Section 10

Appendix 3B: Structural Interface FEA Results

1 Scope

This document records a calculation performed on the SPIRE Beam Steering Mirror flex pivots and structure mounting bolts.

2 Calculation

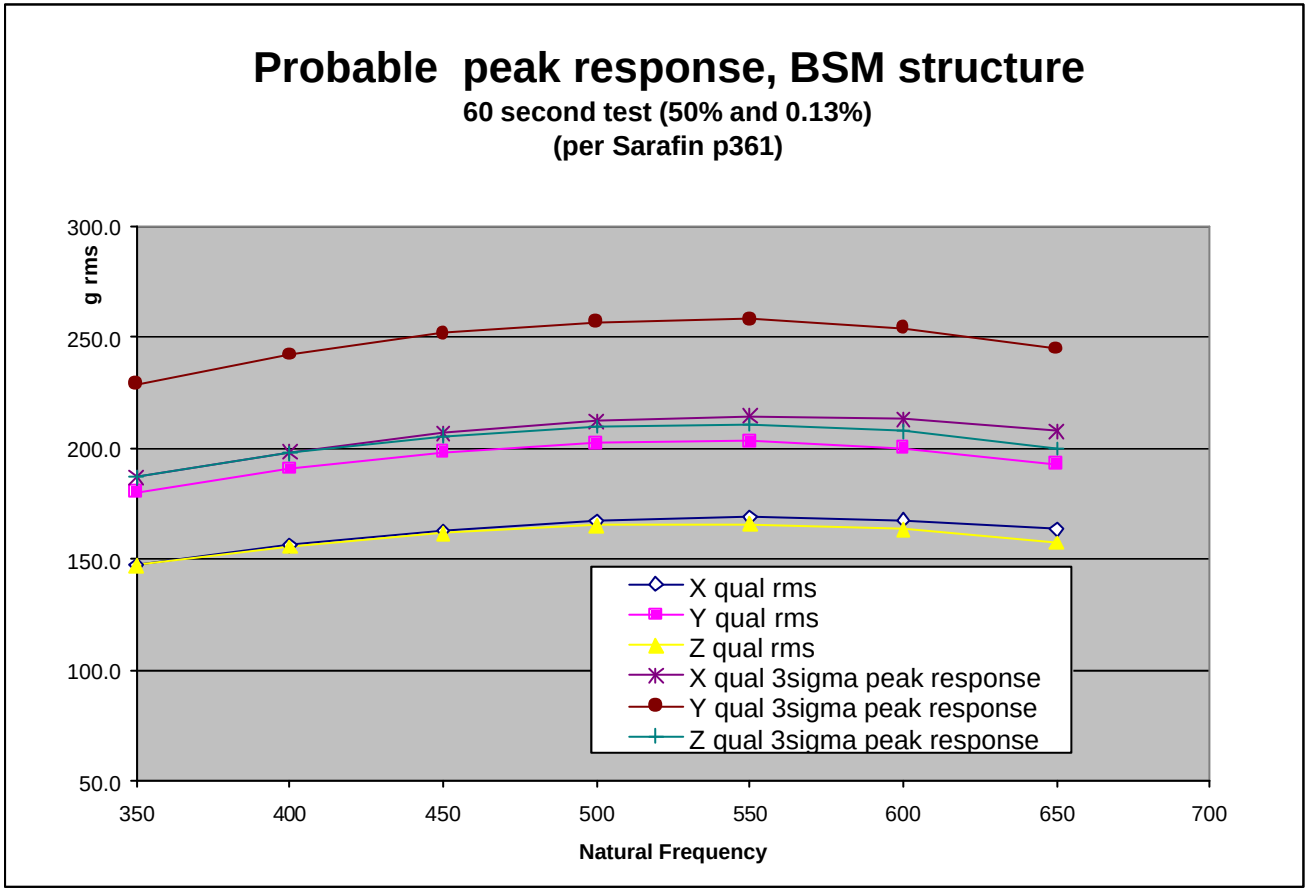
The Input load is as provided in the table below. A static equivalent accelration laod is appled by assuming a Single Degree of Freedom system and using the Miles approximation:

rms accel = (pi . Fn. Wx(Fn)) / 4L)^0.5

where,
Fn = natural frequency
Wx(Fn) = structure input accel from the PSD at the frequency
L = damping ratio = 1/sqrt(Frequency)

BSM random Specification			Ref. instrument co-ordinate system				supplied by B.Winters, 26.Jun.01			
X 60 sec	X g^2/hz	X g^2/hz		Y 60 sec	Y g^2/hz	Y g^2/hz		Z 60 sec	Z g^2/hz	Z g^2/hz
f	Accept	Qual		f	Accept	Qual		f	Accept	Qual
20	0.004	0.008		20	0.006	0.011		20	0.005	0.01
40	0.016	0.032		40	0.022	0.044		40	0.02	0.039
60	0.036	0.072		60	0.05	0.1		60	0.044	0.089
80	0.064	0.128		80	0.089	0.177		80	0.079	0.158
100	0.1	0.2		85	0.1	0.2		90	0.1	0.2
150	0.1	0.2		100	0.7	1.399		200	0.1	0.2
155	0.1	0.2		150	0.7	1.399		210	0.1	0.2
230	0.1	0.2		160	0.15	0.3		250	0.1	0.2
235	0.1	0.2		165	0.15	0.3		255	0.1	0.2
350	0.1	0.2		300	0.15	0.3		300	0.1	0.2
800	0.019	0.038		800	0.021	0.042		800	0.014	0.028
1000	0.012	0.024		1000	0.013	0.027		1000	0.009	0.018
1500	0.005	0.011		1500	0.006	0.012		1500	0.004	0.008
2000	0.003	0.006		2000	0.003	0.007		2000	0.002	0.004
g-rms	8.1	11.4		g-rms	11.1	15.7		g-rms	7.7	10.9

BSM Response				**calculated 10.Jul.01**	**I.Pain**			**version 2.0**		
fn	freq	interpolate spec		damping = 1/freq^0.5	rms accel (Miles)	multiplier: probable peak response, 60 sec test		50 % peak response	X qual 3sigma peak response	
					X qual rms					
350	350	0.200		0.053452	32.1	4.6		147.2	187.0	
400	400	0.182		0.05	33.8	4.6		156.2	198.4	
450	450	0.164		0.04714	35.1	4.6		162.9	206.9	
500	500	0.146		0.044721	35.8	4.7		167.1	212.3	
550	550	0.128		0.04264	36.0	4.7		168.8	214.4	
600	600	0.110		0.040825	35.6	4.7		167.7	213.0	
650	650	0.092		0.039223	34.6	4.7		163.5	207.6	
					Y qual rms				Y qual 3sigma peak response	
350	350	0.300		0.053452	39.3	4.6		180.3	229.0	
400	400	0.271		0.05	41.3	4.6		190.7	242.3	
450	450	0.243		0.04714	42.7	4.6		198.1	251.6	
500	500	0.214		0.044721	43.3	4.7		202.3	257.0	
550	550	0.185		0.04264	43.3	4.7		203.1	258.0	
600	600	0.157		0.040825	42.5	4.7		200.2	254.2	
650	650	0.128		0.039223	40.8	4.7		192.8	244.9	
					Z qual rms				Z qual 3sigma peak response	
350	350	0.200		0.053452	32.1	4.6		147.2	187.0	
400	400	0.181		0.05	33.7	4.6		155.7	197.8	
450	450	0.162		0.04714	34.8	4.6		161.8	205.5	
500	500	0.143		0.044721	35.4	4.7		165.2	209.8	
550	550	0.124		0.04264	35.4	4.7		165.9	210.6	
600	600	0.104		0.040825	34.7	4.7		163.4	207.5	
650	650	0.085		0.039223	33.3	4.7		157.4	199.9	


Probable peak response, BSM structure
60 second test (50% and 0.13%)
(per Sarafin p361)
g rms
300.0
250.0
200.0
150.0
100.0
50.0
350
400
450
500
550
600
650
700
Natural Frequency
X qual rms
Y qual rms
Z qual rms
X qual 3sigma peak response
Y qual 3sigma peak response
Z qual 3sigma peak response

BSM margin - flex pivots & structural bolt				**calculated 10.Jul.01**	**I.Pain**		**version 2.0**		
Component	mass (incl contingency)	load limit of component (N)	required margin	survival load (in g) for 2 pivots	margin on rms response	margin on 50% peak response		margin on 3-sigma peak response	
chop axis flex pivot	20	25.4	1.5	172.6	4.0	**0.8**		**0.7**	
jiggle axis flex pivot	97	245.0	1.5	343.3	7.9	1.7		1.3	
structure bolt (1 M4 only)	909	400	1.5	293.4	6.8	1.4		1.1	

This analysis does not cover
(a) flex pivots at their resonant frequency (approx >1000hz)
(b)flex pivots at resonant frequencies of rotating masses (approx 15 and 30 Hz), as these are not the driving design case

3 Discussion

The load limits are as per the catalogue data for 429 grade stainless steel components. Inconel components are advised by Lucas to have xxx load ratings.

The BSM flex pivots do not have a positive survival margin for qualification. This however applies both a 1.5x qualification load factor and includes a 1.5x margin on the component loads. Reducing the required margin on the loads to unity (accepting that the qualification load factor provides adequate reserve, but that there is thus a risk of failure on qualification) the margin on 3-sigma peak response for the flex pivots would be 0.7 x 1.5 = 1.05

4 Conclusion :

The margin for 3-sigma peak response during vibration testing is:

- chop axis flex pivots 1.05
- jiggle axis fl;ex pivots 1.95
- Structure bolts 1.65 (any one of three bolts alone)