour	add	-747.36	2		1	2	3.6E+05	1	**0**	1	0
Electrical - .05<<0.5 Utility power	AC power	broken	luminosity	mult	0.00	2		1	2	3.6E+05	1	1	1	0
Electrical - >0.5 beamline	AC power	broken	luminosity	mult	0.00	4		1	2	3.6E+05	1	1	1	0
Electrical - >0.5 klystron	AC power	broken	energy overhead e+ sour	add	-747.36	4		1	2	3.6E+05	1	**0**	1	0
Electrical>0.5 Utility power	AC power	broken	luminosity	mult	0.00	4		1	2	3.6E+05	1	1	1	0
FC pulser beamline	PS + conti	broken	luminosity	mult	0.00	2		1	2	3.5E+04	1	**-1**	**-1**	0
Flow Switch - quads beamline	Water sys	broken	luminosity	mult	0.00	1		1	1	2.5E+06	1	1	**-1**	1
Flow Switch beamline	Water sys	broken	luminosity	mult	0.00	1		1	1	2.5E+06	1	**0**	**-1**	0
Flow Switch klystron	Water sys	broken	energy overhead e+ sour	add	-747.36	1		1	1	2.5E+06	1	**-1**	**-1**	0
Flux Concentrator beamline	Magnets	broken	luminosity	mult	0.00	8	spare targe	-1	1	2.0E+07	-1	-1	-1	-1
HVPS beamline	PS + conti	broken	luminosity	mult	0.00	2		1	2	1.0E+06	1	1	1	1
HVPS controller beamline	PS + conti	broken	luminosity	mult	0.00	1		1	1	1.0E+06	1	1	**-1**	0
insulating vacuumP cryo module	Cryo	leak	energy overhead e+ sour	add	0.00	8		1	2	1.0E+05	1	1	1	1
insulating vacuumP cryo string	Cryo	leak	energy overhead e+ sour	add	-2491.20	8		1	2	1.0E+05	1	1	1	1
Kicker diagnostic	Diagnostic	broken	luminosity	mult	0.95	8		1	2	1.0E+05	1	1	1	1
Kicker pulser - ext beamline	PS + conti	broken	e+ source ext kick	add	-0.03	2		1	2	3.5E+04	1	1	**-1**	1
Kicker pulser - inj beamline	PS + conti	broken	e+ source inj kick	add	-0.03	2		1	2	3.5E+04	1	1	**-1**	1
Kicker pulser beamline	PS + conti	broken	luminosity	mult	0.00	2		1	2	3.5E+04	1	1	**-1**	1
Kicker pulser diagnostic	Diagnostic	broken	luminosity	mult	0.95	2		1	2	3.5E+04	1	1	**-1**	1
Kickers - extraction beamline	Magnets	broken	e+ source ext kick	add	-0.03	8		1	2	1.0E+05	1	1	1	1
Kickers - injection beamline	Magnets	broken	e+ source inj kick	add	-0.03	8		1	2	1.0E+05	1	1	1	1
Kickers beamline	Magnets	broken	luminosity	mult	0.00	8		1	2	1.0E+05	1	1	1	1
Klys Power supply klystron	RF power s	broken	energy overhead e+ sour	add	-18.00	4		1	2	5.0E+04	1	**-1**	1	0
klys pre-amp klystron	RF power s	broken	energy overhead e+ sour	add	-747.36	1		1	1	1.0E+05	1	**-1**	**-1**	0
Klystrons klystron	RF power s	broken	energy overhead e+ sour	add	-747.36	8		1	2	4.0E+04	1	1	1	0
laser beamline	Diagnostic	broken	luminosity	mult	0.00	2		-1	2	2.0E+04	**-1**	-1	-1	**-1**
Laser PS beamline	PS + conti	broken	luminosity	mult	0.00	2		-1	2	1.0E+06	**-1**	-1	-1	**-1**
laser wires diagnostic	Diagnostic	broken	luminosity	mult	0.95	2		-1	2	2.0E+04	**-1**	-1	-1	**-1**
LLRF cavity	RF structu	broken	energy overhead e+ sour	add	-31.14	1		1	1	3.0E+05	1	1	**-1**	0
LLRF klystron	RF structu	broken	energy overhead e+ sour	add	-16.94	1		1	1	3.0E+05	1	1	**-1**	0
local backbone sector	controls	broken	luminosity	mult	0.00	1		1	1	3.0E+05	1	**0**	**0**	0
Modulators klystron	RF power s	broken	energy overhead e+ sour	add	-747.36	4		1	2	5.0E+04	1	**-1**	**-1**	0
mover controller beamline	PS + conti	broken	luminosity	mult	1.00	1		1	1	1.0E+06	1	1	**-1**	0
movr or trim beamline	Magnets	retuned	luminosity	mult	0.99	2		1	2	1.0E+50	1	1	1	1
MPS & FastFdbk region	controls	broken	luminosity	mult	0.00	1		1	1	5.0E+03	1	**0**	**0**	0
MPS & FFWD region	controls	broken	luminosity	mult	0.00	1		1	1	5.0E+03	1	1	**0**	0
Octupoles beamline	Magnets	broken	luminosity	mult	0.00	8		1	2	2.0E+07	1	1	1	1
other controls beamline	controls	broken	luminosity	mult	0.00	1		1	1	3.0E+05	1	1	**-1**	0
other controls klystron	controls	broken	energy overhead e+ sour	add	-747.36	1		1	1	3.0E+05	1	1	**-1**	0
power coupler coupler	RF structu	broken	energy overhead e+ sour	add	-747.36	16		1	2	1.0E+07	1	1	1	1
power coupler disc coupler	RF structu	disc	energy overhead e+ sour	add	-31.14	672		1	2	1.0E+50	1	1	1	1
Power supplies - bend beamline	PS + conti	broken	luminosity	mult	0.00	2		1	2	1.0E+06	1	1	**-1**	0
PS - quad can tune around beamline	PS + conti	broken	luminosity	mult	0.00	2	quad or co	-1	2	1.0E+06	-1	-1	-1	-1
PS Corrs can tune around beamline	PS + conti	broken	luminosity	mult	0.00	0.5	quad or co	-1	1	4.0E+05	-1	-1	-1	-1
PS Corrs can't tune around beamline	PS + conti	broken	luminosity	mult	0.00	2		1	1	4.0E+05	1	1	**-1**	0
Power supplies individual beamline	PS + conti	broken	luminosity	mult	0.00	4		1	2	1.0E+06	1	1	**-1**	0
Power supplies strings beamline	PS + conti	broken	luminosity	mult	0.00	4		1	2	1.0E+06	1	1	**-1**	0
Power supplies Trims beamline	PS + conti	broken	luminosity	mult	0.99	1		1	1	4.0E+05	1	1	**-1**	0
PS controller - bend beamline	PS + conti	broken	luminosity	mult	0.00	1		1	1	1.0E+06	1	1	**-1**	0
PS controller - corr can tune around b	PS + conti	broken	luminosity	mult	0.00	0.5	quad or co	-1	1	1.0E+06	-1	-1	-1	-1
PS controller - quad can tune around	PS + conti	broken	luminosity	mult	0.00	1	quad or co	-1	1	1.0E+06	-1	-1	-1	-1
PS controller - corr can't tune around	PS + conti	broken	luminosity	mult	0.00	1		1	1	1.0E+06	1	1	**-1**	[illegible]

Redundancy

- Complex redundancies (energy overhead, extra DR kickers, spare klystron/modulator) are directly accounted for in availsim.
- Simpler redundancies like having 5 power supply regulators where only 4 are needed are not modeled in detail by availsim. Their effect is put in by having a longer MTBF for the overall power supply.
- That is **you** must calculate the system MTBF given the redundancy and the time to repair a bad part that didn't bring the full system down.
- If one part of your system is redundant, it is likely that single points of failure in the non-redundant parts will dominate the MTBF.
- In the calculation of the overall MTBF, it is necessary to know the time to repair the redundant part that broke. Some rules of thumb to use:
  - If it is in the accelerator tunnel: 2 months
  - If it is accessible with beam on but not hot-swappable (repairable without bringing the beam down): 1 week
  - If it accessible with beam on and hot-swappable: 2 hours

Software

- Haven't explicitly budgeted for software downtime. Probably need to. How much?
- Good to make ILC able to run through changes in DB structure, software downloads, and maybe even boots of computers.
- Have uniform user interface with all (even "expert") diagnostics available. Strive to not need experts.

Two aspects to control and availability

- Controls itself should not go down often. That is what we have been addressing above
- Controls needs to give tools to help discover what is wrong in other systems.

Tools to help other systems

- Network access for laptops and diagnostic equipment near all hardware
- Readout and recording of diagnostic information built into other systems (e.g. a power supply may record its voltage and current at a megahertz)
- Either record everything very often or allow flexibly triggered readout of everything or both.
- Provide analysis tools of the data that is recorded.

Example of need for sync readout Based on SLC "flyer pulses"

- Infrequently a single bunch causes very high backgrounds. Need to figure out why.
- Only know few seconds after the fact that a bunch was bad.
- Could be caused by bad kicker pulse. Need to know kicker strength on each bunch.
- Could be caused by DR phase instability (saw tooth). Need to know orbit and phase of that bunch on many turns prior to extraction

Help Solve Subtle Problems

- Phase drifts – compare redundant readouts
- Lying BPMs – chisquared? Redundancy?
- Drifting BPMs (both mechanical and electrical)
- Difficult to localize problems (normal module swaps don't fix it). E.g. noise coupling in on long cable or flakey connector.
- Vacuum bursts in DRs (present PEP problem) – read 1/sec, provide good analysis package

Summary

- We have a starting unavailability budget.
- It will be refined as engineering continues
- Upfront planning is essential to achieve the challenging budget.
- Must also help other systems diagnose their problems