VISTA M2 UNIT
Earthquake Analysis Summary

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CONTENTS

0. SCOPE

This document is a separata of the VISTA M2 Unit analysis report (A.3) and summarises the calculation hypothesis and the result of the calculations showing the behaviour of the VISTA M2 Unit under the load conditions derived from the "instructions to perform Earthquake analysis for VLT instruments and similar equipment" (A.4) and the requirement 5.4.2.3.2 of A.2. It is delivered as a separated document as requested in A.1 (Statement of work for the VISTA M2 unit workpackage) table 1 (DRL). The document finalises analysing the potential hazards derived from earthquake occurrence and the design measures implemented that control the hazard.

This report has been prepared following the rules for DRD 22 described in A.1 Appendix 1 and referring to A.3 in what refers the description of the model.

This document supports the analytical evidence of the compliance of the VISTA M2 design at PDR configuration (preliminary design baseline) with the requirement 5.4.2.3 / 5.4.2.3.2 of the document A.2 (Technical specification for the M2 Unit).

1. APPLICABLE AND REFERENCE DOCUMENTS

Applicable documents to a document are those that the information contained in the present document is traceable to the information in the applicable document.

If the related information on the applicable document is changed, the content of the present document may need to be updated.

Documents listed as the reference ones contain technical or programmatic information useful to develop the activities of the project and to put the project activities into context. Changes in the reference documents would not affect the content of the present document.

1.1 Applicable documents

Ref.	Title	Number	Issue	Date
A.1	Statement of work for the VISTA M2 Unit Work package	VIS-SOW-ATC-05040-0002	2.0	29/11/02
A.2	Technical Specification for the M2 unit	VIS-SPE-ATC-05040-0001	3.0	29/11/02
A.3	M2 Unit Analysis report	VIS-ANA-NTE-50041-0010	1.0	12/03/03
A.4	Earthquake Analysis for VLY Instruments ans Similar Equipment	VLT-SPE-ESO-100000-1853	1	

1.2 Reference documents

Ref.	Title	Number	Issue	Date
RD1	E-mail copied in annex 1 to the document closing action M2U-16-03-01-04			23/01/03

2. ASSUMPTIONS

2.1 Assumptions used in the definition of the model

See A.4

2.2 Assumptions used in defining the boundary conditions

N/A

2.3 Assumptions used in defining the material properties

See A.4

2.4 Assumptions used in defining loads and loading cases

According to A.4, page 7 section 3.1:

"…Therefore an important design goal of the equipment shall be to provide sufficient rigidity to avoid dynamic coupling and magnification effects with the VLT structure by maximising the structural stiffness and minimising the mass. The design goal is reached when the lowest significant eigenfrequency of the equipment is above 30 Hz along the horizontal x and y directions and above 70 Hz along the vertical direction".

This statement, referring to the VLT telescope is also applicable to VISTA as per RD1.

From the eigenmode analysis described in A.3, the first lateral mode is established at about 60 Hz. We estimate that even with further design and analysis refining it will not be below 50 Hz.

The first vertical mode is currently established at about 140 Hz.

Therefore the conditions for which a static load analysis can verify the earthquake loads are fully verified and the static acceleration specified in section 5.8.2 of A.2 can be used for this verification.

2.5 Assumptions used in processing test results

N/A

2.6 Analysis methods

Static load analysis with a simplified (beam elements only) finite element model of the M2 Unit.

3. MODEL

The model is described in A.3

4. LOADING CASES

	Axial Acceleration (g)	Lateral accleration (g)
OBE	1.8	1.8
MLE	2.4	2.4

5. RESULTS

The computation of M2 displacements and hexapod actuator loads is as follows:

	OBE		MLE	
	axial	lateral	axial	lateral
Displacement of M2 I/F point				
• Y	0	104 μm	0	139 μm
• Z	17 μm	1 μm	23 μm	1.4 μm
• Rot_X	0	65 μrad	0	86 μrad
Largest actuator load axial	1085 N	4600 N	1445 N	6120 N
Largest actuator bending moment	7 Nm	18 Nm	10 Nm	24 Nm
Largest flexure joint stress	19 MPa	74 MPa	26 MPa	98 MPa

6. CONCLUSIONS

Earthquake loads are to be evaluated in combination with other loads as defined in A.2.

The following conclusions are drawn from the combined analysis which is reported in A.3:

- Displacements of the M2 assembly in the event of OBE or MLE are much below critical values, hence very safe.
- In the occurrence of an earthquake, the actuator axial loads will exceed the specified 4000 N operational load. The following cases can then be presented:

  1. If the actuators are unpowered and braked, the brake will prevent any backdriving of the actuator screw. Therefore the hexapod will only experience elastic deformations: in this respect the most sensitive components are the flexure joints, in which the induced stresses are much below the critical limits.

  2. If the actuator is in closed loop at the time of earthquake, the induced force of close to 9000 N will greatly exceed the actuation force (limited in all cases to 4500 N). The actuator will start to backdrive. The following cases can be then considered:

  A. If the control software system functions normally, a following error will be reported to the control board which will open the loop and activate the brake[1].

  B. If the software fails and the actuator remains in closed loop while backdriving, the current command will rapidly exceed the hard current limits set by circuit breakers. Then the current will be cut and the brake activated.

  C. If the electrical power is cut, the brake is immediately engaged.

  3. Therefore in all conceivable cases the actuator will be stabilized by its brake long before it reaches its physical hardstops.

- The actuator bending moments remain small and non-critical in all cases.
- The flexure stresses are very minor with respect to the sizing limits. However one shall note that the evaluated cases corresponds to the situation before the actuator actually backdrive. If they do backdrive, the joints will likely bend more as the kinematic configuration of the hexapod changes. Nonetheless the bending is limited by the joint hardstops in the same way as they protect from an operational malfunction.

[1] It is recalled that the brake is passive, meaning that it activates when not commanded to open and also in absence of electrical power.

Annex 1

-----Mensaje original-----
De: Ian Egan [mailto:ie@roe.ac.uk]
Enviado el: jueves 23 de enero de 2003 12:55
Para: 'Pastor, Miquel'; Joan Manel Casalta (E-mail)
CC: Richard Bennett; Simon Craig; vista
Asunto: RE: M2U action items data list {VPO Ref 05040}

Dear Miquel and Joan Manel,

With regards to VPO Actions:

Action M2U-16-03-01-04

The earthquake analysis procedures are covered under AD 04 (Instructions to Perform Earthquake Analysis for VLT Instruments and Similar Equipment VLT-SPE-ESO-100000-1853 Issue 1) of the M2 Unit Technical Specification.

Depending on the results obtained (See Section 3.4.2), a static loads analysis will be acceptable for PDR.

Of note page 7 Section 3.1 identifies

"...Therefore an important design goal of the equipment shall be to provide sufficient rigidity to avoid dynamic coupling and magnification effects with the VLT structure by maximising the structural stiffness and minimising the mass. This design goal is reached when the lowest significant eigenfrequency of the equipment structure is above 30Hz along the horizontal x and y directions and above 70 Hz along the vertical direction".