BSC suspension Failure Effects and Modes – initial study

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1 Background

There has not yet been a full formal FEMA study for the BSC suspensions. As an interim measure, this note sets out what are believed to be the key issues in the spirit of a FEMA but without the rigour of a formal approach. Areas for particularly close scrutiny are failures in which parts are affected other than the failed part, especially when the affected parts may be outside the BSC SUS system. It is intended that it will be replaced in due course by such a fuller study.

2 Previous work

A previous paper, E040329-03 by Romie et al, looked failures in the specific context of repair scenarios. Parts of the current paper will update that work, for example, as regards the use of magnetic mounting for the OSEM flags which will render them less liable to damage than the previous bonded flags. In other areas, E040329-03 is still current.

3 Failure modes and effects

For each failure considered we have set out in the tables below

Effects – what is the result of the failure
Other parts affected
Recovery scenario
And, although this is not a risk management plan, we have for completeness included in brief the risk minimisation strategy associated with the failure.

4 Analysis of failures

	Effects	Other parts affected	Recovery scenario	Risk strategy
4.1 Damage to parts during assembly or installation				
Observed during assembly	One or more damaged components	None (unless timescales affected)	Repair or remake damaged parts; modify assembly procedure to avoid future problems. Note vacuum cleaning requirements may make this a lengthy process.	Assembly procedure carefully planned/reviewed, tested on prototypes.
Not noticed during assembly	One or more damaged components discovered during installation or operation	Likely to impact timescales of other project areas		
4.2 Failure of parts in normal service				
Mechanical failure	This is considered highly unlikely in normal service – mechanical failure is covered below under earthquakes			Use conservative factors of safety and detailed stress analysis.
OSEM failure – coil shorts to ground	OSEM stops actuating. Will initially give high current in driver circuit.	May affect science operations – but note that there is some redundancy in OSEMs. Local drive electronics must be able to handle this condition without failure. Will cause OSEM drive voltage to	OSEM will need to be replaced with a spare. If required, fuse in local drive electronics will need to be changed/reset. If the voltage on the structure has caused nay collateral damage this too will need to	Careful quality control and use of quad thickness insulation. Avoid weakness in wiring between coil and socket. Driver circuit designed to cope

		appear on structure unless TCS prevents this. Tellbacks will inform the TCS. (check Jay/Stuart).	be fixed.	with shorts without damage. Tellbacks allow TCS to disable the driver.
OSEM failure – coil shorts internally	As above except that the voltage on the structure is not an issue.			
OSEM failure – coil goes open circuit	OSEM stops actuating. Will give zero current in driver circuit.	May affect science operations – but note that there is some redundancy in OSEMs.	OSEM will need to be replaced with a spare.	Careful control of the processes of coil construction.
OSEM failure – emitter OSEM failure - detector	OSEM stops sensing. May go open circuit or short internally or to ground.	Effects, correction and mitigation similar to coil failure.		
Coil driver stops producing current	OSEM stops working	As coil failure open circuit	Replace drive card	Careful control of quality during production, attention to ESD during handling and assembly
Coil driver drives goes to max current	OSEM drives mass into a stop	Loss of lock. Damage to mass prevented by stops.	Replace drive card	
Electronics – emitter/detector driver fails	Loss of signal	Loss of lock.	Replace drive card	
4.3 Failure of parts during severe earthquake				
Mechanical failure – ductile parts other than wires	Parts are permanently bent out of shape	Depends on the failure. May be unable to reacquire lock	Replace failed parts	Use appropriate factors of safety and earthquake

				loading calculations.
Mechanical failure - wires	One or masses fall onto their stops; masses above the failed wire will rise onto stops. Flags may become detached.	Loss of lock.	See proposed repair scenario in T060040-04 assembly document. (T000053-03-D section 2.5.2.1.2 requires that the time should not exceed two days)	Use of appropriate safety factors, tests to ensure strength of wires.
Mechanical failure – ribbons or fibres	Test mass falls onto its stops. PM, UIM and top mass will rise to upper stops. Some wire failures may occur.	Loss of lock.	See proposed repair scenario in T060040-04 assembly document. (T000053-03-D section 2.5.2.1.1 requires that the time should not exceed two days)	Use of appropriate safety factors, tests to ensure strength of ribbons/fibres.
Mechanical failure – ear or bond between ear and mass	As ribbon failure	Loss of lock	See proposed repair scenario in T060040-04 assembly document. (T000053-03-D section 2.5.2.1.3 places limits on allowed time)	
Mechanical failure - Fatigue	Part fails suddenly.	Depends on nature of failure – but since the structure is very redundant t is unlikely to be severe	Replace failed part	Fatigue is not expected to be problem given the very low vibration levels.
Flag becomes detached	Loss of OSEM function	Loss of lock	Magnetic flags will re-attach within reasonable bounds; otherwise intervention will	Use of magnetically fixed flags.

			be needed.	
4.4 Failure of parts in other exceptional circumstances				
Mains overvoltage	Potential damage to drive circuits. Design of drive circuits should prevent damage to OSEMs	Loss of lock	Replace failed circuits	Should be prevented by conditioning of incoming mains.
Mains failure (loss of power)	No damage			ICS should be design to shut down gracefully.

5 Changes since E040329-03

- Use of magnetic flag mounts should get around many of the flag failures.
- Distinction between earthquake stop assembly and catcher has become less clear. Affects procedure for repairing ribbons, eg. our intent is that the EQ stops can be used to push the masses into such a position that transport and welding stops can be fitted.
- Stops are fitted between the test mass and the reaction mass, so they cannot hit each other.