



Requirements Review

SEIS-SP Level 2, 3, 4, 5 Requirements

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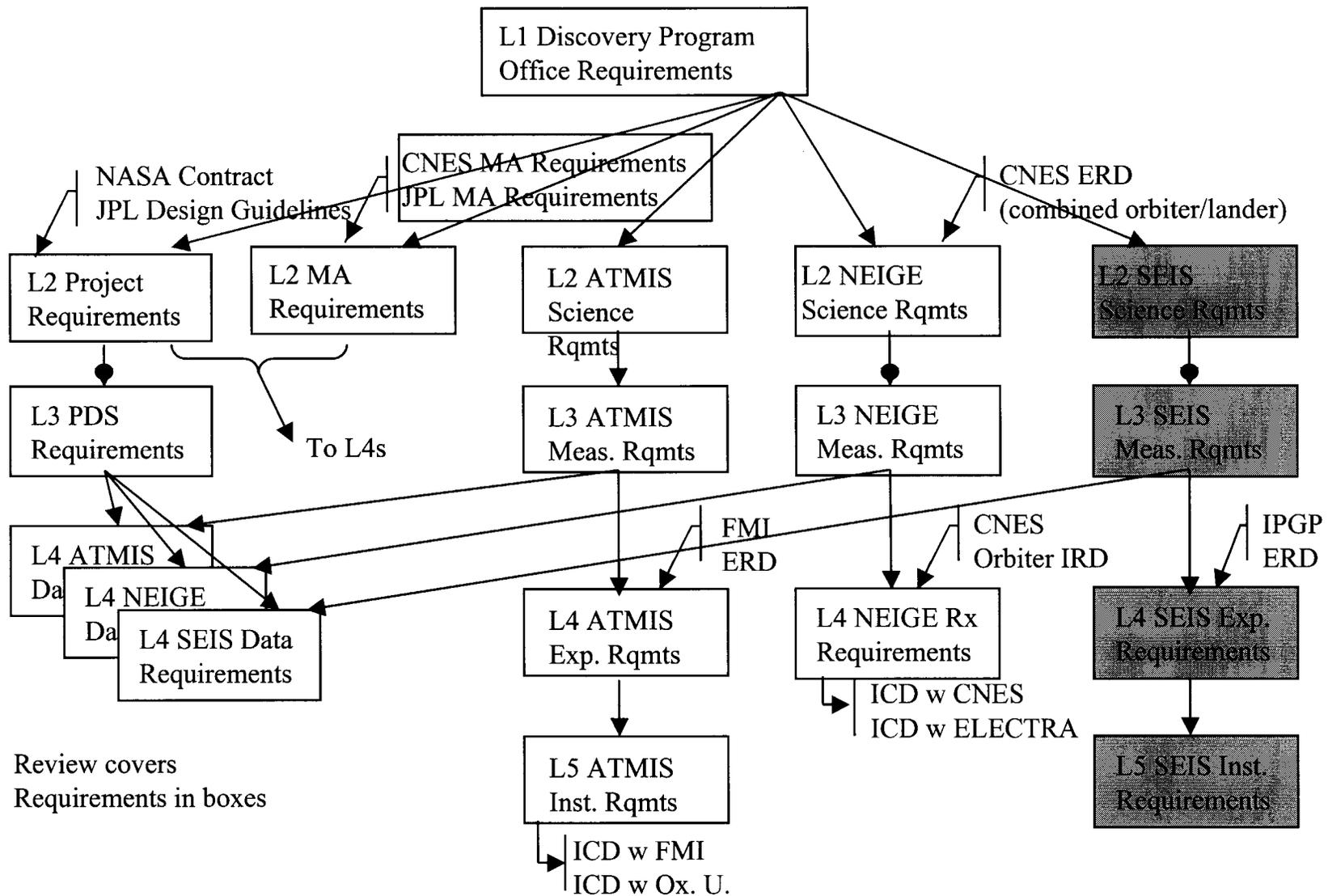
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Mars NetLander Discovery Project: SEIS-SP



Requirements Flow



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Introduction



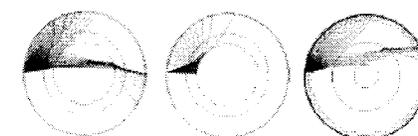
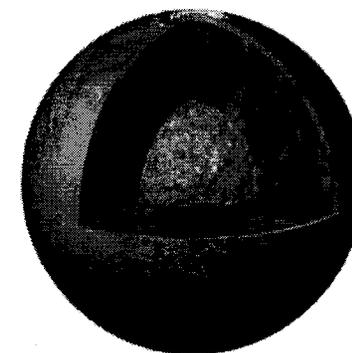
- This presentation will describe the Level 2, 3, 4, and 5 requirements for the SEIS-SP investigation.
- The SEIS investigation goals and objectives will be listed first to provide context for the following Level 2 science requirements.
- This will be followed by the SEIS Level 3 measurement requirements, the SEIS Level 4 experiment requirements and SEIS-SP Level 5 instrument requirements.



Level 2 Science Goals and Objectives

Objectives and Goals

- L.2.10: The Mars NetLander SEIS investigation will determine the internal structure and dynamics of Mars in terms of its composition, mineralogy, and thermal state.
- L.2.11: The Mars NetLander SEIS investigation will determine the level and distribution of Mars' current volcano-tectonic activity, and the current meteoroid flux at Mars.
- L.2.12: The Mars NetLander SEIS investigation will determine the level and distribution of seismic activity.
- L.2.14: The Mars NetLander SEIS investigation will use body wave arrivals at multiple stations to determine the location, origin time, and size of seismic events.
- L.2.15: The Mars NetLander SEIS investigation will evaluate any correlation of contemporary seismicity with the recorded effects of past tectonics as manifested by structures observed on the surface.
- L.2.16: The Mars NetLander SEIS investigation will search for correlations of seismicity with regions for which large stresses are inferred from geophysical studies.
- L.2.17: The Mars NetLander SEIS investigation will use seismicity to investigate the sources of stress responsible for seismic activity.
- L.2.18: The Mars NetLander SEIS investigation will infer the current meteoroid flux at Mars.
- L.2.13: The Mars NetLander SEIS investigation will use seismic information to determine the deep internal structure of the planet.
- L.2.19: The Mars NetLander SEIS investigation will develop travel time versus distance curves for prominent seismic phases, and invert them for seismic velocity as a function of depth.
- L.2.20: The Mars NetLander SEIS investigation will attempt to infer the thickness and physical properties of the Martian crust.
- L.2.21: The Mars NetLander SEIS investigation will use body waves and normal modes to infer the structure and seismic transmission properties of the mantle.
- L.2.22: The Mars NetLander SEIS investigation will use seismic information to infer the size and physical state of the core.
- L.2.13: The Mars NetLander SEIS investigation will provide estimates of the seismic attenuation of the interior and infer its thermodynamic structure.



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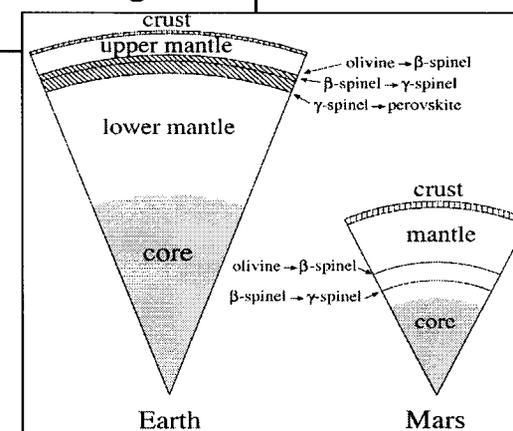
Mars NetLander Discovery Project: SEIS-SP



SEIS Level 2 Science Requirements



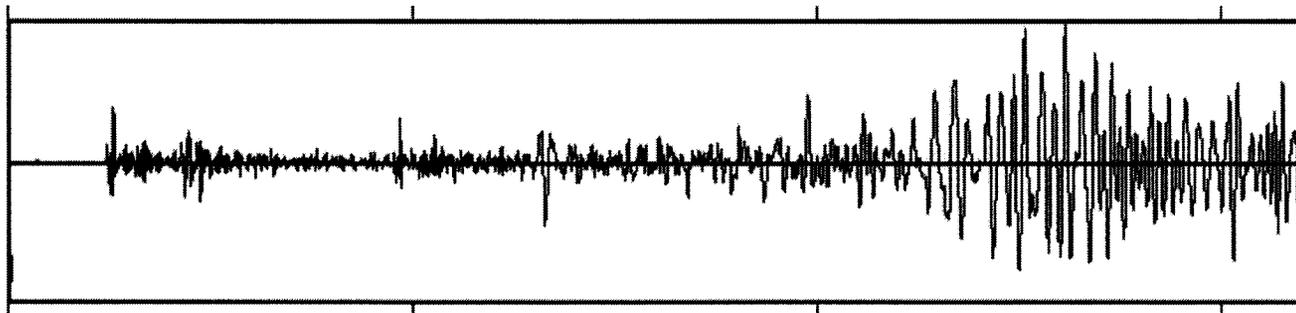
Level 2 Science Requirements	Verification
L.2.56: The Mars NetLander Discovery contribution to SEIS shall be capable of measuring signals from Earth-equivalent magnitude 4 seismic events originating anywhere on Mars.	Design
L.2.43: The Mars NetLander Discovery contribution to SEIS shall be designed to measure both close and distant events.	Design
L.2.44: The Mars NetLander Discovery contribution to SEIS shall have the capability to measure body waves and surface waves.	Design
L.2.45: The Mars NetLander Discovery contribution to SEIS shall have the capability to measure signals from meteorite impacts.	Design
L.2.46: The Mars NetLander Discovery SEIS investigation shall be designed to accumulate data from enough events to provide useful constraints on interior models.	Design



Level 3 Measurement Requirements



Level 3 Measurement Requirements	Verification
L.3.20: The Mars NetLander Discovery contribution to SEIS shall include 3 short period seismometers (SEIS SP) in an orthogonal configuration to measure signals in the band 0.05 to 50 Hz.	Design
L.3.16: The SEIS SP shall have sensitivity to measure ground acceleration down to a level of 10^{-8} m/sec ² or less.	Test
L.3.17: The SEIS SP shall provide a dynamic range of at least 5 decades.	Design
L.3.18: The SEIS SP shall operate over a frequency range of at least 0.05 to 50 Hz.	Test





SEIS Level 4 Experiment Requirements



SEIS Level 4 Hardware Requirements

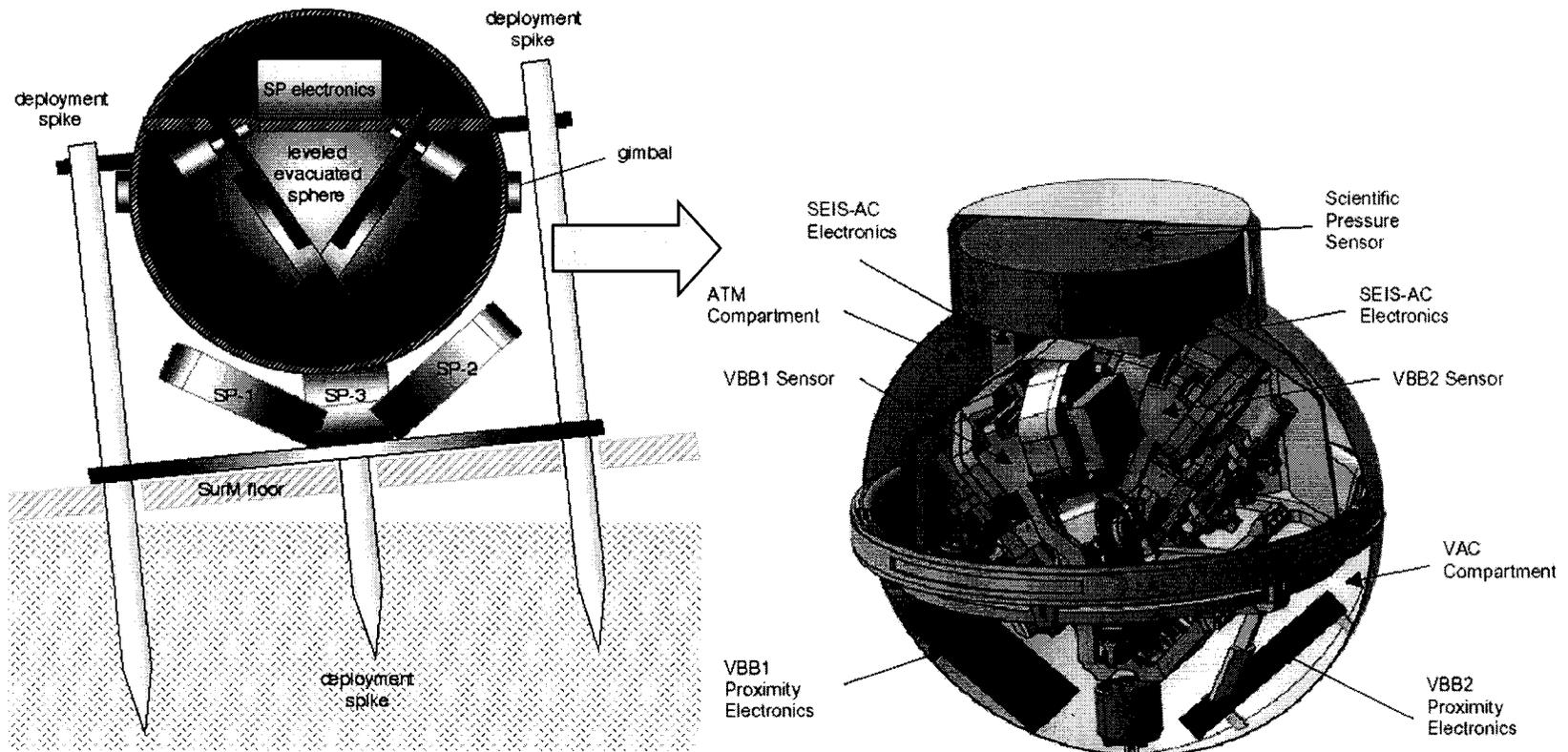


Level 4 Experiment Requirements	Type	Verification
L.4.83: The Mars NetLander Discovery Project shall deliver a SEIS-SP engineering model (EM), a SEIS-SP qualification model (QM), four SEIS-SP flight models (FM), and two SEIS-SP spare models.	Hardware	Inspection
L.4.84: Each SEIS-SP model shall consist of three sensors with their associated electronics.	Hardware	Inspection



SEIS Level 4 Functional Requirements

Level 4 Experiment Requirements	Type	Verification
L.4.2: The three SEIS-SP sensors shall be orthogonal to each other.	Functional	Inspection
L.4.399: The SEIS-SP shall be mounted external to the sphere.	Functional	Inspection
L.4.85: The SEIS-SP sensors shall be mounted without leveling.	Functional	Inspection



Level 4 Planetary Protection Requirements



Level 4 Experiment Requirements	Type	Verification
L.4.33: SEIS-SP, when integrated into the SEIS instrument, shall undergo a bake for planetary protection at 110 C for 30 hours.	Planetary Protection	Test



Level 4 Environmental/QA Requirements



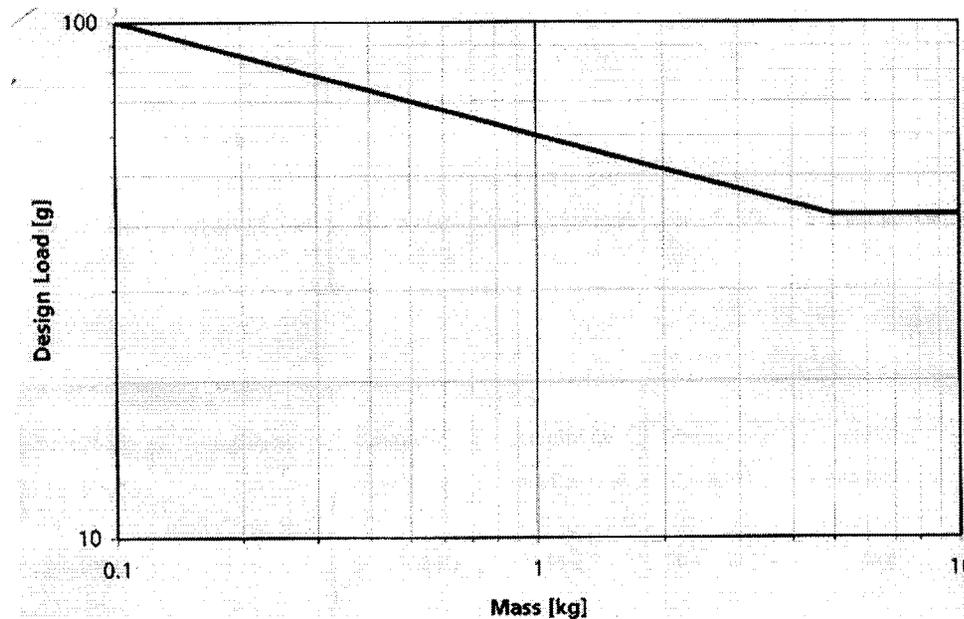
Level 4 Experiment Requirements	Type	Verification
L.4.46: Both cruise and Mars surface thermal environments shall determine the environmental test requirements.	Env./QA	Inspection
L.4.97: The SEIS SP components in the sphere, while not operating, shall survive when exposed to the temperature range: -140C to +80C.	Env./QA	Test
L.4.47: The SEIS SP components in the sphere shall operate nominally when exposed to the temperature range: -55C to +20C.	Env./QA	Test
L.4.30: The SEIS SP components outside the sphere, while not operating, shall survive when exposed to the temperature range: -140C to +80C.	Env./QA	Test
L.4.31: The SEIS SP components outside the sphere shall operate nominally when exposed to the temperature range: -120C to +20C.	Env./QA	Test
L.4.25: SEIS-SP, when integrated into the SEIS instrument, shall have a first eigenfrequency higher than 250 Hz for items with more than 10% of the effective payload mass.	Env./QA	Test



Level 4 Environmental/QA Requirements



Level 4 Experiment Requirements	Type	Verification
<p>L.4.27: SEIS-SP, when integrated into the SEIS instrument, shall have static design loads specified as a function of mass. The following cases shall be considered:</p> <p>x-axis: $\pm DL$ in x $\pm 16g$ in y $\pm 16g$ in z y-axis: $\pm 16g$ in x $\pm DL$ in y $\pm 16g$ in z z-axis: $\pm 16g$ in x $\pm 16g$ in y $\pm DL$ in z</p> <p>The quasi-static design loads for SEIS-SP integrated in the SEIS instrument are given in the figure below.</p>	Env./QA	Analysis



Level 4 Environmental/QA Requirements



Level 4 Experiment Requirements	Type	Verification
L.4.36: SEIS-SP, when integrated into the SEIS instrument, shall withstand a sine vibration qualification level as specified in the table below. The qualification sweep rate shall be 2 oct/min.	Env./QA	Test
L.4.98: The sine vibration acceptance level for the SEIS-SP, when integrated with the SEIS instrument, shall be the sine vibration qualification level divided by 1.25. The acceptance sweep rate shall be 4 oct/min in each axis.	Env./QA	Test

x-direction		y-direction		z-direction	
Frequency	Amplitude	Frequency	Amplitude	Frequency	Amplitude
5 – 40 Hz	x mm 0 to peak	5 – 40 Hz	x mm 0 to peak	5 – 40 Hz	x mm 0 to peak
40 – 50 Hz	Unit design load	40 – 50 Hz	Unit design load	40 – 50 Hz	Unit design load
50 – 120 Hz	15 g	50 – 120 Hz	15 g	50 – 120 Hz	15 g
120 – 200 Hz	7 g	120 – 200 Hz	7 g	120 – 200 Hz	7 g



Level 4 Environmental/QA Requirements



Level 4 Experiment Requirements	Type	Verification
L.4.38: SEIS-SP, when integrated into the SEIS instrument, shall withstand a random vibration qualification level as specified in the table below. Qualification random vibration duration shall be 2 min per axis.	Env./QA	Test
L.4.99: The random vibration acceptance level for the SEIS-SP, when integrated with the SEIS instrument, shall be the random vibration qualification level divided by 2.25. Acceptance random vibration duration shall be 2 min. per axis.	Env./QA	Test

x-direction			y-direction			z-direction		
Freq. [Hz]	PSD [g ² /Hz]	Slope [dB/oct]	Freq. [Hz]	PSD [g ² /Hz]	Slope [dB/oct]	Freq. [Hz]	PSD [g ² /Hz]	Slope [dB/oct]
20	0.0096	6.000	20	0.0096	6.000	20	0.0096	6.000
130	0.4	0.000	130	0.4	0.000	130	0.4	0.000
190	0.4	24.248	190	0.4	24.606	260	0.4	17.664
244	3	0.000	240	2.7	-13.399	450	10	0.000
380	3	24.722	300	1	0.000	480	10	-25.593
440	10	0.000	450	1	17.449	600	1.5	-12.000
510	10	-21.889	550	3.2	-12.000	2000	0.0124	
700	1	-12.000	2000	0.0186				
2000	0.0152							
G _{rms} = 50			G _{rms} = 33.5			G _{rms} = 42.7		

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Level 4 Environmental/QA Requirements



Level 4 Experiment Requirements	Type	Verification
L.4.95: Notching during tests for the SEIS-SP will be allowed for frequencies larger than 150Hz. Prior to any notching, a notching request has to be issued and agreed upon with the SEIS Project who will form DLR Braunschweig if applicable.	Env./QA	Inspection
L.4.40: SEIS-SP, when integrated into the SEIS instrument, shall withstand a qualification level of static load equal to 36g along the Y-axis ± 20 degrees to survive the Mars entry.	Env./QA	Analysis
L.4.41: SEIS-SP, when integrated into the SEIS instrument, shall withstand a shock level defined in the table below during EDLS separation. The shock test shall be defined as a frequency-dependent amplitude level.	Env./QA	Test

Pyrotechnic shock during EDLS separation:

Location	Frequency Range [Hz]	y-acceleration [g]	x,z-acceleration [g]
All Units	500	1500	700
	3000	13000	7000
	10000	13000	7000



Level 4 Environmental/QA Requirements



Level 4 Experiment Requirements	Type	Verification
L.4.100: SEIS-SP, when integrated with the SEIS instrument, shall withstand a load vector of 20g during 0.1s in a cone of 25 degrees angle around the +Y axis to survive the parachute deployment.	Env./QA	Analysis
L.4.42: SEIS-SP, when integrated with the SEIS instrument, shall withstand a Mars landing shock load equal to 180 g half sine 20 ms in a cone of +-45 degrees around the Y axis of the SurfM	Env./QA	Test
L.4.43: SEIS-SP, when integrated with the SEIS instrument, shall withstand a secondary shock load for Mars landing equal to 140 g half sine 20 ms in any direction.	Env./QA	Test
L.4.44: SEIS-SP, when integrated in the SEIS instrument, shall withstand a shock environment due to the drop of the surface module from the airbag to Martian ground as specified in the Table below. The levels are the same as for the pyrotechnic shock which envelopes the drop shock for high frequencies, but is extended to lower frequency shocks which were observed during preliminary drop testing.	Env./QA	Test

Shock due to drop from airbag:

Location	Frequency Range [Hz]	any direction [g]
All Units	100	215
	3000	13000
	10000	13000





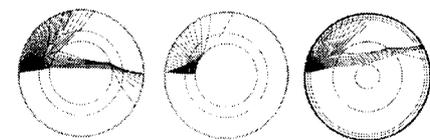
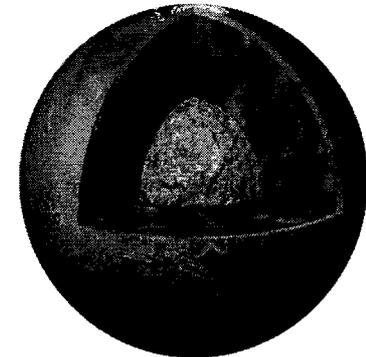
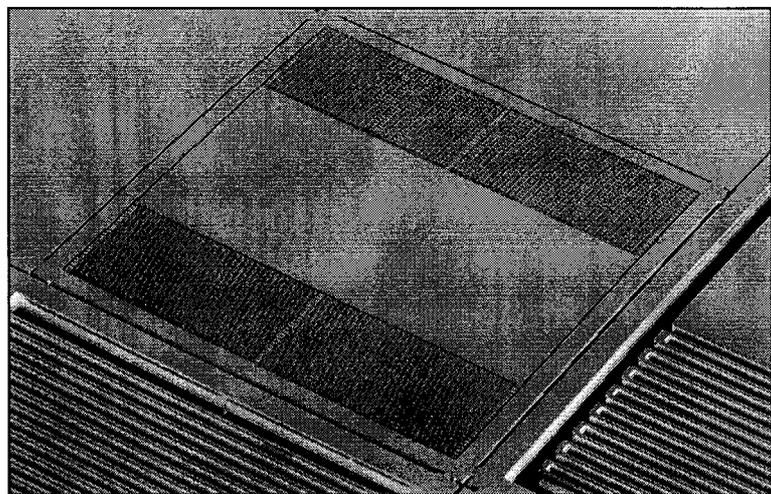
SEIS-SP Level 5 Instrument Requirements



Level 5 Instrument Performance Requirements



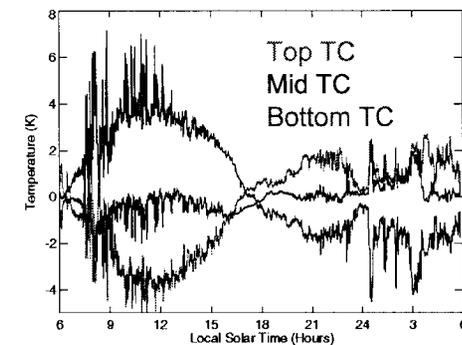
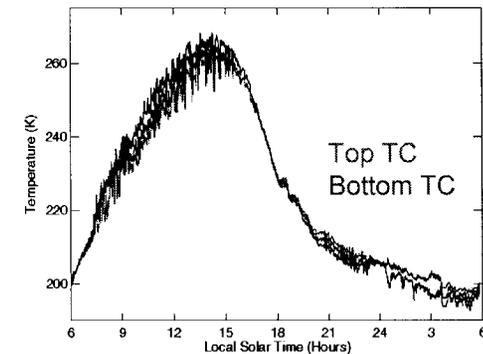
Level 5 Instrument Requirements	Type	Verification
L.5.2: The SEIS-SP shall demonstrate sensor noise of 10^{-8} $\text{ms}^{-2}/\text{rtHz}$ from 0.05Hz to 20Hz and 10^{-7} $\text{ms}^{-2}/\text{rtHz}$ up to 50 Hz.	Performance	Test
L.5.41: The SEIS-SP shall have a dynamic range of 5 decades.	Performance	Test
L.5.3: The SEIS-SP shall provide 24-bit data output streams capable of external processing down to 200 samples per second.	Performance	Test
L.5.4: The SEIS-SP shall meet performance requirements at ± 30 deg off nominal orientation.	Performance	Test



Level 5 Instrument Calibration Requirements



Level 5 Instrument Requirements	Type	Verification
L.5.13: The SEIS-SP shall be calibrated to demonstrate performance as a function of temperature.	Calibration	Test
L.5.14: The SEIS-SP shall be calibrated to demonstrate performance as function of orientation angle.	Calibration	Test



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Mars NetLander Discovery Project: SEIS-SP



Level 5 Instrument Env./QA Requirements



Level 5 Instrument Requirements	Type	Verification
L.5.5: The environmental test program shall be accomplished using a SEIS-SP qualification model (QM).	Env./QA	Inspection
L.5.15: The SEIS-SP QM shall undergo low-level sine sweep to measure frequency resonances to greater than 250 Hz.	Env./QA	Test
L.5.16: The SEIS-SP QM shall undergo quasi-static Limit Loads tests at the following qualification levels: x-axis: +50g in x, +16g in y, +16g in z y-axis: +16g in x, +50g in y, +16g in z z-axis: +16g in x, +16g in y, +50g in z.	Env./QA	Test
L.5.17: The SEIS-SP QM shall undergo power-off sine vibration tests at the following qualification levels. The qualification sweep rate shall be 2 oct/min.	Env./QA	Test

x-direction		y-direction		z-direction	
Frequency	Amplitude	Frequency	Amplitude	Frequency	Amplitude
5-40 Hz	x mm 0 to peak	5-40 Hz	x mm 0 to peak	5-40 Hz	x mm 0 to peak
40-50 Hz	50 g	40-40 Hz	50 g	40-50 Hz	50 g
50-120 Hz	15 g	50-120 Hz	15 g	50-120 Hz	15 g
120-200 Hz	7 g	120-200 Hz	7 g	120-200 Hz	7 g



Level 5 Instrument Env./QA Requirements



Level 5 Instrument Requirements	Type	Verification
The SEIS-SP QM shall undergo power-off random vibration at qualification levels below. Qualification random vibration duration shall be 2 minutes per axis.	Env./QA	Test

x-direction			y-direction			z-direction		
Freq. (Hz)	PSD (g ² /Hz)	Slope (dB/oct)	Freq. (Hz)	PSD (g ² /Hz)	Slope (dB/oct)	Freq. (Hz)	PSD (g ² /Hz)	Slope (dB/oct)
20	0.0134	6.000	20	0.0134	6.000	20	0.0135	6.000
130	0.564	0	130	0.564	0	130	0.564	0
190	0.564	24.248	190	0.564	24.606	260	0.564	17.664
244	4.23	0	240	3.807	-13.399	450	14.1	0
380	4.23	24.722	300	1.41	0	480	14.1	-25.593
440	14.1	0	450	1.41	17.449	600	2.115	-12.000
510	14.1	-21.889	550	4.512	-12.000	2000	0.0175	
700	1.41	-12	2000	0.0262				
2000	0.0214							
Grms=70.5			Grms=47.2			Grms=60.2		



Level 5 Instrument Env./QA Requirements



Level 5 Instrument Requirements	Type	Verification
The SEIS-SP QM shall undergo shock tests at qualification levels below.	Env./QA	Test

Freq. (Hz)	direction	acceleration	source
10	+y-axis, 25 deg cone	20g	parachute deployment
50	+y-axis, 45 deg cone	180g	primary landing shock
50	x-, z-axis	140g	secondary landing shock
100	x-, y-, z-axis	215g	drop from airbag
500	y-axis	1500g	EDLS separation
500	x-, z-axis	700g	EDLS separation
3000	x-, y-, z-axis	13000g	drop from airbag
10000	x-, y-, z-axis	13000g	drop from airbag



Level 5 Instrument Env./QA Requirements



Level 5 Instrument Requirements	Type	Verification
<p>L.5.26: The qualification and acceptance level lower temperatures in Mars atmospheric conditions shall not be below -123C (150K), the condensation temperature of the simulated Mars atmosphere.</p>	Env./QA	Test
<p>L.5.31: For components in the sphere, the SEIS-SP qualification temperatures applicable to cruise conditions shall be:</p> <ul style="list-style-type: none"> Non-operational maximum qualification temp: 100C Non-operational minimum qualification temp: -155C Operational maximum qualification temp: 70C Operational minimum qualification temp: -70C <p>For components outside the sphere, the SEIS-SP qualification temperatures applicable to cruise conditions shall be:</p> <ul style="list-style-type: none"> Non-operation maximum qualification temp: 100C Non-operational minimum qualification temp: -155C Operational maximum qualification temp: 70C Operational minimum qualification temp: -135C 	Env./QA	Test



SEIS-SP Level 5 Instrument Env./QA Requirements



Level 5 Instrument Requirements	Type	Verification
<p>L.5.27: For components in the sphere, the SEIS-SP qualification temperatures applicable to Mars surface operations shall be:</p> <p>Non-operational maximum qualification temp: 100C Non-operational minimum qualification temp: -120C Operational maximum qualification temp: 70C Operational minimum qualification temp: -70C</p> <p>For components in the sphere, the SEIS-SP qualification temperatures applicable to Mars surface operations shall be:</p> <p>Non-operation maximum qualification temp: 100C Non-operational minimum qualification temp: -120C Operational maximum qualification temp: 70C Operational minimum qualification temp: -120C</p>	Env./QA	Test
<p>The SEIS-SP QM shall undergo 8 thermal cycles between non-operational maximum and non-operational minimum temperatures. Three (3) of the cycles will be in vacuum, five (5) of the cycles in a simulated Mars environment. The dwell time at each temperature shall be at least 2 hours.</p>	Env./QA	Test
<p>The SEIS-SP QM shall undergo thermal vacuum tests to demonstrate survival over temperature with extended soaks.</p> <p>Operational max temperature soak time: 50 hrs Operational min temperature soak time: 24 hrs</p> <p>The extended soaks may be demonstrated as one of the thermal cycles.</p>	Env./QA	Test



Level 5 Instrument Planetary Prot. Requirements



Level 5 Instrument Requirements	Type	Verification
L.5.22: The SEIS-SP QM shall undergo a non-operational thermal bake at 110C (TBC) for 30 hrs (TBC) to demonstrate that the hardware can survive the Planetary Protection bake to be conducted at a higher level of instrument integration.	Planetary Protection	Test



Level 5 Instrument Env/QA Requirements

Verification	Type	Level 5 Instrument Requirements
Test	Env./QA	L.5.7: The SEIS-SF FM and spare shall undergo power-off random vibration at workmanship levels.
Test	Env./QA	L.5.32: The SEIS-SF acceptance temperatures applicable to cruise conditions shall be: Non-operation maximum flight acceptance temp: 45C (TBC) Non-operational minimum flight acceptance temp: -55C (TBC) Operational maximum flight acceptance temp: 55C (TBC) Operational minimum flight acceptance temp: -55C (TBC)
Test	Env./QA	L.5.29: The SEIS-SF acceptance temperatures applicable to Mars surface operations shall be: Non-operation maximum flight acceptance temp: 60C (TBC) Non-operational minimum flight acceptance temp: -123C (TBC) Operational maximum flight acceptance temp: 55C (TBC) Operational minimum flight acceptance temp: -123C (TBC)
Test	Env./QA	L.5.9: The SEIS-SF FM and spare model shall undergo 3 thermal cycles between non-operational max and non-operational min temperatures. One (1) of the cycles will be in vacuum, two (2) of the cycles in a simulated Mars environment. The dwell time at each temperature shall be at least 2 hours.
Test	Env./QA	L.5.25: The SEIS-SF FM and spare model shall undergo thermal vacuum tests to demonstrate survival over temperature with extended soaks. Operational max temperature soak time: 40 hrs Operational min temperature soak time: 8 hrs The extended soaks may be demonstrated as one of the thermal cycles.



Level 5 Instrument Functional Requirements



Level 5 Instrument Requirements	Type	Verification
L.5.10: The SEIS-SP shall have the appropriate vent holes.	Functional	Inspection

