

Operations Sparing Plan Approach

- A brief presentation at the 7/31/2013 Systems weekly meeting to explain the basic approach for developing a sparing plan for aLIGO operations.
- See also the companion document T1300519, "Sparing Analysis"
- While purchase and maintenance of spares in the aLIGO era is an operations task, definition of the sparing plan is an aLIGO project task.

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Sparing Plan

- We need a bottom-up estimate of the spares required for minimal down-time
 - » Budgeting
 - » Logistics/ordering
- Likely that best tool to use is "RAMI" (reliability, availability, maintainability, inspectability) software
 - » Integrates spares list with system reliability model, FMECA model, etc.
 - » Can readily update/maintain sparing analysis input based on experience/data
 - » Can perform more sophisticated failure analysis if/as required
 - » Expensive, requires training & learning curve, etc.
 - » Currently investigating software, e.g. ReliaSoft ...
- For now use Excel template (T1300519) to gather inputs

Sparing Plan

 Once each subsystem has provided sparing plan inputs using the Excel template (T1300519) –

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- » An initial spares plan will be published [aLIGO project scope]
- » Consultants will be hired to review the initial reliability (failure/repair rates) for the electronics in an effort to provide better input data to the initial plan [aLIGO project scope]
- » The spares plan & analysis will be improved upon and maintained (including updates for as-experienced failure/repair rates) [Operations scope]
- Eventually we will likely migrate from the Excel template to a RAMI software tool [Operations scope]

Sparing Analysis Inputs

- LRU = Line-Replaceable Unit (or Lowest Replaceable Unit)
 - » Component, or module, level at which spares are stocked and failed units are repaired and/or replaced

• For each LRU:

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- » Identified by LRU by name & part number
- » Also define the next higher level assembly name & part number
- » Define source or manufacturer
- » Define replacement cost (hardware/supply/equipment/procurement cost, not labor)
- » Define repair cost (for most likely repair)
- » MTBF = Mean Time Between Failure; the mean (average) time between failures (repairable or not) [hrs]
 - FR = Failure Rate, $\lambda = 1/MTBF$ [#/hr]
- » MTBR = Mean Time Between Repairs; the mean (average) time between repairs [hrs]
- » Quantities
 - #LRUs required per interferometer
 - #LRU spares likely to be delivered by aLIGO project to Operations
- Don't worry about the calculated spares inventory and replenishment rates & costs calculated in the Excel spreadsheet
 - » Systems will review/fix/revise these in the integrated spares plan

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Sparing Analysis Input Estimates

- If you don't know, then take a 'best guess' (aka an "engineering estimate")
 - » Better to have some reasonable spares plan base on estimates, than no spares plan due to lack of input!
 - » This applies to failure & repair rates (MTBF and MTTR respectively) as well as quantities
- Use the comment field to identify the source(s) of data and the maturity/reliability of the inputs, e.g.
 - » "MTBF is just a order-of-magnitude estimate"
 - » "Replacement costs is just a ballpark guess"
 - » "Not sure of the surviving number of in-process spares; this is a conservative estimate"
 - » This allows us to track which inputs need more attention/refinement as we improve the plan over time

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Sparing Plan Example – SUS partial/incomplete

• Create/assemble bill of materials (BOM) for LRUs

	1	Level	Rack	Rack Desc	Rack #	Chassis	Chassis #	Chassis Qty/rack	LRU	LRU #	LRU Qty/chassis	K LRU Qty/rack
	2	3							Production Monitor Board	D070480	1	
									QUAD and Triple Coil Driver			
	3	3						5	Boards	D0902747	1	
1	_					Triple Top Coil Driver Chassis						
	4	2				Top Assembly	D1001242	5				
	5	3						2	AA & AI filter bd	D070081	4	
	6	3						2	ADC AA Interface	D070100	1	
	7	3							Chassis Power Regulator PCB	D1000217	1	2
-	_					AA Chassis Top Assembly						
	8	2				Drawing (8xDB9 Version)	D0902783	2				
	9	3						3	AA & AI filter bd	D070081	2	(
									18-bit DAC to Anti-Image			
	10	3						3	Interface Board	D1000551	1	
	11	3							Chassis Power Regulator PCB	D1000217	1	
-						18-bit AI Chassis Top						
	12	2				Assembly Drawing (4xDB9	D1000305	3				
	13	3				/ 81		6	Production Monitor Board	D070480	1	
									Triple Suspension Acquisiton			
	14	3						6	Coil Driver	D0901047	1	
-						Triple Acquisition Driver						
	15	2				Chassis Top Assembly	D090006	6				
								-	Binary Out Interface Board (2 x			
	16	3						2	DB9F, 4 x DB25F)	D1002613	1	2
									64 Channel Binary Output			
	17	3						2	Printed Circuit Board	D1001266	1	2
						Binary Output Interface						
-						Chassis (DB9 DB25 version)						
-	18	2				Top Assembly	D1000725	2				
									SUS Binary In Interface Board			
	19	3						2	(2xDB9M, 4xDB25M)	D1002628	1	. 2
	_								64 Channel Binary Input			
	20	3						2	Printed Circuit Board	D1001036	1	
						Binary Input Interface Chassis						
-						(2xDB9M,4x DB25M version)						
_	21	2				Top Assembly	D1000726	2				
	22		L1-SUS-C1	HAM3-4	D1200856							
		_							AA Interface Board 2 x 9 Dsub,			
	23	3						6	2 x 25 Dsub	D10000486	1	6

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Sparing Plan Example – SUS partial/incomplete

Use LRU BOM to determine quantities

6 Rack List	SUS Chassis List	
v Labels 🖛		Т,
	18-bit AI Chassis Top Assembly Drawing (4xDB9 Version)	
US-C1	D1000305	
SUS-C2	AA Chassis Top Assembly Drawing (8xDB9 Version)	
SUS-C3	D0902783 A Monitor Chassis Top Assembly (2xDB9 and 2xDB25 version)	
US-C4	D1000721	
	Binary Input Interface Chassis (2xDB9M,4x DB25M version) Top Assembly	,
SUS-C5	D1000726	
SUS-C6	Binary Input Interface Chassis (8xDB9 Male Version) Top Assembly	
SUS-C7	D1001726	
SUS-C8	Binary Output Interface Chassis (DB9 DB25 version) Top Assembly	
US-R1	D1000725	
	HAM-A Coil Driver Chassis Top Level Assembly Drawing	
SUS-R2	D1100687	
US-R3	IO Expansion Chassis - Top Assembly D1001715	
US-R4	PUM Coil Driver Chassis Top Assembly	
US-R5	D1100303	
JS-R6	Quad Top Coil Driver Chassis Top Assembly	
	D1001782	
JS-XC1	SUS Binary Out Interface Chassis (8 x DB9 Female version) Top Assembly	
JS-XC2	D1002593	
JS-XR1	Triple Acquisition Driver Chassis Top Assembly	
US-YC1	D090006	
	Triple Top Coil Driver Chassis Top Assembly	
US-YC2	D1001242	
US-YR1	UIM Coil Driver Chassis Top Assembly	3

Count of LRUs from Racks	
Row Labels	Sum of LRU
■ 18-bit DAC to Anti-Image Interface Board	8
D1000551	8
= 64 Channel Binary Input Printed Circuit Board	6
D1001036	6
= 64 Channel Binary Output Printed Circuit Board	6
D1001266	6
∃AA & AI filter bd	92
D070081	92
■ AA Interface Board 2 x 9 Dsub, 2 x 25 Dsub	13
D10000486	13
	7
PCIe-16AI64SSC-64-50M	7
🗏 ADC AA Interface	19
D070100	19
🗏 ADC Adapter boards, 16 bit	7
D0902006	7
ADC Adapter boards, 18 bit	7
D1000654	7
🗏 Binary IO card	7
PN DIO-1616L-PE	7
■ Binary Out Interface Board (2 x DB9F, 4 x DB25F)	4
D1002613	4
Binary Out Interface Board (8 x DB9 Female)	2
D1001050	2
Chassis Power Regulator PCB	31
D1000217	31
🗏 Duotone board	7
D080335	7
= HAM-A Coil Driver	4
D1100117	4
🗏 Interface backplane	7
D0902029	7



Sparing Plan Example – SUS partial/incomplete

• Estimate, or look-up, input parameters for the LRUs

| | ON PARTIAL | SUS EXAMP | LE | | | | | | | |
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|---|---|---|--|--|--|---|---|--|--|--
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---|---|
| ssembly | LRU
Item/Part Name | Part Number
(COTS)
Drawing Number
(custom) | Source/
Manufacturer | Units
(board, optic, meter,
each, etc.) | COTS (Y.N)
Lead Time
(months) | Purchase Price
per unit (\$) | Repairable? (Y.N) | MTTR (days)
Repair Cost
ber unit (\$) | In Vacuum (Y/N)
Fradility (LM/H) | Criticality (LM/H) | MTBF or MTBR
(hrs) [1/ 1,
 | Shelf Lifetime (yrs)
Duty Cycle | Duty cycle | olect |
 | # Replenishment
Spares
per year

 | Replensihment Cost
per year
 | Factor (N* 1.R) | Actual Confidence | Min # Inventory
Req'd | Number to initially
purchase | Spares Inventory
 | 2
Comments, DCC#s |
| I suspensions except | B-OSEM | D060218 | U of Birmingham | each | N 9 | | | | | |
 | | 00. | 178 9 | 1
 | 1.123

 | \$140
 | 0.277 | | | 1 0 |
 | see MTBF estimate in E1000289-v1, but this is updated with failure data
the PD from E1000177-v1
see OTSEM court in E1000042-v2, but note that FM qtv becomes spares
see rough unit costs in M070018-v1
Assume repair is replacement of flexicircuit with PD & LED; assumed s.
10 [fexicircuit cost as for A-OSEM for repair |
| Il suspensions except BS,
MC, Aux/TT & TMS | A-OSEM | D0901065 | LIGO Lab | each | м 9 | \$600 | Y | 10 \$125 | 5 Y L | н | 1.39E+06
 | 10 1.0 | . 00 | 108 66 | 5
 | 0.681

 | \$85
 | 0.168 | 0.9874 | | 1 0 | \$
 | see MTBF estimate in E1000289-v1, but this is updated with failure data
the PD from E1000177-v1
see DSEM court in E1000042-v2
(0) see rough A-USEM costs in G0500533-v1 |
| uads | fibers | NA | LIGO Lab | set of 4 | N 0.25 | \$100 | N | 15 \$100 | οчн | н | 8.76E+03
 | 1.0 | 10 | 4 | L
 | 4.000

 | \$400
 | 0.986 | 0.9818 | 3 | 3 0 | 5
 | Why don't we have a drawing/part number for the fibers? Where are the
dimensional and material specifications defined?
long repair time (MTTR), a WAG remove lower SUS assy from chamber
weld fibers, re-install, pump down and wait for water pressure to get low
to weld fibers, re-install, pump down and wait for water pressure to get low |
| e rack BOM for LRU sheet | 18-bit DAC to Anti-Image
Interface Board | D1000551 | | Ьd | N 4 | \$2.000 | Y | 5 \$10 | | н | 8.76E+03
 | 10 1.0 | 10 | 8 1 |
 | 8.000

 | \$800
 | 1.973 | 0.9844 | 5 | 5 0 |
 | engineering estimate on replacement & repair costs. Likely initial spares
0 guess |
| | 64 Channel Binary Input
Printed Circuit Board | D1001036 | | bd | N 4 | \$2,000 | Y | 5 \$10 | 0 N L | . н | 8.76E+03
 | 10 1.0 | 10 | 6 2 | 2
 | 6.000

 | \$600
 | 1.479 | 0.9824 | 4 | 1 2 | \$4,0(
 | engineering estimate on replacement & repair costs. Likely initial spares
00 guess |
| | | D1001266 | | bd | N 4 | \$2,000 | Y | 5 \$100 | ONL | н | 8.76E+03
 | 10 1.0 | 10 | 6 (|
 | 6.000

 | \$600
 | 1.479 | 0.9824 | 4 | 4 | \$8,00
 | engineering estimate on replacement & repair costs. Likely initial spares
10 guess |
| ee rack BOM for LRU sheet | AA & Al filter bd | D070081 | | bd | N 4 | \$2,000 | Y | 5 \$100 | | н | 8.76E+03
 | 10 1.0 | 10 | 92 1 |
 | 92.000

 | \$9,200
 | 22.68 | 0.9625 | 3. | 1 21 | \$42,00
 | engineering estimate on replacement & repair costs. Likely initial spares
10 guess |
| ee rack BOM for LRU sheet | AA Interface Board 2 x 9
Dsub, 2 x 25 Dsub | D10000486 | | bd | N 4 | | | | | |
 | | | 13 5 | 5
 | 13.000

 |
 | | | e | 5 1 |
 | engineering estimate on replacement & repair costs. Likely initial spare:
00 guess |
| | ADC | | | | | | | | | |
 | | | 7 | 3
 |

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 | | | 4 | 1 |
 | 00 engineering estimate on replacement & repair costs. Likely initial spares
00 engineering estimate on replacement & repair costs. Likely initial spares |
| | suspensions except
wSDS
suspensions except BS,
dC, Aux/TT & TMS
ads
e rack BDM for LRU sheet
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e rack BDM for LRU sheet | suspensions except wSDS B-OSEM suspensions except BS, A-OSEM A-OSEM ads fibers ads fibers rack BOM for LRU sheet rrack BOM for LRU sheet rack BOM for LRU sheet a rack BOM for LRU sheet rack BOM for LRU sheet a rack BOM for LRU sheet b rack BOM f | LFU
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Drawing Number
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