Availability Task Force:

Gathering ‘best practice' MTBF data for modeling with Availsim

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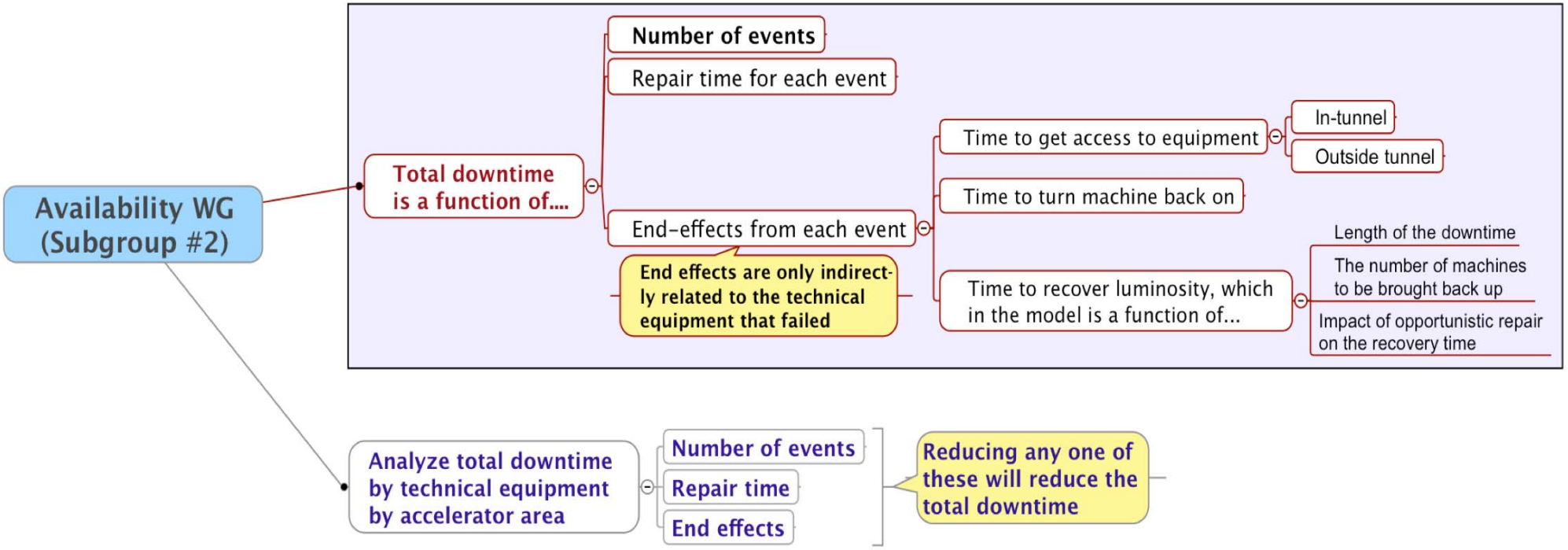
Context

- Availability Working Group is studying issues associated with single tunnel linac for the two HLRF configurations

- Availsim largely uses operations experience and availability data from a single facility (SLC)
  - **Large database of component reliability experience**
  - **Operations / maintenance model**
  - **Represents machine experience, but may not represent the 'best in class' for all the individual elements**

- Revise the component database to selectively use 'best in class' availability data
  - **It's in our interest to show availability in a positive light,**
  - **Element-by-element use the best reliability numbers we can defend**

Too many components to go after the best data for every one – select and sort based on Availsim output



- Analyze downtime events by Area System and Technical System
- Are there dominant effects from...?
  - **End effects, eg tunnel access times, time to recover luminosity**
  - **Repair times for particular components**
  - **Numbers of failures of particular components**
- Will provide valuable guidance for future simulations

Availsim output:
Ranked downtime events over 20yrs

Sum of n failures causing down	re	sub													
system	comp name	e+ source	e- DR	e+ DR	e- linac	e+ linac	e+ compressor	e- compressor	e- source	e+ BDS	e- BDS	Cryo plants	Site power	Global controls	IP	Grand Total
PS + controllers		362	386	350	204	209	98	98	92	21	25				0	1845
controls		179	124	114	186	203	59	59	101	221	220					1466
RF power sources		70	21	24	88	46	168	139	67	17	15					655
Vacuum		157	51	58	54	50	5	8	19	24	25					451
Water system		87	37	45	22	13	40	40	38	32	18					372
RF structure		32	21	35	42	19	64	73	34	1	3					324
AC power		15	56	56	60	41	20	23	28	10	12					321
lumped												117	57	40		214
Magnets		16	21	20	4	5	4	1	6	34	35					146
Cryo		8	2	1	31	16	9	4	3	2	0					76
Diagnostic		0	0	0	0	0	0	0	4	0	0					4
schedMaint															0	0
Grand Total		926	719	703	691	602	467	445	392	362	353	117	57	40	0	5874

Availsim output:
Ranked downtime events over 20yrs

Sum of n failures causing down	re	sub													
system	comp name	e+ source	e- DR	e+ DR	e- linac	e+ linac	e+ compressor	e- compressor	e- source	e+ BDS	e- BDS	Cryo plants	Site power	Global controls	IP	Grand Total
PS + controllers		362	386	350	204	209	98	98	92	21	25				0	1845
controls		179	124	114	186	203	59	59	101	221	220					1466
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schedMaint															0	0
Grand Total		926	719	703	691	602	467	445	392	362	353	117	57	40	0	5874

Availsim output: Ranked downtime fraction over 20yrs

Sum of 09:13 ILC2 but with undulator e+ a															
system	comp name	e- linac	Cryo plants	e+ source	e- DR	e+ DR	e+ linac	Site power	e- source	e- compressor	e+ compressor	e+ BDS	e- BDS	Global controls	IP	Grand Total
lumped			241					112						44		396
controls		36		33	30	18	25		26	10	5.8	24	25			232
PS + controllers		28		38	60	38	19		16	12	6.1	4.2	4.1		0	225
Vacuum		29		81	29	27	14		8.5	5.2	1.3	14	12			221
RF power sources		82		5.8	13	12	24		11	15	15	0.7	0.6			179
Water system		17		43	23	20	8.7		12	5.1	5.3	6.9	4.6			146
AC power		22		3.7	26	15	10		10	4.6	1.8	2.4	3.3			99.4
Cryo		42		9.6	3.2	1.2	17		4.6	6.9	11	3.1	0			98.6
RF structure		17		8.6	5.2	5.3	8.2		12	20	15	0.1	0.8			92.1
Magnets		0.7		14	26	21	0.6		5	0.1	0.2	4.6	3.9			75.4
Diagnostic		0		0	0	0	0		1.3	0	0	0	0			1.3
schedMaint															0	0
Grand Total		273	241	236	216	157	126	112	108	80	61	60	54	44	0	1766

Divide the numbers by 100 to get downtime in percent
(based on 6570 operating hours per year)

Availsim output:
Ranked downtime fraction (expanded) over 20yrs

Sum of n failures causing down		re	subr														
system	comp name	e+ source undulator	e+ source transport	e- linac	target1	target2	after target	e+ source Total	e- DR	e+ DR	e- linac	e+ linac	e+ compressor	e- compressor	e- source	e+ BDS	e- BDS	Cryo plants
PS + controllers	PS Corrs can tune around beamline	96	74	35				205	194	153	101	113	62	64	47			
	PS controller - corr can tune around beamline	68	38	17				123	168	171	38	47	35	29	23			
	PS - quad can tune around beamline										32	28						
	PS controller - quad can tune around beamline										33	21						
	Power supplies strings beamline	4	2	0	2			8	3	8			0	3	8	1	0	
	PS controller string beamline	1	4	2	1			8	2	7			1	2	2	0	2	
	Power supplies individual beamline															11	13	
	PS Corrs can't tune around beamline				6			6							7	6	4	
	PS controller - corr can't tune around beamline				7			7							4	3	6	
	Kicker pulser - inj beamline								14	2								
	Kicker pulser - ext beamline								5	9								
	FC pulser beamline					5		5										
	HVPS beamline														1			
	mover controller beamline	0						0							0	0	0	
	HVPS controller beamline														0			
	Power supplies - bend beamline																	
	Laser PS beamline														0			
	Kicker pulser beamline	0	0	0	0			0							0	0	0	
	Power supplies Trims beamline	0	0	0	0			0	0	0			0	0	0	0	0	
PS + controllers Total		169	118	54	16	5		362	386	350	204	209	98	98	92	21	25	
controls		60	32	47	39		1	179	124	114	186	203	59	59	101	221	220	
RF power sources				70			0	70	21	24	88	46	168	139	67	17	15	
Vacuum		32	112	5	5	3	0	157	51	58	54	50	5	8	19	24	25	
Water system		32	9	27	18		1	87	37	45	22	13	40	40	38	32	18	
RF structure				32			0	32	21	35	42	19	64	73	34	1	3	
AC power		5	1	6	3		0	15	56	56	60	41	20	23	28	10	12	
lumped																		117
Magnets		9	3	1	1	2		16	21	20	4	5	4	1	6	34	35	
Cryo		0	0	8	0			8	2	1	31	16	9	4	3	2	0	
Diagnostic		0	0	0	0			0	0	0	0	0	0	0	4	0	0	
schedMaint																		
Grand Total		307	275	250	82	10	2	926	719	703	691	602	467	445	392	362	353	117

Divide the numbers by 100 to get downtime in percent (based on 6570 operating hours per year)

Availsim output: Ranked downtime events by component

Sum of n failur | region | subregion

comp name	e+ source	e- DR	e+ DR	e- linac	e+ linac	e+ compressor	e- compressor	e- source	e+ BDS	e- BDS	Cryo plants	Site power	Global controls	IP	Grand Total
PS Corrs can tune around beamline	205	194	153	101	113	62	64	47							939
MPS & FastFdbk region	116	41	44			26	25	58	210	206					726
PS controller - corr can tune around b	123	168	171	38	47	35	29	23							634
local backbone sector	48	74	63	97	119	4	9	23	7	8					452
VacV controller beamline	123	42	47	38	44	5	5	12	15	18					349
Electrical - .05<<0.5 Utility power	11	53	53	54	37	3	9	24	4	9					257
coupler interlock electronics coupler	25	0	3	32	13	44	56	27	1	0					201
Klystrons klystron	18	6	7	34	17	46	39	18	3	8					196
Modulators klystron	14			16	10	39	29	18	6	1					133
cryo plant beamline											117				117
other controls klystron	9	4	3	15	4	22	20	16	1	4					98
VacG/Ctrl klystron	14	4	4	12	4	29	19	7	1	1					95
VacP power supply klystron	8	5	5	11	5	23	17	10	4	3					94
Water instr beamline	22	6	8	4	3	4	1	11	10	9					87
MPS & FFWD region				37	44										81
klys pre-amp klystron	8	1	1	7	6	20	28	8	1	0					80
Water pumps klystron	5	4	2	6	3	19	18	9	4	2					72
VacV beamline	29	7	9	13	6	0	2	0	2	4					72
VacP power supply coupler	2	21	32	1	0	7	6	0	0	0					69
Water pumps beamline	20	7	9	3	3	2	2	8	7	5					66
Flow Switch - quads beamline	27	18	20			1	0	0	0	0					66
Water instr klystron	10	2	2	7	4	12	16	7	3	1					64
Q/S Movers beamline	0								31	33					64
PS - quad can tune around beamline				32	28										60
site power beamline												57			57
PS controller - quad can tune around beamline				33	21										54

Consider four categories of equipment...

- Commodity equipment
  - **We buy the quality of service we want (or can afford)**
  - **eg controls backbone network**
- ‘Standard’ accelerator components
  - **Vacuum pumps, flow switches, circuit breakers, ...**
  - **COTS parts**
- Technical systems with large operating base
  - **Magnets, power supplies, controls,...**
  - **Good statistics for reliability estimates**
- Technical systems with little / no operating base
  - **Newly developed parts, challenging specs**
  - **Insufficient data for estimating MTBF**

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  Industry

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  - **COTS parts**

  Accelerators + industry

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  Accelerators

- Technical systems with little / no operating base
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  - **Insufficient data for estimating MTBF**

  Hmm...

Reasonable MTBFs for unproven technologies?

- Difficult

- Could be extrapolated based on failures over a number of test hours ...but only to a limited extent
  - **Eg 10,000hrs without a failure might be enough to claim an MTBF of 30,000+hrs (but not 300,000hrs)**
- Can be estimated using data from similar equipment
- Calculate using one of several methods (maybe)

- Suggest using best guess based on engineering experience, iterate with data from Availsim to help assess what's needed.

Some work to apply and integrate data from different facilities

- It will take some work and some experience to integrate with our Availsim data
  - **'Commodity' elements should be straight forward, eg computing infrastructure**
- For the rest (accelerators)... plenty of data, but...
  - **May be categorized differently**
  - **May be somewhat different contexts and applications, eg is klystron running at 100% or 80% of max power?**
  - **Based on different operations and maintenance models**
- OK, so let's start...