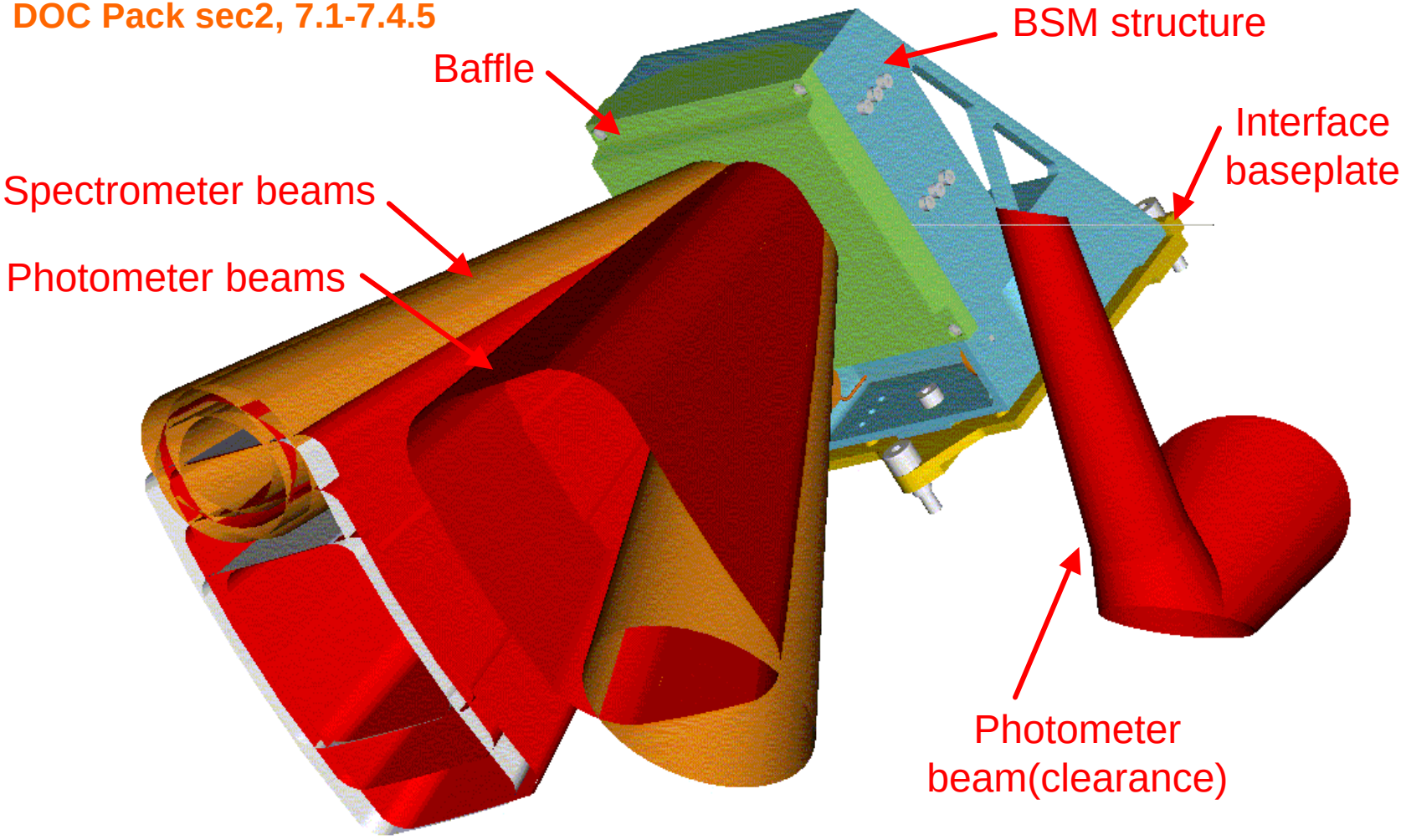
UK Astronomy Technology Centre

Mechanical Design

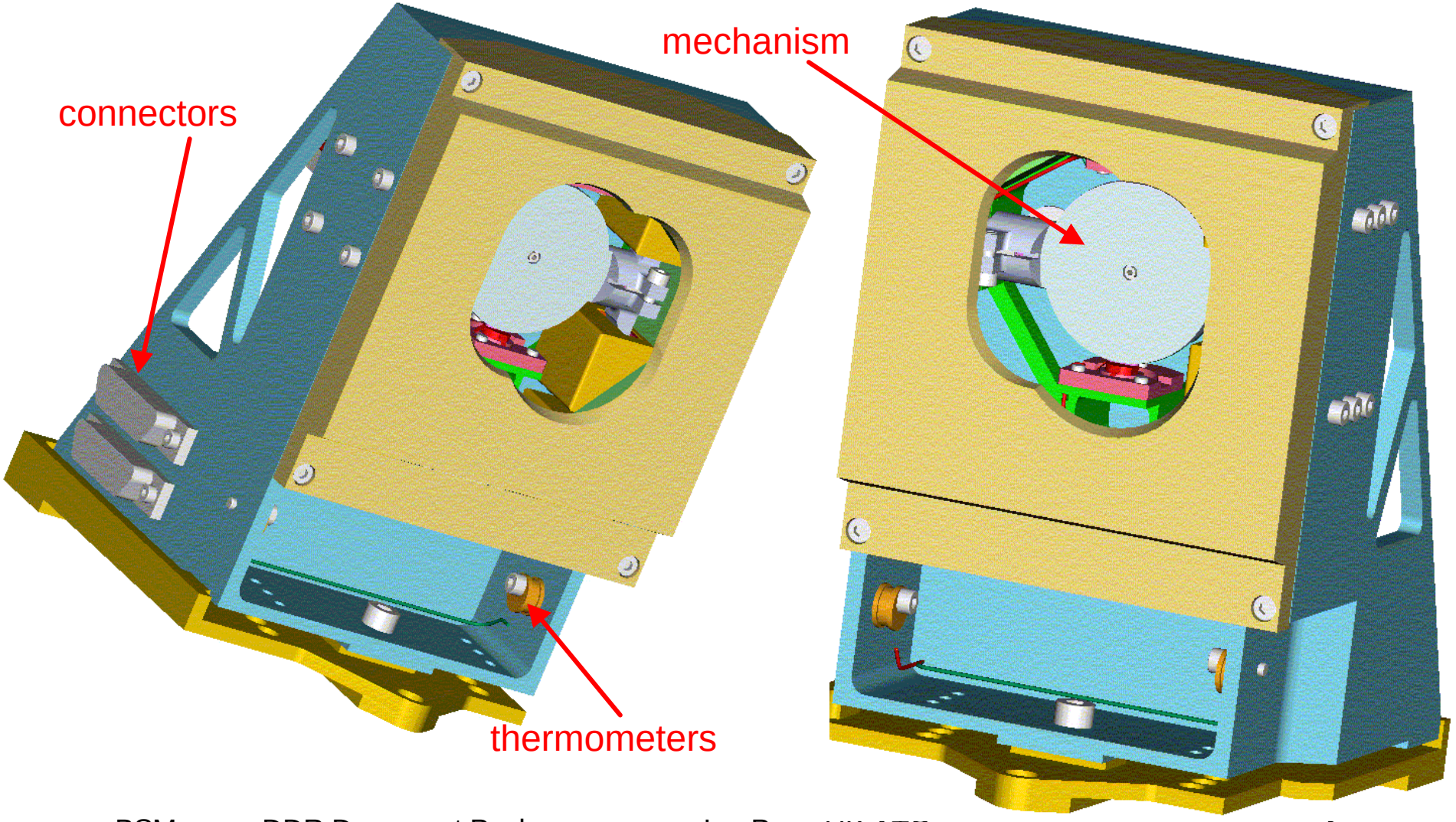
Ian Pain

BSM Overview

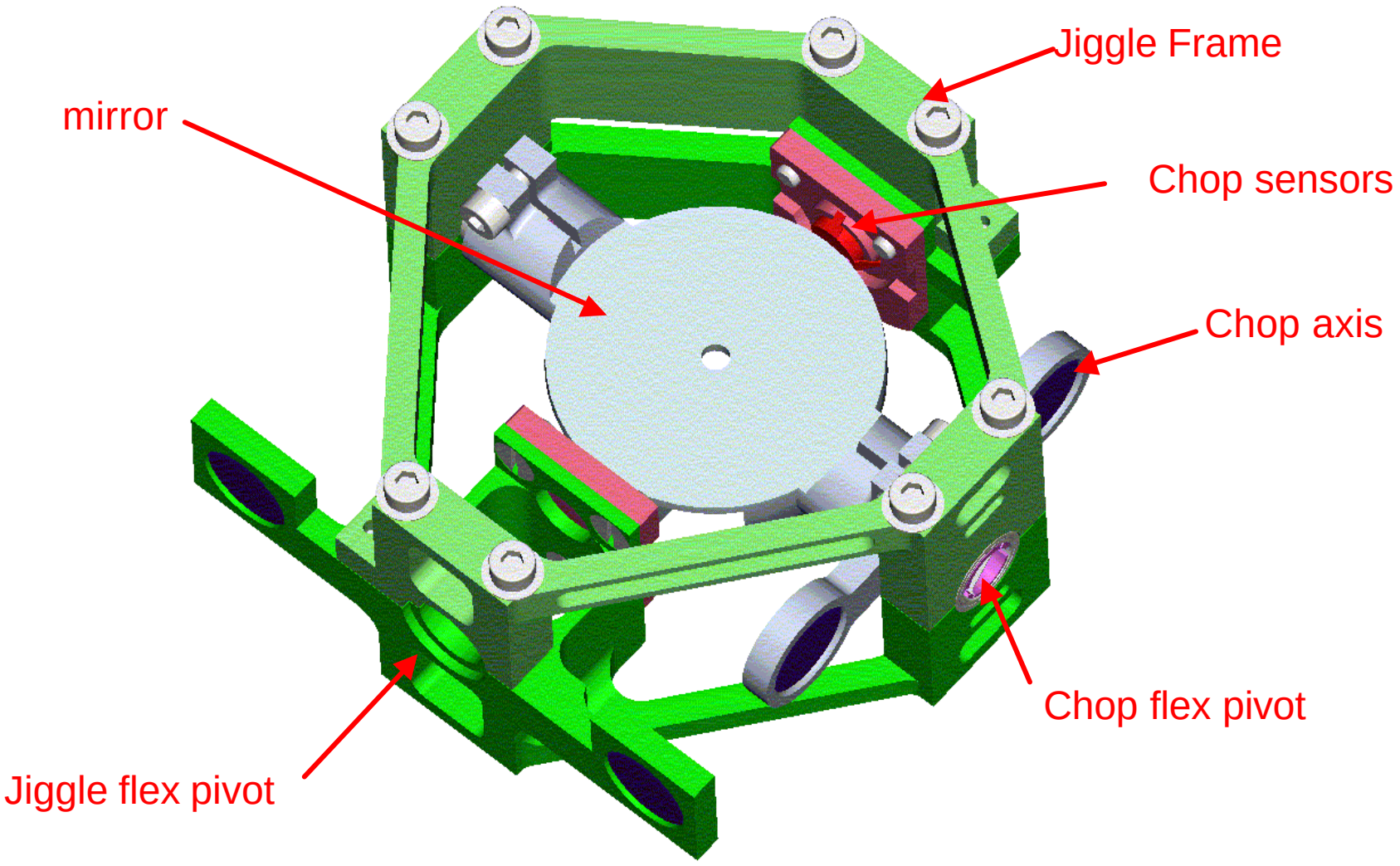
DOC Pack sec2, 7.1-7.4.5



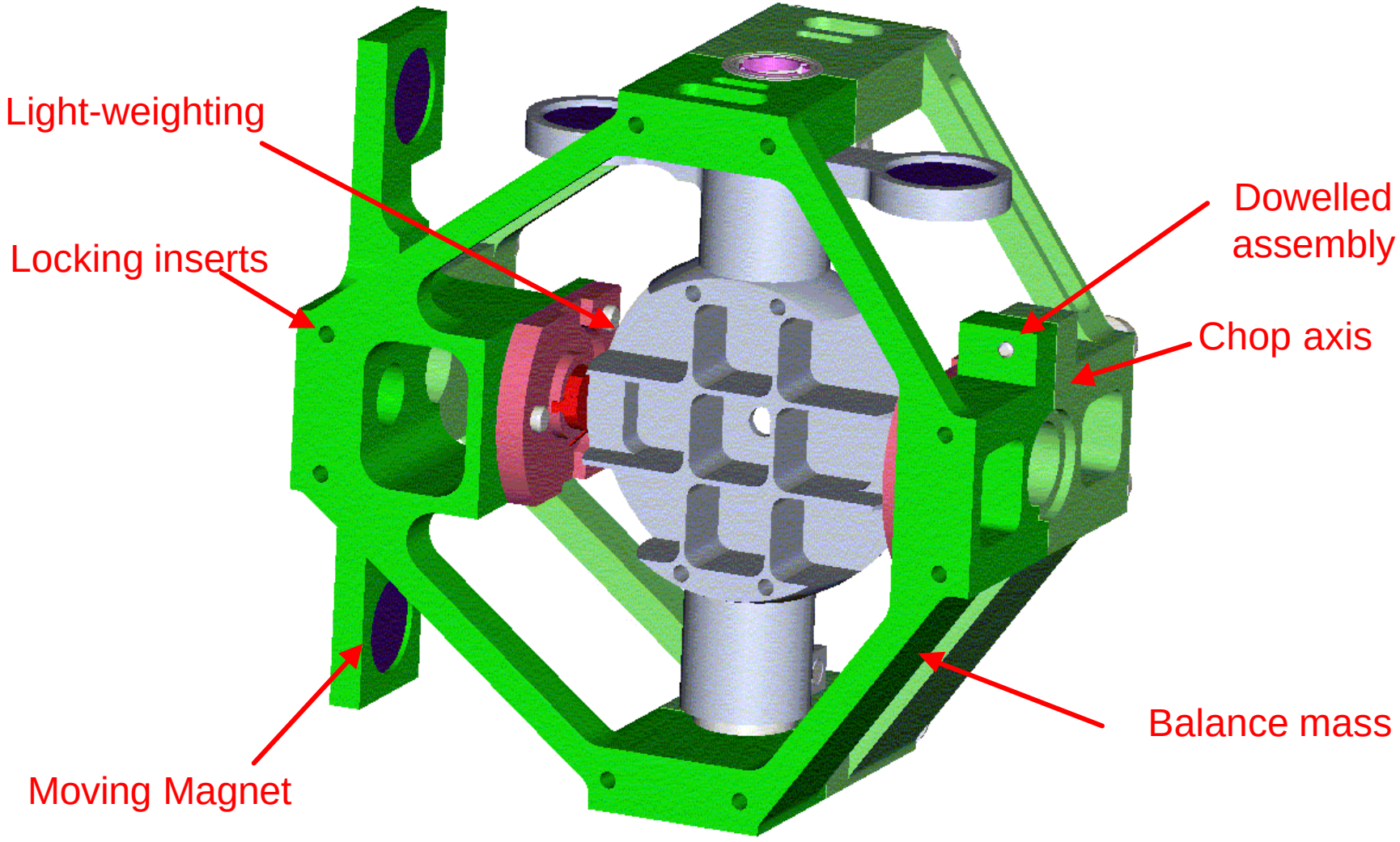
BSM Assembly



Mechanism

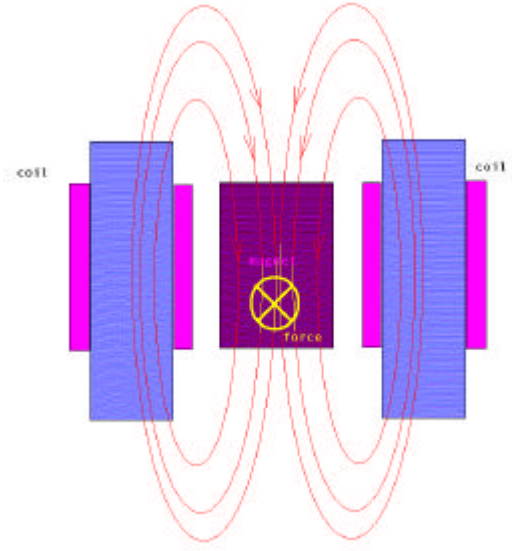

Jiggle Frame
mirror
Chop sensors
Chop axis
Chop flex pivot
Jiggle flex pivot

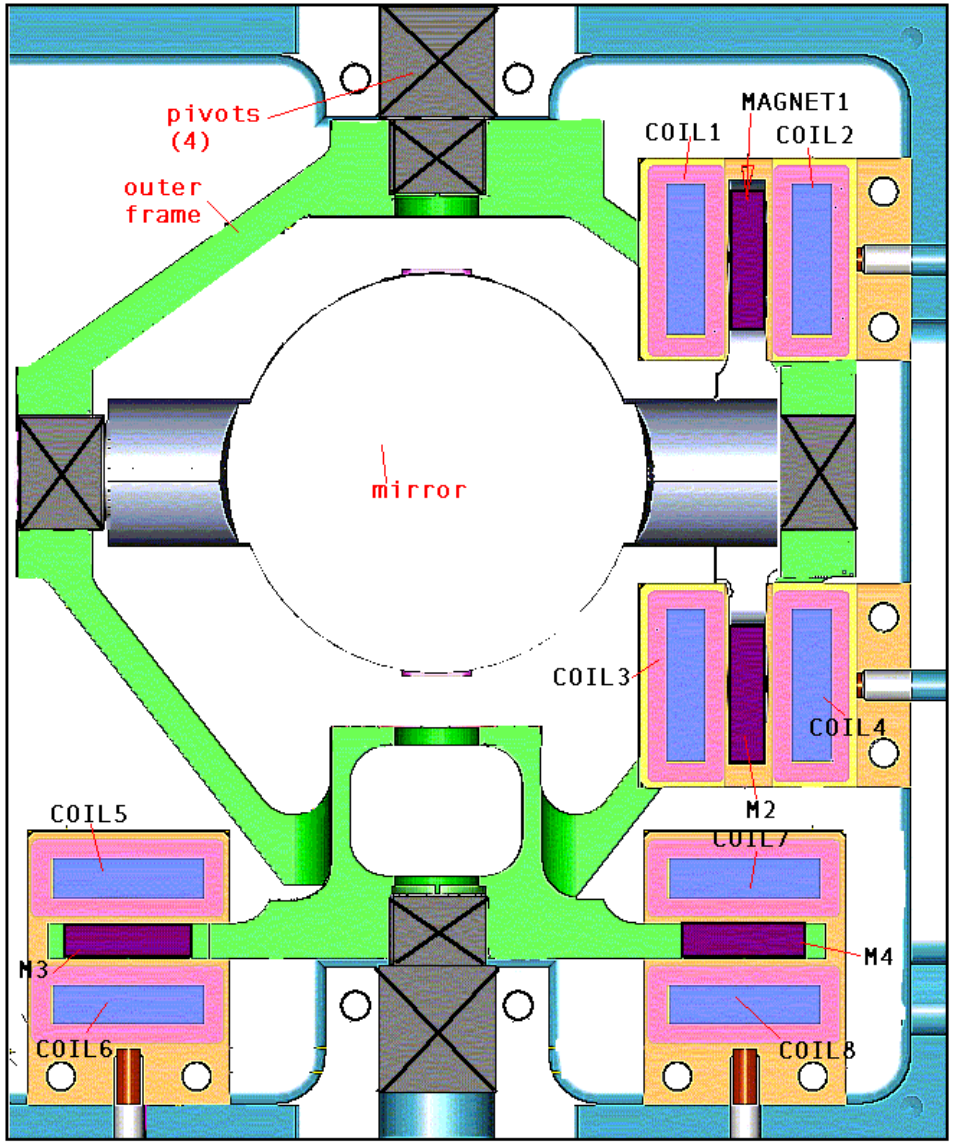
Mechanism


Light-weighting
Locking inserts
Dowelled assembly
Chop axis
Balance mass
Moving Magnet

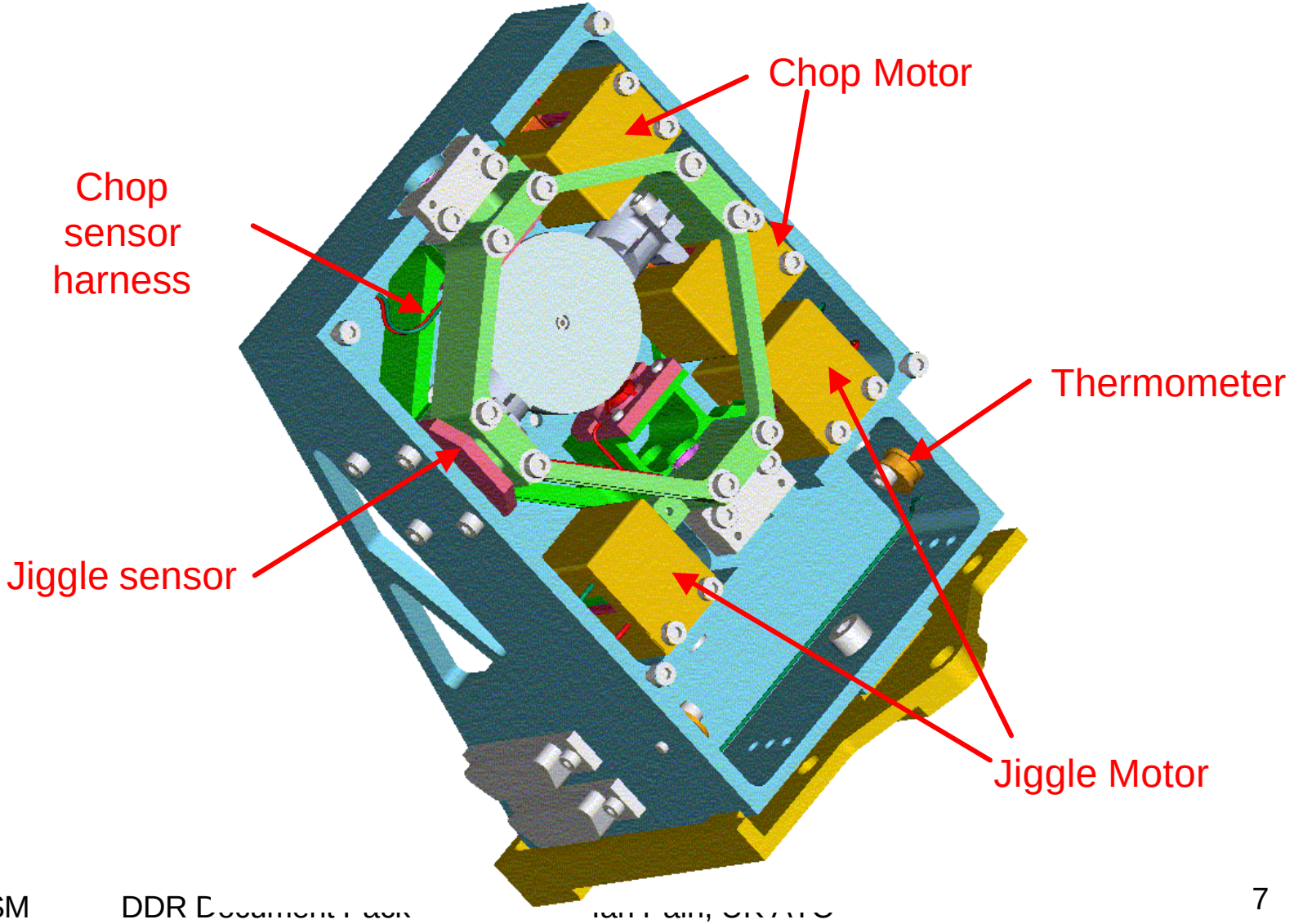
Motor Function

- Each axis has 2 prime coils & 2 redundant coils
- Prime chop = C2 + C4
- Prime Jiggle = C6 + C8

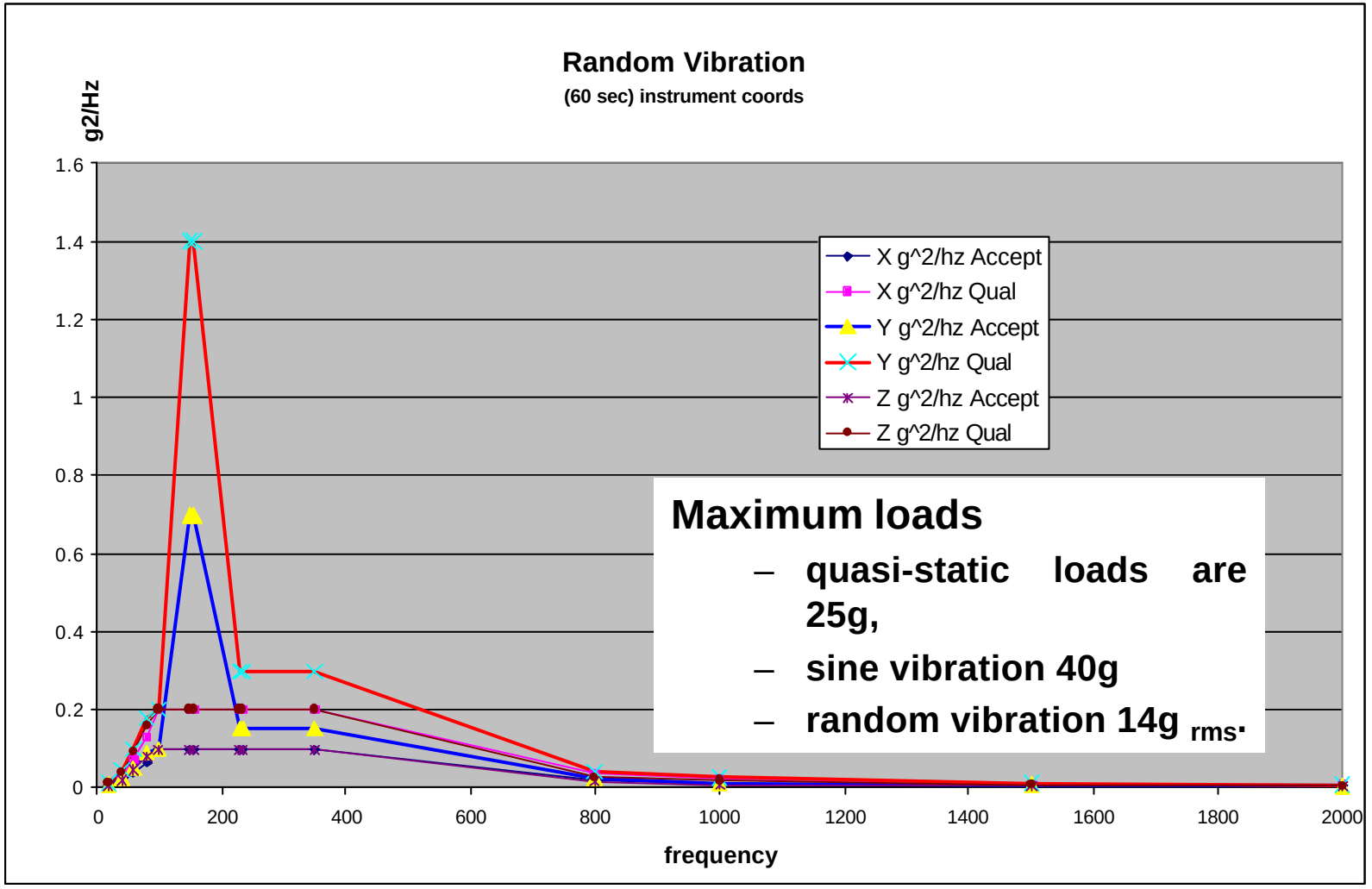




BSM Assembly



Launch Loads

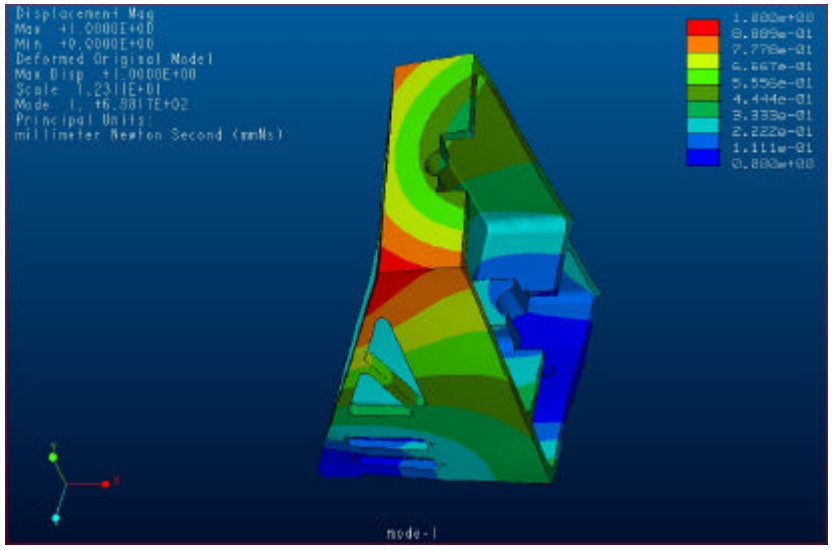


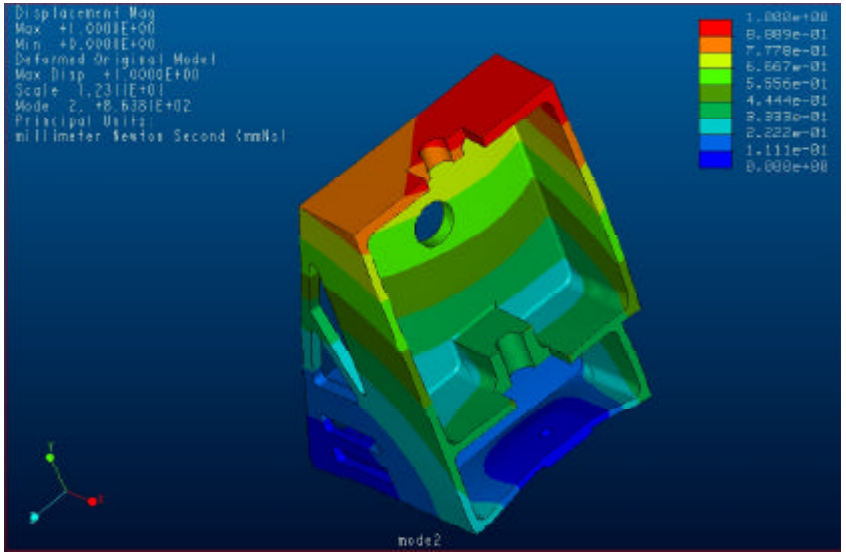
BSM Response to vibration

Doc Pack. Sec.3 Appendix 3

- **Gimbal FEA**
- **Structure FEA**
- **Hand calcs**
- **Next steps**
  - **combined resonance FEA**
  - **Warm Vibration tests**

BSM Structure FEA





FEA prediction for Response of structural interface		Approximate assembly response (see scale factor)
Mode	Frequency (Hz)	Frequency (Hz)
1	688	433
2	864	544
3	1781	1121
4	2715	1710
5	3058	1926
6	3284	2068
7	3345	2106
8	3614	2276
9	3957	2492
10	4097	2579
11	4677	2945
12	5185	3265
	mass of structure	291
	mass of assembly	734
	scaling for resonance	0.630

Table 1: Structural Interface Principal Modes

Miles Equation

Miles

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

where,

Fn = natural frequency

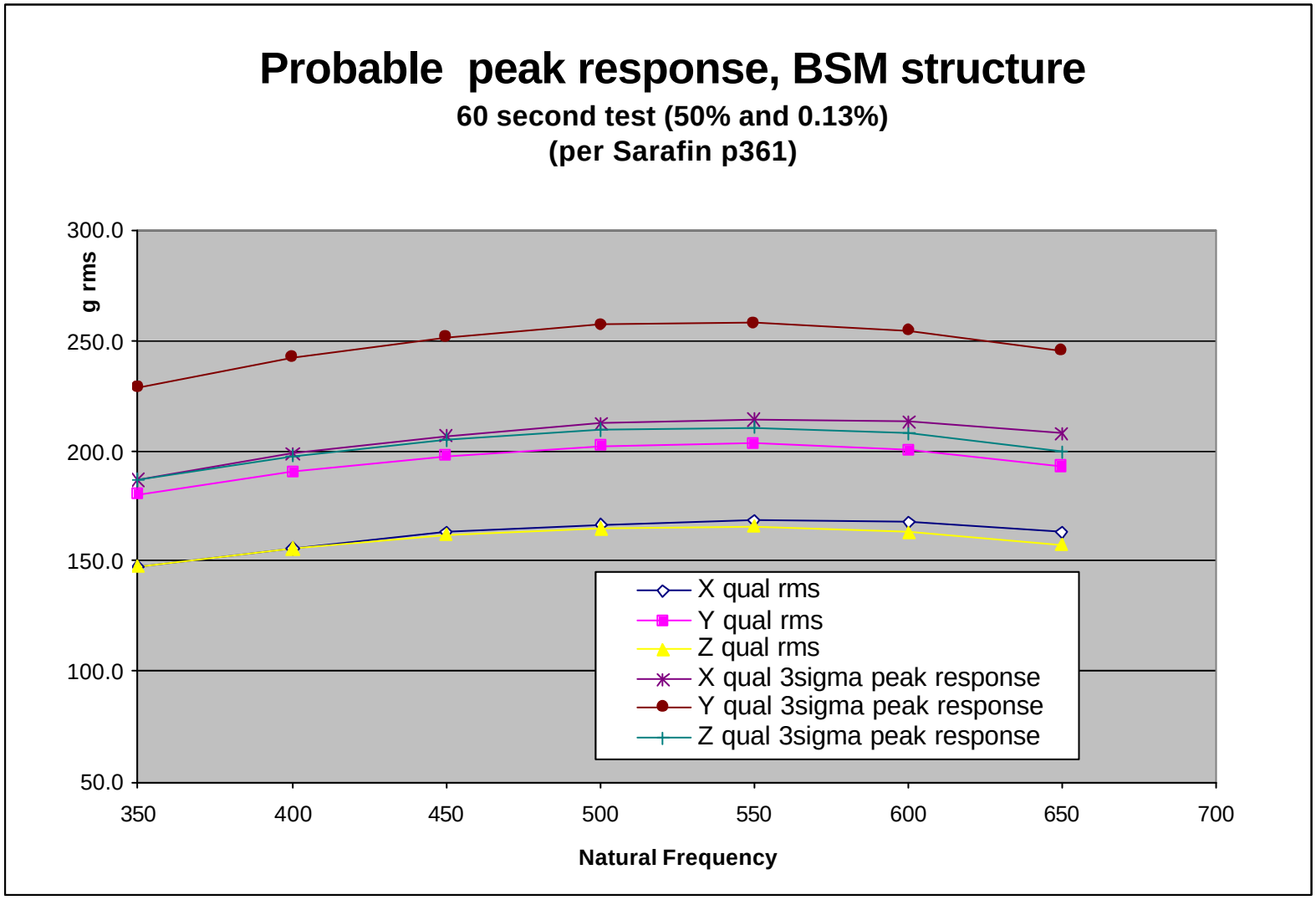
Wx(Fn) = structure input accel from the PSD at the frequency

L = damping ratio = 1/sqrt(Frequency)

from the rms value, multiply up for chance that a particular peak will be exceeded:

50%	**4.6-4.7x (freq dependent)**
0.13% = 3-sigma	**a further ~1.27x**

BSM Response to vibration



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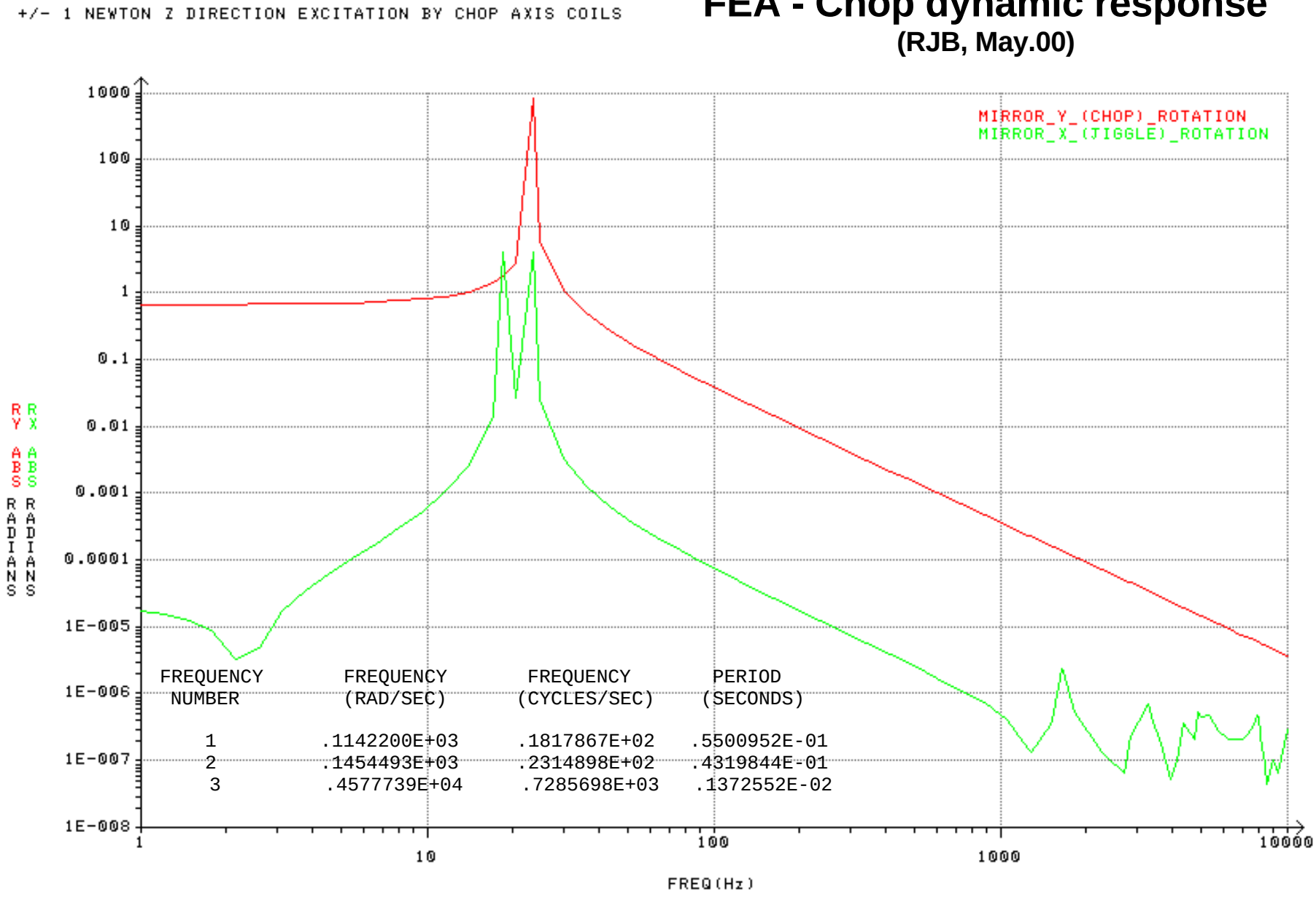
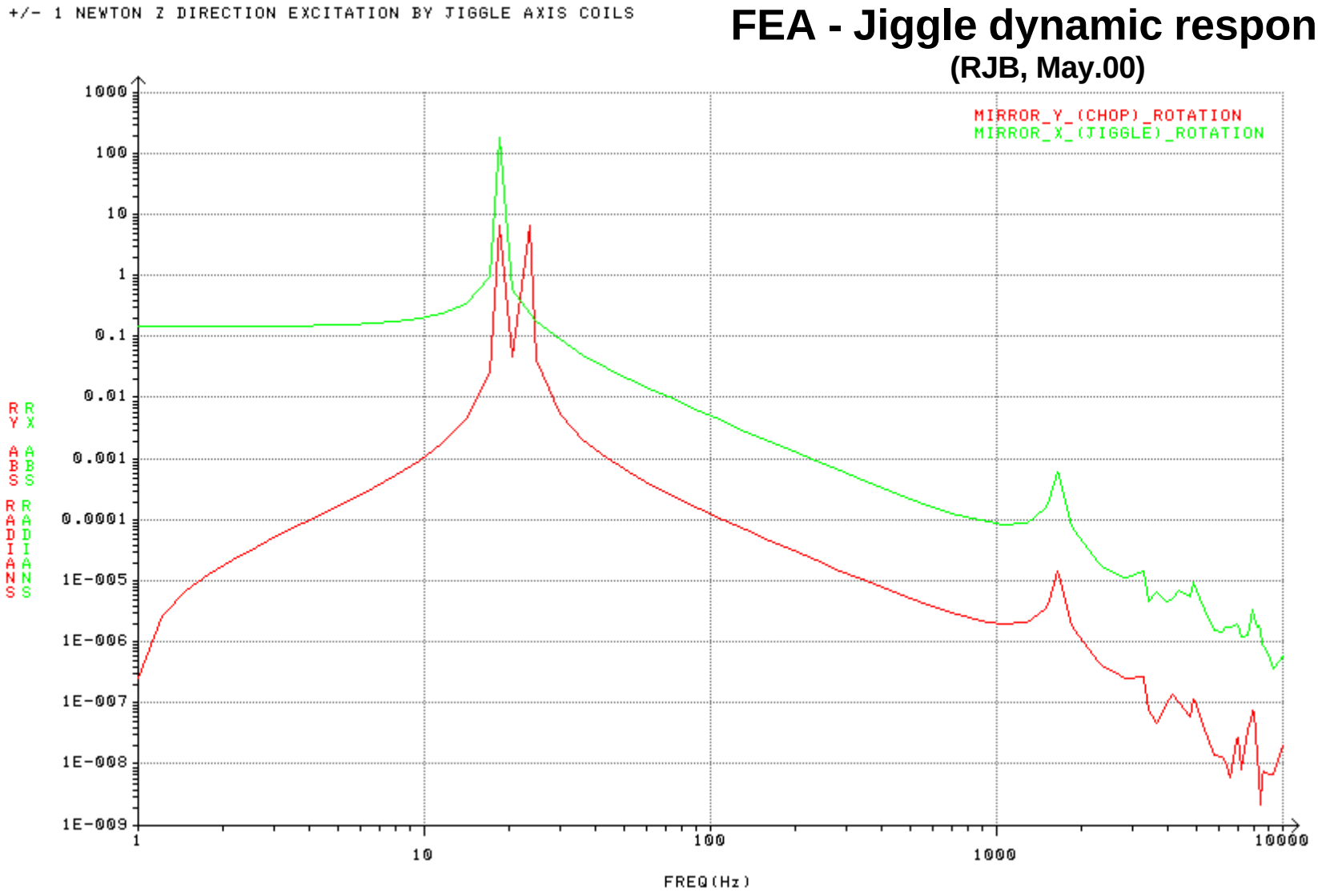
FEA - Chop dynamic response

(RJB, May.00)



FEA - Jiggle dynamic response

(RJB, May.00)



BSM Gimbal FEA & Hand calcs

Axis	Mode	Spring Stiffness (N-m/rad or N/m)	Inertia (kgm²)	Mass of suspended part (grammes)	1st Resonant frequency (Hz)
Chop	**Torsional**	0.05875	1.70E-06		29.6
	Radial Orthogonal	1225887.6		16	1393.1
	Radial 45 degrees	875634		16	1177.4
	Axial	1751268		16	1665.1
Jiggle	**Torsional**	0.4625	4.65E-05		15.9
	Radial Orthogonal	2101521.6		88	777.8
	Radial 45 degrees	1576141.2		88	673.6
	Axial	3152282.4		88	952.6

Table 1 : Suspended Mass Principal Modes

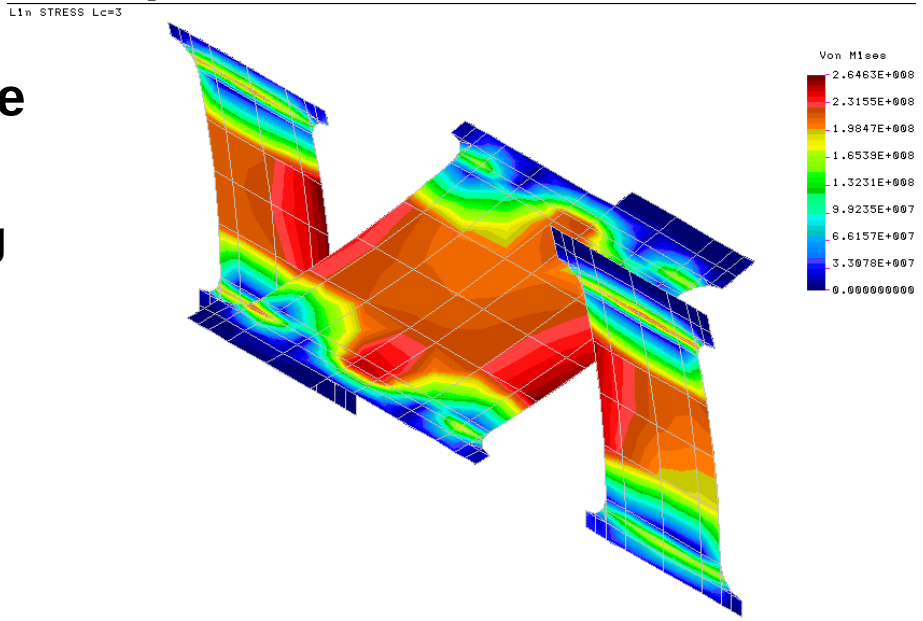
Table values are increased by 25% to account for connection by a stiff mount. This correction need not be applied for the torsional rate, which based on

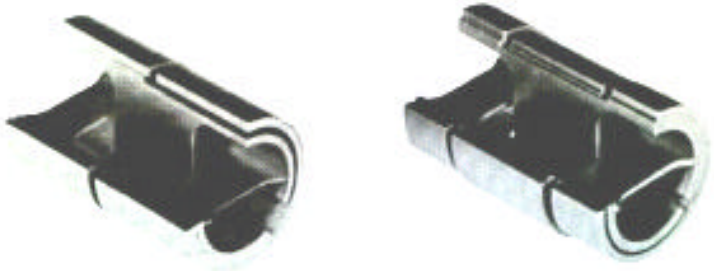
- 5010-800 (chop) - 0.046 Nm/rad
- 5010-600 (jiggle) - 0.367 Nm/rad
- $f_n = \frac{\sqrt{(k/I)}}{2\ Pi}$

will give 1st resonant frequencies of 26Hz and 14.2 Hz

BSMm - Flex pivots

- **Design for adequate reserve**
  - **Lucas flexures - Inconel.**
  - **Initial FEA: reserve >3 (50g static load).**
  - **But ~£3k EACH (need 36 minimum)**
- **Alternatives?**
  - **Spark eroded flexures (Zeiss, WS Atkins)**
  - **BE systems (LAM)**





Lucas TRW calculations

Axis	Mass (gm)	Material	Temperature	Load (lbs.)	spring type	Margin of safety (fatigue)	Approx. max G loading (extrapolated)	FoS on 260G 3-sigma launch load
Jiggle	90	420 SS	77F	3.3	600	7.6	126.7	0.5
		304 SS	77F	no data	600	no data	no data	no data
		Inconel 718	77F	3.3	600	4.6	76.7	0.3
		420 SS	-423F	no data	600	no data	no data	no data
		304 SS	-423F	no data	600	no data	no data	no data
		Inconel 718	-423F	3.3	600	10	166.7	0.6
Chop	20	420 SS	77F	9.9	800	2.5	562.5	2.2
		304 SS	77F	9.9	800	1.1	247.5	1.0
		Inconel 718	77F	9.9	800	1.3	292.5	1.1
		420 SS	-423F	9.9	800	no data	no data	no data
		304 SS	-423F	9.9	800	4.6	1035.0	4.0
		Inconel 718	-423F	9.9	800	3.7	832.5	3.2

Above table for FoS on infinite fatigue life
Chop values are latest issue, jiggle values need updating

Flex Pivots- material data, load rating estimates

Material	Temperature (deg F)	Ultimate Tensile Strngth (psi)	E (psi)	Fatigue Strength (psi)
420 SS	77	230000	29 E^6	60000
Inconel 718	77	180000	29.4 E^6	40000
304 SS	77	95000	28 E^6	35000
304 SS	-423	257000	29 E^6	94500
Inconel 718	-423	265000	30.5 E^6	80000

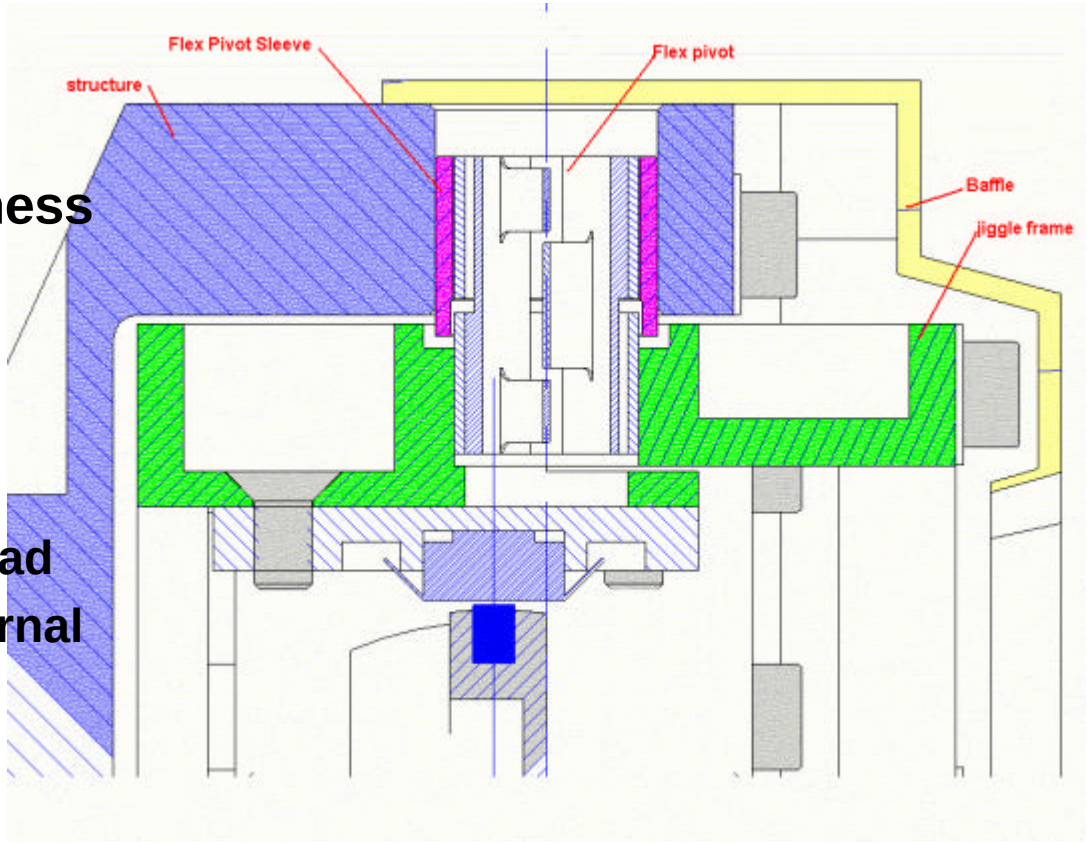
Based on rated catalogue data (420 SS),

- chop axis flex pivots (5010-800) 1.05
- jiggle axis flex pivots (5010-600) 1.95
- structure bolts (any one of three bolts alone) 1.65

Based on buckling failure, margin on 3 sigma load for chop axis 1.55

Flex pivot protection

- Reduce loads
  - light-weight
  - stiff structure
- High Strength/Toughness Pivots
  - Inconel 718
- Flex pivot sleeves
  - 50-75µm clearance
  - prevent shear overload
  - act as redundant journal bearings
- Launch Latch?
- launch “damper”

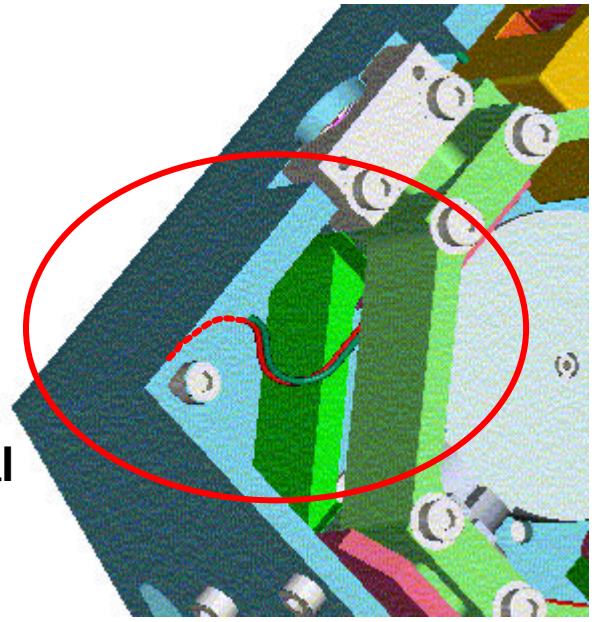


Declared Lists

- **Declared Materials List**
  - **All materials have space and cryogenic heritage**
  - **Refs in table need completing**
- **Declared Components List**
  - **Fasteners**
  - **CPP request**
  - **BSMe via LAM**
  - **Motors - as PACS**
  - **Sensors (Infineon) - as ISOPhot**
- **Critical Items List**
  - **Launch Latch (if flown)**
- **Declared Processes list**
  - **14 processes**
    - 3 electrical,
    - 3 plating,
    - 7 adhesive bonding
    - 1 thermal cycle
  - **All processes known to be space approved, table needs completing**

Chop Sensor Flexible harness

- 'S bend' link, mounted securely to the structure bulkhead and the jiggle frame
- Conventional solution:
  - High Purity Cu Wire, annealed
  - 80-160 microns
  - 5 wires x 2 sensors
  - Vespel SP-1 guides for vibration survival
- Alternate solution (under investigation)
  - flexi-PCB
  - 5 track, kapton insulation
  - no vibration support
  - in use by ESO Cryogenically and by RAL SSD



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Mass Budget

MASS BREAKDOWN OF THE SPIRE BEAM STEERING MIRROR ASSEMBLY			v1.2	dated 16.Jun.01					
MODEL : SPIRE-BSM-020-001									
			DENSITY (kg/mm^3)	COMPONENT MASS (kg)		ASSY. MASS (kg)	CONTINGENCY (%)	CONTINGENT MASS (kg)	MASS INCL CONTINGENCY (kg)
Part Number	DESCRIPTION	MATERIAL:			QUANTITY				
SPIRE-BSM-020-001-001	BSM STRUCTURAL INTERFACE	AL_TO_BS_1470_6082	2.78E-06	0.2910	1	0.2910	10%	0.0291	0.3201
SPIRE-BSM-020-001-002	BASEPLATE	AL_TO_BS_1470_6082	2.71E-06	0.0838	1	0.0838	10%	0.0084	0.0922
SPIRE-BSM-020-001-003	JIGGLE AXIS FLEX CLAMP (L)	AL_TO_BS_1470_6082	2.71E-06	0.0026	1	0.0026	10%	0.0003	0.0029
SPIRE-BSM-020-001-005	JIGGLE AXIS FLEX CLAMP (U)	AL_TO_BS_1470_6082	2.71E-06	0.0023	1	0.0023	10%	0.0002	0.0026
SPIRE-BSM-020-001-004	PCAL SPACE ENVELOPE	ASSEMBLY	6.00E-06	0.0507	1	0.0507	25%	0.0127	0.0633
SPIRE-BSM-020-001-006	BAFFLE (CONCEPT)	AL_TO_BS_1470_6082	2.72E-06	0.0337	1	0.0337	50%	0.0169	0.0506
SPIRE-BSM-020-001-007	LAUNCH LATCH (ENVELOPE)	ASSEMBLY	7.00E-06	0.0509	1	0.0509	25%	0.0127	0.0636
SPIRE-BSM-020-003	GIMBAL ASSEMBLY	ASSEMBLY	3.23E-06	0.0883	1	0.0883	10%	0.0088	0.0971
SPIRE-BSM-020-005	COIL ASSEMBLY	ASSEMBLY	2.06E-06	0.0133	4	0.0534	10%	0.0053	0.0587
SPIRE-BSM-020-006	SENSOR ASSY JIGGLE	ASSEMBLY	2.45E-07	0.0004	1	0.0004	10%	0.0000	0.0004
SPIRE-BSM-020-008	SHIELDED FLEXURE ASSY	ASSEMBLY	7.73E-06	0.0031	2	0.0063	15%	0.0009	0.0072
SPIRE-BSM-020-009	HARNESS ASSY (CONCEPT)	ASSEMBLY	2.71E-06	0.0046	2	0.0092	50%	0.0046	0.0138
DISC-SPRING-ID-3_2	DISC SPRING	STAINLESS-STEEL	7.91E-06	0.0000	4	0.0002	10%	0.0000	0.0002
CERNOX-THERMISTOR	CERNOX-THERMISTOR	COPPER-CANISTER	8.90E-06	0.0048	2	0.0096	10%	0.0010	0.0105
CAP-HD-SCREW-SS-M4X10	CAP-HD-SCREW-SS-M4X10	STAINLESS-STEEL	7.91E-06	0.0020	3	0.0061	10%	0.0006	0.0067
CAP-HD-SCREW-SS-M2X10	CAP-HD-SCREW-SS-M2X10	STAINLESS-STEEL	7.91E-06	0.0004	4	0.0016	10%	0.0002	0.0018
CAP-HD-SCREW-SS-M2-5X7_75	CAP-HD-SCREW-SS-M2-5X7_75	STAINLESS-STEEL	7.91E-06	0.0006	2	0.0011	10%	0.0001	0.0013
CAP-HD-SCREW-SS-M2-5X7	CAP-HD-SCREW-SS-M2-5X7	STAINLESS-STEEL	7.91E-06	0.0005	15	0.0081	10%	0.0008	0.0089
CAP-HD-SCREW-SS-M2-5X6	CAP-HD-SCREW-SS-M2-5X6	STAINLESS-STEEL	7.91E-06	0.0005	8	0.0040	10%	0.0004	0.0044
CAP-HD-SCREW-SS-M2-5X12	CAP-HD-SCREW-SS-M2-5X12	STAINLESS-STEEL	7.91E-06	0.0007	4	0.0029	10%	0.0003	0.0032
37WAY_CONN	37 WAY MDM CONNECTOR	CONNECTOR	2.10E-06	0.0063	2	0.0125	20%	0.0025	0.0150
UN-MODELLED PARTS	ADHESIVE	ADHESIVE	2.00E-06	0.0010	10	0.0100	10%	0.0010	0.0110
(approx mass only)	P-CLIPS	BRASS (TBC)	8.45E-06	0.0003	16	0.0055	10%	0.0006	0.0061
	P-CLIP FASTENERS	STAINLESS-STEEL	7.91E-06	0.0004	16	0.0064	10%	0.0006	0.0071
	MDM FASTENERS	STAINLESS-STEEL	7.91E-06	0.0004	4	0.0016	10%	0.0002	0.0018
	LOCKING INSERTS	STAINLESS-STEEL	7.91E-06	0.0003	56	0.0168	20%	0.0034	0.0202
	DOWELS	STAINLESS-STEEL	7.91E-06	0.0001	8	0.0009	15%	0.0001	0.0010
	COATING	Nickel (10um) & Gold (3 um)	1.13E-05	0.0159	1	0.0159	15%	0.0024	0.0183
	PAINT	QMW BLACK (40 um)	3.00E-06	0.0130	1	0.0130	15%	0.0019	0.0149
	LACING	TBD	1.50E-06	0.0020	2	0.0040	15%	0.0006	0.0046
					TOTAL	**0.7927**	TOTAL CONTINGENCY	**0.1166**	

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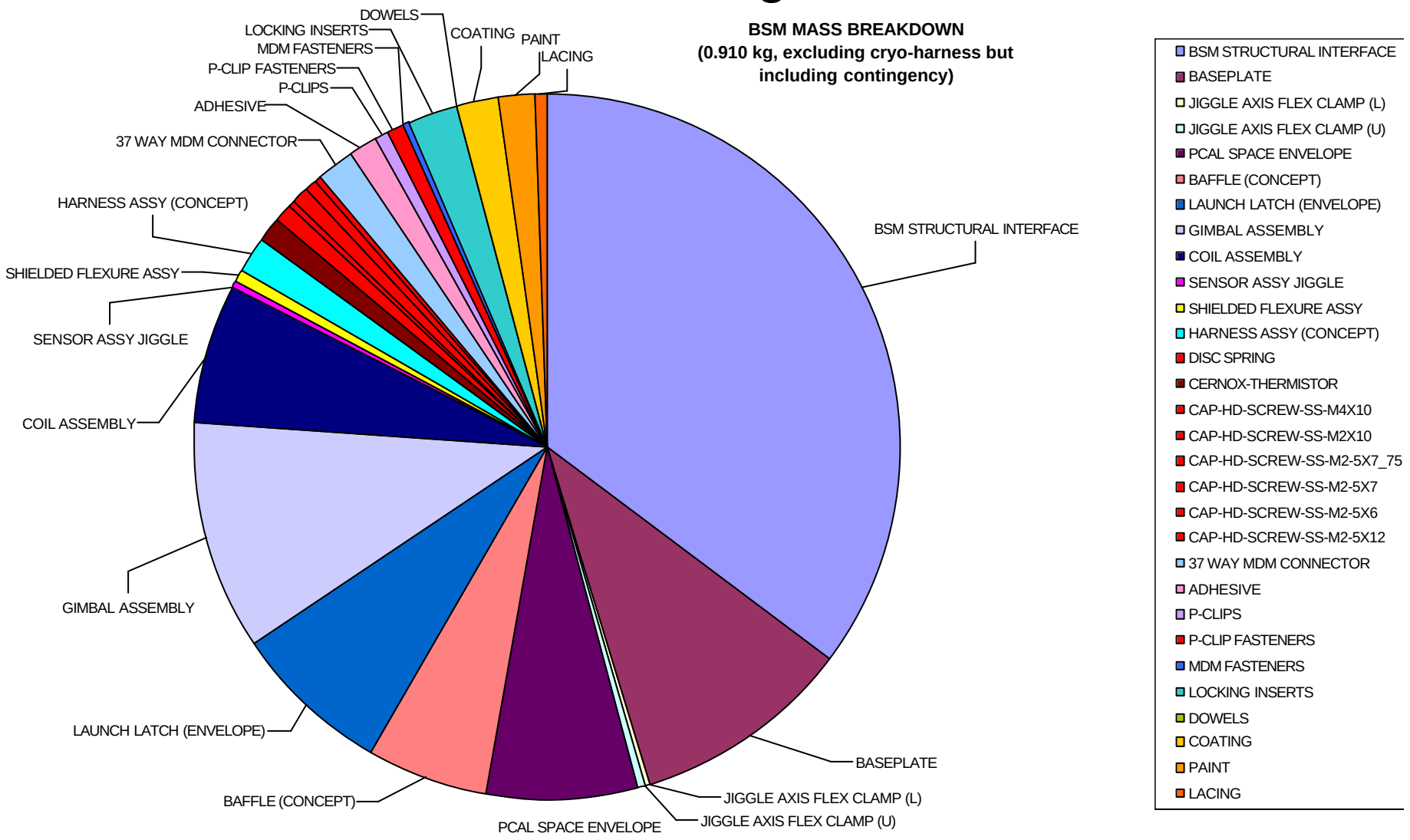
Mass Budget



BSM Launch Latch

- **No Single Point Failure**
  - **Redundancy**
  - **Scan - Map fallback**
  - **ensure spectrometer field of view (+/- 1.5 º) retained**
- **Launch Latch Candidate**
  - **Identified by LAM**
  - **design changes in hand (reduced moving mass, microswitch indication). Will have 2mm dia. Pin and 3mm stroke**
  - **qualification to be undertaken (ATC will collaborate)**
  - **ATC to front-mount and add a compliant pin to prevent impact loading (G10 would be one candidate)**