CASSIS SYSTEM REQUIREMENTS DOCUMENT

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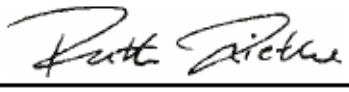
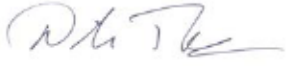
Instrument name:	Colour and Stereo Surface Imaging System (CaSSIS)
Origin Name:	Physikalisches Institut, Universität Bern
WBS code:	N/A
Package code:	N/A
Restrictions:	N/A

	Name	**Signature**	**Date**
Prepared by	Ruth Ziethe Project Manager		19 | 02 | 2014
Approved by	Nicolas Thomas Principal Investigator		19 | 02 | 2014

DOCUMENT CHANGE RECORD

Issue	Revision	Date	Pages, Tables, Figures affected	Modification	Initials
0	1		All	Draft	RZ
0	2		All	Formatting and updates	NT, RZ
1	1	17.9.13	All	Correcting the Requirements and add a new Functional Block Diagram	CZ
1	2	20.9.13		Title changed	RZ
1	4	20.9.13	Front page	Administrative corrections	NT
1	4	20.9.13		[CAS-CAM-0005] TBR removed. Changed error to +/- 0.2 deg to be consistent with TRD	NT
1	4	20.9.13		[CAS-CAM-0040] Simplified	NT
1	4	20.9.13		Higher level requirements added where possible	NT
1	4	20.9.13		[CAS-CAM-0290], [CAS-CAM-1100] Deleted	NT
1	4	20.9.13		[CAS-CAM-0622], [CAS-CAM-0624], [CAS-CAM-0625], [CAS-CAM-0626], [CAS-CAM-0001], [CAS-CAM-0002], [CAS-CAM-0003], [CAS-CAM-0242], [CAS-CAM-0244], [CAS-CAM-0302], [CAS-CAM-0304], [CAS-CAM-0308], [CAS-CAM-0225] Added	NT
1	4	20.9.13		Imaging Method section added (we never specified it anywhere!)	NT
1	4	20.9.13		[CAS-CAM-1160], [CAS-CAM-1230] modified for consistency with higher level	NT
1	4	20.9.13		[CAS-CAM-0270] moved	NT
1	4	20.9.13		[CAS-CAM-1090] modified	NT
1	5	18 Febr 2014	10	Figure 1 updated	RZ
				Figure 4 (Hardware Responsibilities) updated	RZ
			All	Changed requirements into table style	RZ

Table of Contents

Scope

This specification states the instrument requirements and functional description for the Colour and Stereo Surface Imaging System (CaSSIS) Camera for the 2016 ExoMars Trace Gas Orbiter (TGO).

1 CaSSIS Camera Description

The CaSSIS instrument is a narrow field-of-view (FOV) visible/near-infrared camera with a CMOS two dimensional array in the focal plane of a 3-mirror anastigmat telescope. The telescope includes an additional (slightly powered) fold mirror to minimize volume which, because of additional constraints, may be required to have some optical power. The sensor is 2048 pixels wide resulting in a 6-8km swath at the surface. Filters are attached directly to the detector using a single stripe-butted filter produced from different fused silica pieces with different transmission properties which are glued together.

Because the TGO spacecraft will yaw arount the nadir axis (-Y) the acquisition of either single images or for stereo image capture within the same orbit, the telescope is mounted to a rotation mechanism as part of the CRU (Camera Rotation Unit). This mechanism will align the individual images with the ground track and thus will facilitate along-track stereo imaging. A stereo pair is acquired by first rotating the telescope to point ahead of 10° to capture the first image, then rotating it 180° to point 10° behind for the second stereo view. For this stereo mode, fixed nadir pointing of the S/C is foreseen as baseline and CaSSIS only has to align the images along track. However, for single image acquisition the S/C will remain in nominal nadir mode, where the yaw rotation is not stopped. In this mode image acquisition and camera rotation have to be coordinated.

The telescope, focal plane assembly (FPA), CRU and associated structural mounts together comprise the imager assembly. The instrument electronics (ELU = Electronics Unit) are located in a separate non-rotating housing adjacent to the imager assembly. The focal plane electronics are part of the camera rotation unit.

The CaSSIS team will deliver a Structural-Thermal Model (STM), which is a hardware item used by the spacecraft provider to facilitate mechanical and thermal integration & test activities prior to delivery of the proto-flight unit.

The CaSSIS team will also deliver an Electrical Interface Model (EIM), which is a hardware item used by the spacecraft provider to facilitate electrical integration & test activities prior to delivery of the proto-flight unit.

A combination of the STM and EM will be produced for schedule reasons. This combination will be referred to as the Placeholder Model (PH).

A detailed description of the camera and its operation is located in chapter **Error! Reference source not found.**, 'Functional Description'.

2 REQUIREMENTS WEIGHTING FACTORS

"Shall" designates the most important weighting level—mandatory. Any deviations from these mandatory requirements require approval by the PI or his representative prior to implementation. "Shall" requirements appearing in section 5 require verification of compliance.

"Should" designates requirements requested by Systems Engineering and are not mandatory. Unless required by other contract provisions, non-compliance with "should" requirements does not require approval by the PI but he or his representative shall be informed of any deviation.

3 TBD/TBR/TBC

The term "To Be Determined (TBD)" applied to a missing requirement means that the University of Bern (UBE) will determine the missing requirement.

The term "To Be Resolved (TBR)" means that the requirement is subject to review for appropriateness by UBE.

The term "To Be Confirmed (TBC)" means that the requirement is the current best estimate and that confirmation by UBE is still needed.

Each instance of a TBD, TBC or TBR in this specification is identified by either the acronym "TBD", "TBC", or "TBR," respectively.

4 APPLICABLE DOCUMENTS

4.1 General

The following documents, except those identified as Reference documents, form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the contract.

4.2 European Space Agency Documents

Identifier	Name	Number
ESA-REF1	Experiment-Instrument Requirements Document	EXM-PL-IRD-ESA-00003 Issue 2 Rev 0 TGO E-IRD (JCCB - Signed)
ESA-REF2	Science Management Plan	[IR 5] ExoMars Science Management Plan - Issue 5.4 - 12feb10
ESA-REF3	EMC and Power Quality Requirements	EXM-MS-SSR-AI-0002, [IR 131]

4.3 Reference Documents (UBE)

Identifier	Name	Number
UBE-REF1	CaSSIS to EMTGO Experiment Interface Control Document (E-ICD)	EXM-CA-ICD-UBE-00001
UBE-REF2	Product and Mission Assurance Plan	EXM-CA-PLN-UBE-00015
UBE-REF3	CaSSIS Mechanical Interface Drawing (MICD)	EXM-CA-DRW-UBE-20001
UBE-REF4	Statement of Work	EXM-CA-SOW-UBE-00001
UBE-REF5	List of Acronyms Iss 1 Rev 0	EXM-CA-LIS-UBE-00001

4.4 Order of Precedence

In the event of conflict between the applicable documents and the contents of this specification, the order of precedence shall be as follows (TBC) unless stated otherwise. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

a) Higher-level specifications per the specification tree
b) This specification
c) Contract statement of work
d) Applicable documents other than a) or b)

4.5 Specification Tree

The following diagram shows the relationship between the CaSSIS System Requirements Document (SRD) and other top level program documentation.

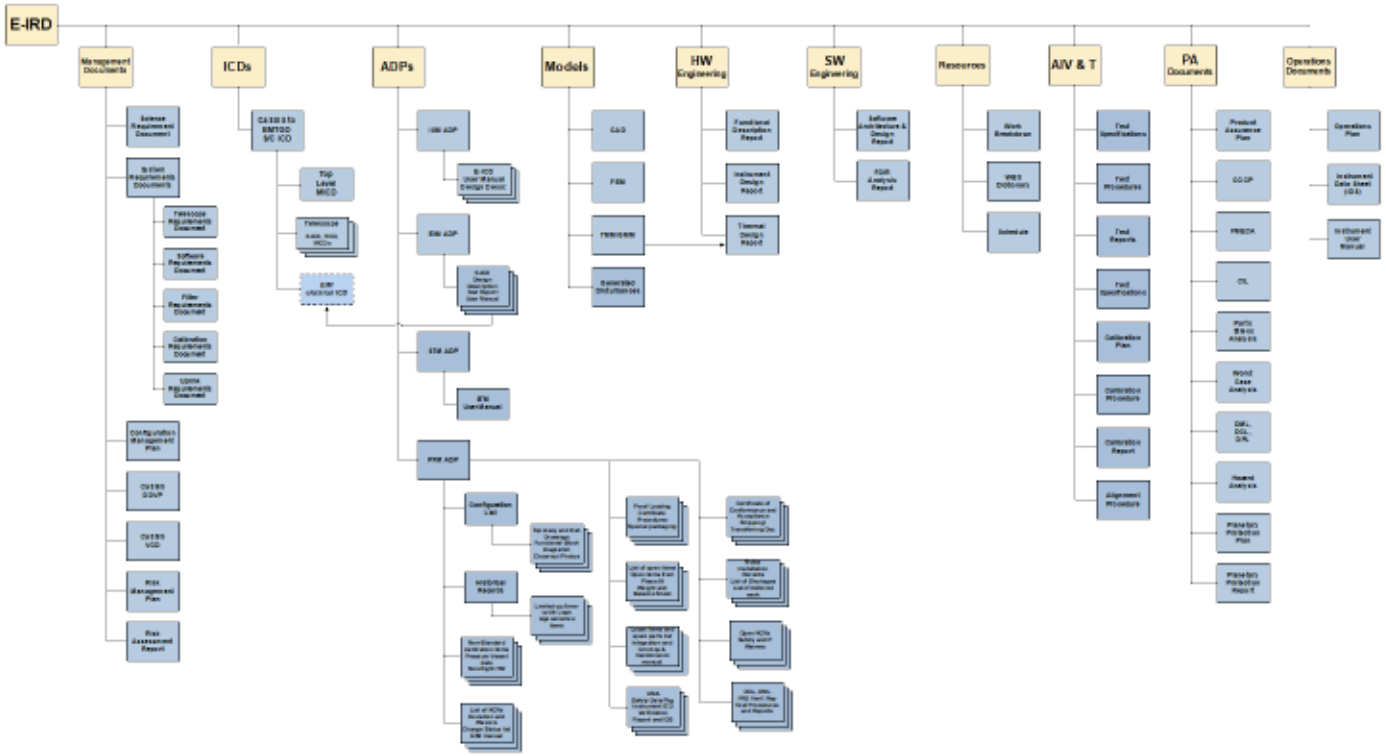


Figure 1: Top level documentation tree

5 REQUIREMENTS

5.1 Characteristics

This subsection should contain the required characteristics of the system or item. Typical requirements in this subsection include weight limits, volume/envelope limits, electrical voltage/power limits, center of gravity, moments of inertia, mission life, and mechanical resonant frequencies. If separate ICDs control the interface between this system or element and other systems or elements, then this subsection will likely refer to them. Environmental requirements appear in subsection 5.9.

5.2 Definitions

For each requirement the verification method and test level (component, subsystem, spacecraft) will be stated. See section 'verification Methods for definitions.

5.3 Description

See chapter **Error! Reference source not found.** (Functional Description) for a detailed functional breakdown and description of the instrument including the functional block diagram, hardware breakdown diagram and concept of operations (CONOPS).

5.3.1 Instrument Description and Requirements

Description: **Error! Reference source not found.** depicts the units that comprise the CaSSIS instrument. The two major units are Camera Rotation Unit (CRU) and the Electronics Unit (ELU). The Camera Rotation Unit consists of the Telescope, the rotation mechanism, and the Focal Plane Subsystem (focal plane array and proximity electronics). The ELU contains three modules: Rotaion control module (RCM), Power Converter Module (PCM) and Digital Processing Module (DPM).

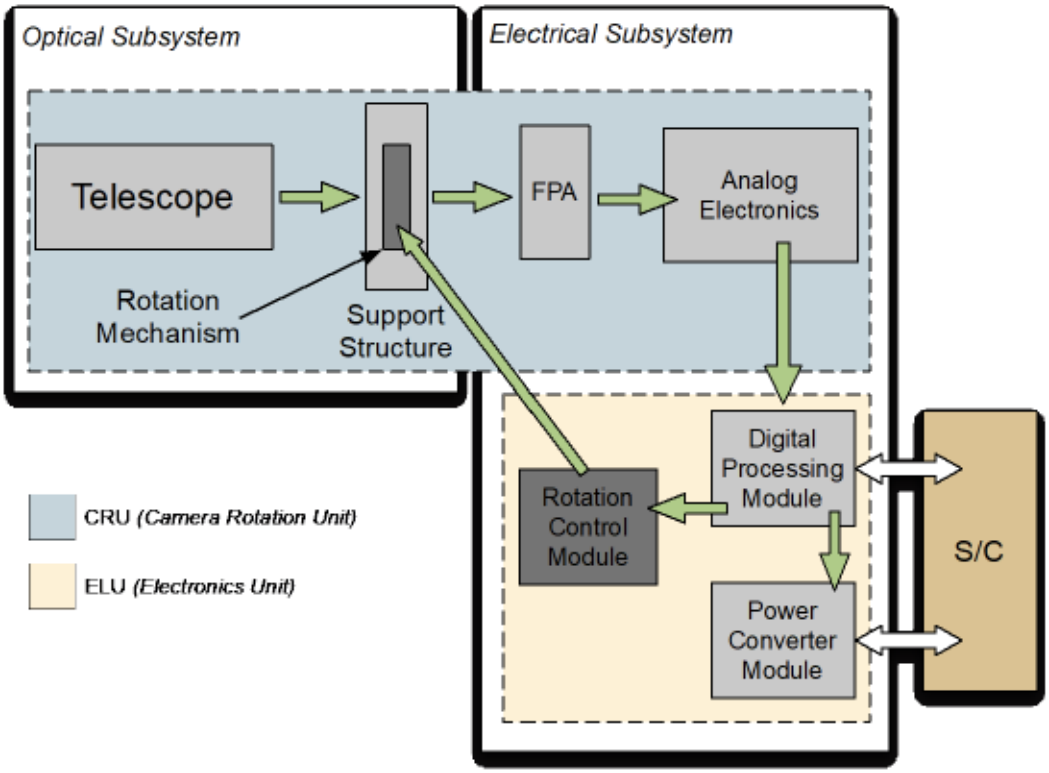


Figure 2: CaSSIS Unit Interaction

5.3.2 Imaging Method

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0001	The instrument shall implement a "push-frame" method of imaging.					X							X					
CAS-CAM-0002	The instrument shall provide continuous coverage of a >8 km wide swath for a distance of > 32 km (along track). *Information: We try to specify here the minimum image size along track for sizing the repetitions and the memory(s).*					X							X					
CAS-CAM-0003	The instrument shall use a rotation mechanism to provide stereo coverage by pointing first forward along-track and then turning by 180 degrees (nominally) to view backwards. *Information: We try to specify here the minimum image size along track for sizing the repetitions and the memory(s).* *Higher level req.: [CAS-SCI-0110]*					X							X					

5.3.3 Telescope Optical Axis

Description: The Telescope Assembly contains the telescope/relay optics, mirror mounts, telescope structure and baffles.

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0005	The telescope optical axis shall be pointed 10.0±0.2° from the CRU rotation axis in the telescope plane of incidence. *Higher Level Req.: [CAS-SCI-0050], [CAS-SCI-0110]*				X								X					

Description: The telescope structure consists of the optical bench, field stop, Lyot stop, rotation mechanism interface and associated multi-layer insulation (MLI).

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0010	The telescope structure shall support the telescope optics, baffles, stops, and focal plane subsystem.					X							X					

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0020	The telescope structure shall maintain performance specifications under all expected environmental conditions.				X								X					

5.3.4 Telescope optics

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0030	The telescope optics shall produce high-resolution images across the entire FOV that meet the performance specifications in Section 5.5.1 of this specification.					X							X					
CAS-CAM-0031	The instrument shall acquire images at a pixel scale of between 4.2 and 5.0 m/px. *Higher Level Req.: [CAS-SCI-0120]*				X								X					
CAS-CAM-0032	The instrument PSF (x) shall be 1.2<x<1.8 pixels in both directions under nominal conditions. *Note: If the rotation mechanism fails it is expected that this requirement cannot be held. Nominal conditions assumes that the instrument is functioning as intended.* *Higher Level Req.: [CAS-SCI-0120]*				X								X					
CAS-CAM-0033	The distance to the surface of Mars shall be assumed to be 400 km (circular orbit).					X							X					

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0034	The instrument shall acquire images in 3 colours plus a panchromatic channel. *Higher Level Req.: [CAS-SCI-0140]*					X							X					
CAS-CAM-0035	The instrument shall be sensitive to photons in the wavelength range between 400 nm and 1100 nm. *Higher Level Req.: [CAS-SCI-0140]*				X								X					
CAS-CAM-0036	The primary mirror shall be ≥13.4 cm in diameter.					X							X					
CAS-CAM-0037	The total instrument throughput (detector plus optics, excluding filters) shall exceed 50% between 475 nm and 1050 nm. *Higher Level Req.: [CAS-SCI-0140]*				X								X					
CAS-CAM-0038	The instrument unvignetted field of view shall exceed 1.30° (cross-track) x 0.85° (along-track). *Higher Level Req.: [CAS-SCI-0120]*				X								X					

5.3.5 Focus mechanism

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0040	No focus mechanism shall be required.					X							X					

5.3.6 Thermal control system

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0090	The thermal control system shall maintain the instrument components within their specified operational temperature ranges. Information: The operational temperature ranges are listed the E-IRD [ESA-REF1]. To reduce contamination and ease testing, the entire imager assembly should be maintained at a temperature above the local equilibrium temperatures of the surrounding spacecraft.				X								X					
CAS-CAM-0100	Operational heaters shall be driven by active control loops that sense temperatures at various locations within the instrument to maintain the instrument components at pre-selected temperatures.				X								X					
CAS-CAM-0110	The operational temperature setpoints shall be commandable from the ground.				X							X						
CAS-CAM-0120	At times during the mission when the instrument is powered off, instrument temperatures shall be maintained within the survival ranges by redundantly thermostatically or with simple analog-electronic controlled heaters powered by redundant sources from the spacecraft.					X							X					
CAS-CAM-0130	The thermal control system shall maintain the instrument components within their survival operational temperature ranges while consuming a maximum orbital average power of 4.5 W (TBC).					X							X					

	Information: The survival temperature ranges are listed in the E-IRD [ESA-REF1].																
CAS-CAM-0140	The thermal control system shall include two pairs (2 nominal and 2 redundant) survival thermal sensors (PT100 or PT1000) to be monitored by the spacecraft.					X						X					

5.3.7 Rotation Unit

Description: The aft end of the Telescope Assembly is attached to rotation unit. The support bracket supports the telescope and focal plane array and provide +/- 180° rotation about an axis 10° offset from the telescope boresight (see above). Internal to the rotation unit is a twist capsule with flex circuit cables, which provide electrical feedthroughs between the rotating and non-rotating sections of the instrument.

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0116	The rotation mechanism shall hold its position during launch without the application of power.					X							X					
CAS-CAM-0150	The rotation mechanism shall be capable of rotating the complete Imager Assembly including Telescope by +/- 180° in less than 15 seconds. *Information: this also defines a maximum strip length for an image of about 90km.* *Higher Level Req.: [CAS-SCI-0110]*				X								X					
CAS-CAM-0160	The rotation mechanism including complete Imager Assembly and Telescope shall reach its commanded position to an accuracy of +/- 1°. *Higher Level Req.: [CAS-SCI-0110]*				X								X					
CAS-CAM-0170	The position of the telescope following rotation shall be known to an accuracy of +/- 1°. *Higher Level Req.: [CAS-SCI-0110]*				X								X					

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0175	The complete imager assembly with telescope shall be rotationally balanced.				X								X					

5.3.8 Focal Plane Subsystem (FPS)

Description: The Focal Plane Subsystem (FPS) consists of the Focal Plane Array (FPA), Analog electronics (also called proximity electronics) and interconnecting cables.

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0180	The FPS shall be capable of acquiring images.				X								X					
CAS-CAM-0190	Image Exposure times shall be commandable and the FPS shall acquire the images with exposure times from 1us to 300ms with a resolution of 1us and from 300ms to 10s with a resolution of 1ms.				X								X					
CAS-CAM-0200	The FPS shall be able to produce images at a rate of >4 Hz (<0.25 s).				X								X					
CAS-CAM-0210	The FPS shall allow individual binning of each sub-exposure to 1 x 1 (default), 2 x 2, 4 x 4, and 8 x 8 pixels.					X							X					
CAS-CAM-0220	The FPS shall allow addressing of at least 6 individual areas on the sensor for transmission to the digital processing module. These areas shall					X							X					

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
	provide images simultaneously of the available scene. *Higher Level Req.: [CAS-SCI-0140]*																	
CAS-CAM-0225	The individual areas of the FPS shall be defined with a resolution of 1 pixel (along-track) and 64 pixels (cross-track) *Info: The FPS system effectively reads out in blocks of 64 pixels cross-track. This needs to be accounted for.*				X								X					
CAS-CAM-0230	The FPS shall produce images digitized to 14 bits per pixel. *Higher Level Req.: [CAS-SCI-0142] needs at least 10 bits to reach the SNR over the whole sensor.*				X								X					

5.3.9 Focal Plane Assembly

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0240	The Focal Plane Array (FPA) shall consist of a single 2048 x 2048 pixel CMOS hybrid imaging sensor with its mount and associated electronics required to be immediately adjacent to the sensor. *Information: Attached to the substrate are heater mats, temperature sensors and thermostats to provide operational and survival thermal control.*							X				X						
CAS-CAM-0241	A filter strip assembly (FSA) shall be mounted as part of the FPA and shall perform bandwidth limiting of the light striking the sensor.					X						X						

5.3.10 The Sensor

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0242	The sensor shall have a pixel pitch of nominally 10 microns.					X						X						
CAS-CAM-0270	The sensor full–well shall exceed 90 kelectrons.					X						X						
CAS-CAM-0244	The sensor quantum efficiency shall exceed the values given in the following Table 1. *Higher Level Req.: [CAS-SCI-0140]*				X	X						X						

Table 1: Sensor Quantum Efficiency

Wavelength [nm]	Quantum Efficiency
475	60%
500	75%
550	80%
600	85%

Wavelength [nm]	Quantum Efficiency
650	90%
700	90%
750	90%
800	85%
850	85%
900	60%
950	50%
975	30%

5.3.11 Sensor Themal Control

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0250	The sensor temperature shall be controlled in the sensor's qualification temperature range 253 K – 293 K with a precision of +/- 2K					X						X						
CAS-CAM-0260	The nominal sensor temperature shall be 273 (+/- 2) K.					X						X						

5.3.12 Filter Strip Assembly (FSA)

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0280	The filter strip assembly shall contain four individual filters bonded together with an opaque adhesive strip-butted arrangement. *Higher Level Req.: [CAS-SCI-0110]*					X						X						
CAS-CAM-0290	DELETED																	
CAS-CAM-0300	The filter assembly shall be designed to minimize thermal stress and optical crosstalk.					X						X						
CAS-CAM-0302	The filters in the FSA shall be on fused silica substrates.					X						X						
CAS-CAM-0304	The filters in the FSA shall have a thickness of 1.0 ±0.1 mm. *Info: Required as input to the optical design,*					X						X						

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0306	The filters in the FSA shall have the transmission properties as defined in [CAS-CAM-1090] below.					X						X						
CAS-CAM-0308	The filters in the FSA shall have coatings and edges designed to minimize ghost images arising from multiple reflections with the optics. *Higher level req.: [CAS-SCI-0150]*					X						X						

5.3.13 Focal Plane Electronics

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0310	The proximity electronics shall provide CMOS bias and clock signals; and contain analog/digital signal processing for the image data from the CMOS.					X							X					

5.3.14 Focal Plane Electronics Enclosures

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0320	Enclosures shall be provided to house the focal plane array and proximity electronics, to protect them from damage during the expected vibration modes, shield them from radiation and EMI, and maintain them within their operating or non-operating temperature ranges.					X							X					

5.3.15 Electronics Unit (ELU)

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0330	The instrument support electronics box ELU shall contain the folowing 3 boards: - PCM Power converter Module - DPM Digital Processor Module - RCM Rotation Control Module *Information: These boards provide S/C interface, engineering/housekeeping data handling, and command and control. The boards are directly connected together via board to board connectors.*					X							X					
CAS-CAM-0340	The ELU shall provide drive and control electronics for 6–8 (TBR) operational heater control zones.					X							X					
CAS-CAM-0350	The ELU shall send signals to the focal plane system for binning, windowing, and image acquisition.					X							X					
CAS-CAM-0360	The ELU shall provide drive and control electronics for the motor in the rotation unit.					X							X					

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0370	The ELU and its sub-assemblies shall be maintained at temperatures consistent with the operating and non-operating temperature ranges for the components during cruise, aerobraking and during the science phase.			X									X					
CAS-CAM-0380	The instrument shall contain redundant relays (TBR) for power switching per the CaSSIS to EMTGO E-ICD [UBE-REF1].					X							X					
CAS-CAM-0390	The ELU shall maintain an instrument time code derived from the spacecraft time clock per the CaSSIS to EMTGO E-ICD [UBE-REF1].					X							X					

5.3.15.1 *Digital Processing Module (DPM)*

Description: This board houses the CPU and its associated memory and other circuitry that control the operations of the instrument.

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0400	The DPM shall provide the command & telemetry interface to the spacecraft as specified in the CaSSIS to EMTGO E-ICD [UBE-REF1].					X							X					
CAS-CAM-0410	The DPM shall add the instrument telemetry data from the moment of image taking onto the science data stream sended via Space Wire to the S/C.					X							X					
CAS-CAM-0420	The DPM shall control the thermal control system, and the housekeeping/engineering telemetry.					X							X					

5.3.15.2 *Rotation Control Module (RCM)*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0430	The RCM shall control the rotation drive.					X							X					

5.3.15.3 *Power Converter Module (PCM)*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0450	The PCM shall consist of one board, which receives unregulated power from the spacecraft (according to section 6.8 in E-IRD [ESA-REF1]) and supply the proper regulated voltages to the instrument.					X							X					

5.3.16 Cable Assemblies

Description: There are two main cable harnesses within the instrument; one set of interconnect cabling between the ELU and the rotation unit and a second set between the rotation unit, focal plane system and telescope assembly.

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0460	Cabling shall be provided to carry drive power for the survival heaters, rotation motor and the camera thermal control system.					X							X					
CAS-CAM-0470	Connectors should have a 10% sparing of pins.					X							X					

5.3.17 CaSSIS Firmware and Software

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0480	The combination of firmware and software shall allow CaSSIS to collect, compress, store and route high quality image data of the Martian surface from the mapping orbit. *Information: See 5.4.4 for additional software requirements.*					X							X					

5.4 Resources

5.4.1 Mass

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0490	The total instrument mass shall not exceed 17.7 kg. *Information: Instrument mass includes: in-flight covers; thermal hardware (e.g., radiators, heaters, MLI/blankets, thermostats, etc.); internal harnesses; and electrical, mechanical & thermal interface hardware as needed for accommodation of the instrument on the mounting plane.*				X								X					

5.4.2 Electrical Power

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0500	The instrument orbital average Predicted Power shall not exceed 22 W at any voltage across the 22V to 36V range of the unregulated power bus. *Information: This assumes nominal thermal conditions in 400 km altitude Mars orbit and collection of one stereo pair of images during the orbit.*				X								X					
CAS-CAM-0510	The instrument in-rush current and peak predicted power consumption shall be compatible with the limits imposed by the LCL current rating and resultant peak power for 5A, 110W at 22V.					X							X					

5.4.3 Volume

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0530	The instrument volume shall not exceed the envelope specified in the CaSSIS MICD [UBE-REF3].					X							X					

5.4.4 Software

5.4.4.1 *Command and Engineering Data*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0540	The instrument flight software (FSW) shall accept commands from the TGO SMU as a Remote Terminal (RT) over a redundant the MIL-STD-1553 Data Bus and and report housekeeping/engineering data back.					X							X					

5.4.4.2 *Rotation Drive and Thermal Control*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0550	The FSW shall manage the rotation mechanism and provide closed-loop control of operational (non-survival) heaters.					X							X					

5.4.4.3 *Focal Plane System Control*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0560	The FSW shall have a means to control power to the focal plane electronics.					X							X					
CAS-CAM-0570	The FSW shall configure the focal plane electronics for science exposures on command from the spacecraft C&DH.					X							X					

5.4.4.4 *Look Up Table (LUT) and Lossy Compression*

Description: The primary function of a LUT is to compress science data from 14 bits to 10 bits per pixel. The use of 10 bits rather than 8 bits means that a single nonlinear (almost square-root) LUT should be adequate for all Mars images.

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0600	The DPM shall optionally compress the resulting data using LUTs.				X								X					
CAS-CAM-0610	The DPM shall be capable of storing at least four LUTs.					X							X					
CAS-CAM-0620	There shall be space for ≥4 LUTs to be stored in FSW nonvolatile memory.					X							X					
CAS-CAM-0622	A lossy compression algorithm based on wavelet (JPEG2000) compression or similar shall be implemented. *Higher Level Req.: [CAS-SCI-0120]*					X							X					

5.4.4.5 *Science Data Handling*

5.4.4.5.1 Nomenclature

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0624	Imaging data shall have the following nomenclature (Table 2).					X							X					

Table 2: Imaging Data Nomenclature

Term	Definition
Detector Frame	The full detector area shall be referred to as the detector frame.
Exposure	Each individual exposure of the 2048 x 2048 array shall be referred to as an exposure.
Sub-exposure	Each sub-array of the exposure shall be referred to as the sub-exposure. This is appropriate for each individual colour sub-array acquisition.
Exposure sequence	CaSSIS shall acquire N sub-exposures in a sequence following a single command on the mission timeline.

Term	Definition
Image	The full exposure sequence shall be referred to as an image.
(Nominal) stereo pair	When two images are acquired of the same target on the same orbit by rotating the telescope, this shall be described as a (nominal) stereo pair
Non-nominal stereo pair	When two images are acquired of the same target on different orbits by whatever means, this shall be described as a non-nominal stereo pair

5.4.4.5.2 Data

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0625	Data shall be packetized by the instrument and passed to the spacecraft via a SpW interface.					X							X					

5.4.4.6 *Data Headers*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0626	Every sub-exposure shall be returned in telemetry with a header indicating (as a minimum) - SCET - Exposure time - Detector corners and size (or similar to determine the position on the detector from which the image was taken) - Binning - Compression type - Compression factor - Detector temperature - Rotation angle					X							X					

5.4.4.7 *Image Timing*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0640	Images shall be acquired with a timing knowledge of <1 ms.					X							X					

5.4.4.8 *Commands, Data, and Telemetry*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0740	Time tags for both command and telemetry shall be unique over the lifetime of the mission.					X							X					

5.4.4.9 *Engineering Telemetry*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0750	The instrument design shall provide the necessary engineering telemetry for the investigation team to assess the instrument's performance, mode of operation, and to support instrument fault responses.					X							X					
CAS-CAM-0760	The instrument design shall provide the capability for engineering telemetry separate from the science data.					X							X					
CAS-CAM-0770	Instrument designs shall provide sufficient engineering telemetry to enable correlation of environmental, instrument state, health, and safety data with collected science data.					X							X					
CAS-CAM-0780	CaSSIS shall provide the capability to determine the environment and state of the instrument and assess its health and safety within 30 minutes after a change in the environment or state of the orbiter or after 30 minutes of receipt of data after uplink lockup at all downlink rates.					X							X					

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0800	CaSSIS shall have the capability of capturing sufficient information to enable ground operators to verify receipt and integrity of commands sent from the spacecraft C&DH within 30 minutes of the transmission of those commands to the instrument, assuming that *CaSSIS* engineering telemetry is being downlinked in near-real-time. *Information: These times do not include light travel time to/from Mars.* *Information: The FSW will implement this requirement by means of command accept/reject counters whose values are included in telemetry, which CaSSIS sends back to the C&DH. The C&DH then downlinks this CaSSIS telemetry to the ground in near real time, or the 30 minute-requirement may not be met. Whether or not near-real-time telemetry downlink for CaSSIS is enabled at the time commands are sent from the C&D to CaSSIS is not under CaSSIS control.*					X							X					

5.4.4.10 *Downlink Data*

5.4.4.11 *Commands*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0840	CaSSIS commands shall control the following functions: - Power (FPE, operational heaters) on/off - Rotation mechanism control - Heater control - General system enables / disables - Loading look-up tables, general data such as patchable constants, and FSW code - Resets and flushes (reverse clocking) - Exposure / image acquisition control				X								X					
CAS-CAM-0850	Power on and reset commands shall leave the instrument in a known and safe state.				X								X					
CAS-CAM-0860	The instrument shall not be damaged or put in an unsafe condition when the power input line is switched-off at any time.				X								X					

5.4.5 Payload and Spacecraft Interfaces

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0880	The interface between the CaSSIS instrument and the spacecraft shall be governed by the CaSSIS to EMTGO E-ICD [UBE-REF1].					X							X					

5.4.5.1 *Mechanical Interfaces*

TBD

5.4.5.2 *Instrument Interfaces*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0890	The Instrument Assembly shall interface to the spacecraft through a mounting scheme specified in CaSSIS to EMTGO E-ICD [UBE-REF1].					X							X					
CAS-CAM-0900	The ELU shall be mounted at locations and mounting schemes specified in CaSSIS to EMTGO E-ICD [UBE-REF1].					X							X					

5.4.5.3 *Instrument Assembly Alignment*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0910	CaSSIS shall be designed such that the combination of 1) the uncertainty in the alignment measurement between the alignment reference cube and the instrument boresight and 2) any changes in alignment between the instrument boresight and the instrument mounting plane over the life of the mission, shall be less than 0.5 mrad per axis.					X							X					

5.4.6 Electrical Interfaces

Basic requirements for electrical grounding and electrical isolation are contained in the TGO EMC Control Plan [ESA-REF3]. Specific system-level requirements of electrical interface circuits, grounding methods, signal levels, and timing relationships are contained in the ICD.

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0920	The electrical interfaces to the spacecraft shall be as specified in the CaSSIS to EMTGO E-ICD [UBE-REF1].					X							X					

5.5 Performance

5.5.1 Field-of View (FOV)

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0970	The camera shall be capable of collecting images from 400-km altitude with a minimum swath width (cross-track) of 8 km in all four spectral bands. *Higher level req.: [CAS-SCI-0120]*					X							X					
CAS-CAM-0980	In the event of the spacecraft pointing up to 15° off-nadir, CaSSIS shall perform nominally. *Information: The intention here is that off-nadir pointing shall not result in any performance degradation (taking into account any scale changes on the surface resulting from the increased slant distance to the surface).*					X							X					

5.5.2 Modes

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-0990	The camera shall have 3 modes of operation: - POWER OFF – only Survival Heaters on - BOOT MODE o DPU (Reduced HK + Configuration) o Survival Heaters are on (with operational power) o FPS and Motor are off - OPERATIONAL MODE o DPU (Full HK TM, Image compressing, Configuration) o control of operational temperature o FPS control (on/off Image taking) o Motor control (on/off rotating) *Information: See Section 6.2 for detailed description of modes.*				X								X					

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1000	On power up the instrument shall enter the standby state.				X								X					
CAS-CAM-1010	Except during commanded rotations, the rotation motor shall remain un-powered.				X								X					

5.5.3 Operational Requirements

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1030	The CaSSIS camera shall be capable of acquiring color images at any time during the Cruise Phase, Primary Science Phase (PSP), and during the transition orbit after the end of aerobraking after the warm up period specified in this section.					X							X					

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
	Information: There are no science performance requirements for CaSSIS imaging during MOI or Aerobraking.																	
CAS-CAM-1040	The camera shall be capable of warming up to operational temperatures following a 12-hour maximum warm-up period, starting from thermal equilibrium at survival temperatures in the cruise environment.			X									X					
CAS-CAM-1045	The instrument shall be capable of acquiring one stereo image pair and one non-stereo image (both in colour) per orbit.				X								X					
CAS-CAM-1050	The telescope structure shall be designed to minimize opportunities for sunlight to enter the telescope tube; however, it is recognized that there will be pointing geometries (documented in the ICD) that are not allowed during operations due to sunlight entering the telescope aperture.					X							X					
CAS-CAM-1060	The camera shall be designed to meet all performance requirements during an orbit when three 20-second images are acquired during the daylight part of the orbit.					X							X					

5.5.3.1 *Science Orbit*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1070	CaSSIS shall operate within specification in the orbit described in the CaSSIS to EMTGO E-ICD [UBE-REF1].					X							X					

5.5.4 Performance Capability

5.5.4.1 *Spectral Requirements*

5.5.4.2 *In-band spectral response*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1090	The camera spectral pass-bands shall be as defined in Table 3. *Higher level req.: [CAS-SCI-0140]*				X								X					
CAS-CAM-1100	DELETED																	

Table 3: Spectral Bandpasses

Central Wavelength [nm]	Bandwidth (FWHM) [nm]	Identifer	Peak transmission
985(±5)	220(±10)	NIR	>90%

485(±5)	165(±10)	BG	>90%
840(±5)	100(±10)	RED	>90%
675(±10)	250(±20)	PAN	>90%

5.5.4.3 *Out-of-band spectral response*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1090	Less than 5% of the signal shall come from outside the filter 10% cut-off wavelengths. *Information: The filter cut-off wavelengths are on the long wavelength side of the Blue-Green filter, the short wavelength side for the NIR filter, and both the short wavelength and long wavelength side of the Red filter, with less than XX% coming from either side of the Red filter.*				X								X					

5.5.4.4 *Amplitude Resolution*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1140	The digitized camera output signal shall have a resolution of 14 bits per pixel.				X								X					

5.5.4.5 *Scattered Light*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1160	Scattered light from the disk of Mars shall be minimized, with a goal of less than 1% of the nominal signal after removing the contribution of diffraction. *Higher level req.: [CAS-SCI-0142]*				X								X					
CAS-CAM-1170	This shall be evaluated by measurement of a 20-pixel diameter black spot in a circular white field target.				X								X					
CAS-CAM-1180	Using an optical model of CaSSIS, the measured value at the center of the black spot will be used to infer a diffuse scattering coefficient.				X								X					
CAS-CAM-1190	This scattering coefficient shall then be used to model the expected normalized brightness at the center of such a black spot when viewing an otherwise uniform field, but limited in viewing by the telescope baffles.				X								X					

5.5.4.6 *Pixel-to- Pixel Calibration*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1210	At beginning of life, the camera shall have a pixel-to-pixel (output pixels) relative calibration accuracy of better than 1% for 99.5% of the pixels within the area of the array used for imaging. *Higher level req.: [CAS-SCI-0142]*				X								X					
CAS-CAM-1210	At beginning of life, the change in pixel calibration during a 10 second long series of images shall be correctable to less than 0.5% (TBR) for 99.5% of the pixels. *Higher level req.: [CAS-SCI-0142]*				X								X					
CAS-CAM-1210	As a goal over the life of the mission, the change in pixel calibration during a 10 second long series of images should be correctable to less than 0.5% (TBR) for 99.5% of the pixels. *Higher level req.: [CAS-SCI-0142]*				X								X					

5.5.4.7 *Absolute Pixel Calibration*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1230	Over the life of the mission, the absolute calibration accuracy shall be better than 15%. *Higher level req.: [CAS-SCI-0160]*				X In flight								X					

5.5.4.8 *Spectral Response*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1250	The relative spectral response of each pixel over the entire FOV shall be determined to 5% precision from 400-1100 nm in steps of 10 nm.				X								X					

5.5.4.9 *Vignetting*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1260	Vignetting across the FOV shall produce a signal loss of less than 5%.				X								X					

5.5.4.10 *Spatial Resolution Requirements*

5.5.4.10.1 Pixel Scale

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1270	In the highest resolution mode, the camera shall have a pixel scale of between 10.5 and 12.5 µrad/pixel.				X								X					

5.5.4.10.2 MTF

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1280	CaSSIS shall be able to detect a sinusoidal or bar pattern of intensities (black to white) with a period equivalent to <10 metres on Mars from 400 km altitude, and at 100:1 or better SNR. *Information: Detection is via plots of 3-row averages perpendicular to the bars, which clearly detect (above the noise level) a bright-dark-bright-dark pattern.* *Higher level req.: [CAS-SCI-0100]*				X								X					
CAS-CAM-1290	The camera shall meet this requirement with the sinusoidal or bar pattern at any orientation (vertical, horizontal, diagonal).					X							X					
CAS-CAM-1300	The effective wavelength of the test target illumination shall be between 600 and 800 nm.					X							X					

5.5.4.11 *Dynamic range and Read Noise*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1310	The dynamic range of the system shall be sufficient to capture the bright areas of Mars.					X							X					
CAS-CAM-1320	The system read out noise shall be <100 e rms.				X								X					

5.5.4.12 *Linearity*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1330	The linearity of the system digital output to the input intensity of the illumination shall be measured to better than 1.0% of reading over the full range of the A/D converter under all binning conditions. *Information: This will be done after subtracting the bias and dark current values.*				X								X					

5.5.4.13 *Geometric distortion*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1340	Distortion from the center of the FOV to the full field angle shall be less than 2%.				X								X					

5.5.4.14 *Crosstalk*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1380	Optical and electronic crosstalk between channels shall be not noticeable in images.				X								X					
CAS-CAM-1390	Imaging of a b/w chart shall show no ghost images.				X								X					

5.6 Reliability, Availability, and Maintainability

This subsection should state the reliability, availability, and maintainability requirement(s) for the system/element. A reliability requirement should consist of a specified reliability, success criteria, time associated with the specified reliability, and a desired confidence level. For example, one could specify that a product should have a 90% reliability at 1000 hours of operation with a 95% confidence level. In simpler terms, this means that we want to be 95% confident that 90% of the population will survive at least 1000 hours.

Maintainability and availability measure of the quickness and ease with which a failed system can be restored to operating condition. It is a design consideration that centers on making system repairs as easily, quickly and inexpensively as practical. It should state the numerical maintainability requirements in such terms as Maintenance man-hours per flight or operational hours, Median Time to Repair/Restore (MedTTR), Maximum Time to Repair (MaxTTR), Mean Time To Repair (MTTR), and Maintenance Ratio (MR). For un-manned spaceflight systems, on-orbit maintainability might include requirements related to the time to isolate failures and utilize redundancy (mean time to restore), the ability to upload new software to the spacecraft, or perhaps even for an astronaut to replace one element with another.

5.6.1 Redundancy

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1400	Redundant interfaces shall be included as specified in the CaSSIS to EMTGO Spacecraft Interface Control Document.					X							X					
CAS-CAM-1410	Any drive mechanisms shall have redundant coils.					X							X					
CAS-CAM-1420	Redundant survival temperature sensors and heater elements shall be provided.					X							X					

5.6.2 Lifetime

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1430	The CaSSIS camera shall be designed to operate within specifications for the necessary check-out and calibration operations prior to start of the Primary Science Mission and for 24 months after start of the Primary Science Mission per the TGO E-IRD.					X							X					

5.6.3 Fault Tolerance

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1440	The FSW shall provide protection against inadvertent or incorrect commands.					X							X					
CAS-CAM-1440	The FSW shall not execute these commands and shall report the error per the ICD.					X							X					
CAS-CAM-1440	The priority for instrument fault handling shall be: 1. Critical functionality (power, thermal, commandability…) 2. Consumables and recovery of fault diagnosis data 3. Performance and protection against disruption to normal sequence operation and 4. Simplify ground recovery response.					X							X					

5.7 Design

This subsection should state requirements related to the design of the system/element. Typical requirements address human factors, design margins, load margins, computer reserve capacity, use of metric units, design-for-manufacturability, etc.

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1470	The metric system shall be used in all instrument design and operations including: mission design analysis, flight and ground software, and interface control documents. *Information: Exceptions for hardware are allowed when residual hardware or design is in English units, or fabrication/procurement in metric is much more expensive due to lack of metric machine tools and hardware.*					X							X					
CAS-CAM-1470	The instrument design and science investigation shall be in accordance with the E-IRD [ESA-REF1].					X							X					

5.7.1 EMC / EMI

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1490	CaSSIS shall be designed to operate in all modes simultaneously with all other instruments while meeting all requirements in E-IRD [ESA-REF1] except during actual science data collection.				X								X					

5.7.2 General Construction

5.7.2.1 *Contamination*

Information: The CaSSIS camera shall be compatible with the contamination requirements in §7.10.4 of the EIRD.

5.7.2.2 *Planetary Protection*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1530	CaSSIS shall be designed, assembled, tested, and stored in accordance with the CASSIS or TGO Planetary Protection Plan.					X							X					

5.7.2.3 *Special Accommodations*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1540	The instrument shall be purged with dry (LN_2 boil-off gas or equiv.), filtered (less than 3 micron filter) N_2 gas any time it is practical.					X							X					

5.7.3 Ground Support Equipment (GSE) requirements

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1550	Electrical GSE (EGSE) that simulates the spacecraft interface shall be provided and software developed to deliver all CaSSIS commands within the Command Dictionary.					X							X					
CAS-CAM-1560	The GSE shall be capable of powering the CaSSIS survival circuits as defined in the CaSSIS to EMTGO Spacecraft Interface Control Document [UBE-REF1].					X							X					
CAS-CAM-1570	The EGSE interface shall match the CaSSIS to EMTGO Spacecraft Interface Control Document [UBE-REF1] and shall be used to test each command to the instrument and to receive both housekeeping and science data from the instrument.					X							X					
CAS-CAM-1575	The EGSE shall include all necessary tools to mount and dismount all electrical related parts of the CaSSIS instrument and the EGSE itself.					X							X					
CAS-CAM-1580	Mechanical GSE shall be provided as necessary to hold and align the instrument for testing and handling; it shall be capable of meeting all the safety requirements in Section 5.11.					X							X					

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1582	The GSE shall include all necessary tools to mount and dismount the CaSSIS instrument.					X							X					
CAS-CAM-1585	The non-flight (red-tag) removeable aperture cover shall have a seal to prevent moisture and contamination from entering the telescope aperture.					X							X					
CAS-CAM-1590	Optical GSE shall be capable of stimulating the detectors to test for full functionality of the instrument.					X							X					

5.7.3.1 *Electrical Interface Model (EQM) and Structural Thermal Model (STM)*

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1591	The EQM and STM in the case of CaSSIS shall be combined to generate a placeholder model (PH) for preliminary integration with the spacecraft.					X							X					
CAS-CAM-1592	The EQM elements of the PH shall meet the requirements specified in the SOW (UBE-REF4).					X							X					
CAS-CAM-1596	The STM elements of the PH shall meet the requirements specified in the SOW (UBE-REF4).					X							X					

5.8 Materials

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1600	Material usage and selection shall follow the requirements in §8.3 of the CaSSIS Mission Assurance Plan [UBE-REF2].					X							X					
CAS-CAM-1610	Fastener inserts for aluminum graphite composite material shall be selected based on the specific properties of the material, instead of using standard selection criteria for aluminum.					X							X					

5.9 Environment

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1620	The CaSSIS instrument shall be compatible with the environments specified in the E-IRD [ESA-REF1].					X							X					
CAS-CAM-1630	The CaSSIS instrument shall be capable of withstanding sun exposure for TBD seconds or indefinitely if the angular rate is greater than 1 degree/sec].					X							X					

5.10 Workmanship

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1640	Instrument development shall follow the workmanship requirements as specified in Section 4.5.4 of the CaSSIS Mission Assurance Plan [UBE-REF2].				X							X						

5.11 Safety

5.11.1 Personnel Safety

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1650	Instrument development shall follow the personnel safety requirements specified in §6 of the CaSSIS Mission Assurance Plan [UBE-REF2].				X							X						

5.11.2 System Safety

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1660	Instrument development shall follow the system safety requirements specified in §6 CaSSIS Mission Assurance Plan [UBE-REF2].				X							X						
CAS-CAM-1670	Proper fixtures and enclosures shall be provided to safely handle and transport the CaSSIS instrument.				X							X						
CAS-CAM-1680	Attachment points shall be provided on the instrument to connect the instrument to handling fixtures.				X							X						
CAS-CAM-1690	In order to insure the cleanliness of the interior of the telescope, particularly optical surfaces and baffles, a non-flight removable cover shall always be in place when practical. *Information: No deployable cover is required for contamination control.*				X							X						
CAS-CAM-1700	Precautions shall be taken to prevent damage to the instrument from deliberate or inadvertent rotation of the telescope whenever a purge line is connected to the telescope.				X							X						

5.12 Identification and Marking

This subsection should contain requirements for affixing identifying information (nameplates, labels, markings, etc.) to the system/item and/or components thereof. Identifying information could include part number, serial number, date codes, ancillary markings (e.g. hazards, ESD sensitivity, connector/cable identifications), markings of components to be removed before flight, color codes, security classification (if applicable), etc. Requirements are usually stated in general terms and reference is made to existing standards on the content and application of such markings.

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1710	The instrument shall be identified with the appropriate markings that uniquely identify it.				X							X						

6 FUNCTIONAL DESCRIPTION

Information: The entire contents of §6 is for information only.

6.1 Description and Characteristics

The CaSSIS instrument is a camera designed to fulfill the high-resolution imager role for the EMTGO spacecraft. It shall provide the following functionality:

a) Image forming optics capable of collecting high spatial resolution and high quality near infrared and visible images of the Martian surface from the nominal mapping orbit.
b) A focal plane that is capable of collecting high quality visible and near-infrared images of the Martian surface from the mapping orbit.
c) Spectral filters that shall allow the images to be collected in three broad wavelength bands to allow multi-spectral analysis of features on the Martian surface.
d) A mechanical structure that can support and protect the instrument and its subsystems over the thermal, vibration and radiation environments that will be encountered during the mission. Also, a mechanical design that fits within the mass, volume and thermal constraints of the spacecraft.
e) A thermal control system that maintains the optics, focal plane assembly, and electronics at their proper operating temperatures. To reduce contamination and ease testing, the entire imager assembly should be maintained at a temperature above the local equilibrium temperatures of the surrounding spacecraft.
f) Electronics that are capable of controlling the collection of the images by the focal plane, converting the analog signals from the focal plane into digital signals that can be transmitted to the spacecraft processor, accepting commands from the spacecraft processor, transmitting instrument telemetry to the spacecraft processor, and generating the necessary regulated power signals from the unregulated spacecraft power. An electrical design that fits within the power, data volume, and electrical interface constraints of the spacecraft.
g) Data buffering internal to CaSSIS that enables transfer of image data to the S/C data recorder without exceeding the maximum rate specified in the CaSSIS to EMTGO E-ICD [UBE-REF1].
h) Software and firmware that is capable of controlling the sequencing for the collection of the images by the focal plane, then inserting headers into the image data so that it can be interpreted by the spacecraft processor, and the ground data system.

The overall performance of the camera system can be summarized in the following table.

Performance parameter (400 km altitude)	CaSSIS performance
Pixel scale	~4.75 m/pixel
Resolution	~16-metre-scale objects
Swath width, all colors	8 km
Color Bands	4 colors; panchromatic, 650 nm (250 nm) blue-green, 475 nm (150nm) near-infrared 850 nm (120nm) infrared 950 nm (150nm).
Coverage in one martian year	0.45%

The CaSSIS camera is considered a subsystem on the spacecraft; it consists of the following assemblies as defined below. Refer to Figure 3 for the system block diagram showing partitioning into assemblies and sub-assemblies. Notice that there are two separable parts to CaSSIS, the Imager Assembly (IA) connected by a cable harness to the Instrument Support Electronics (Electronics Unit ELU).

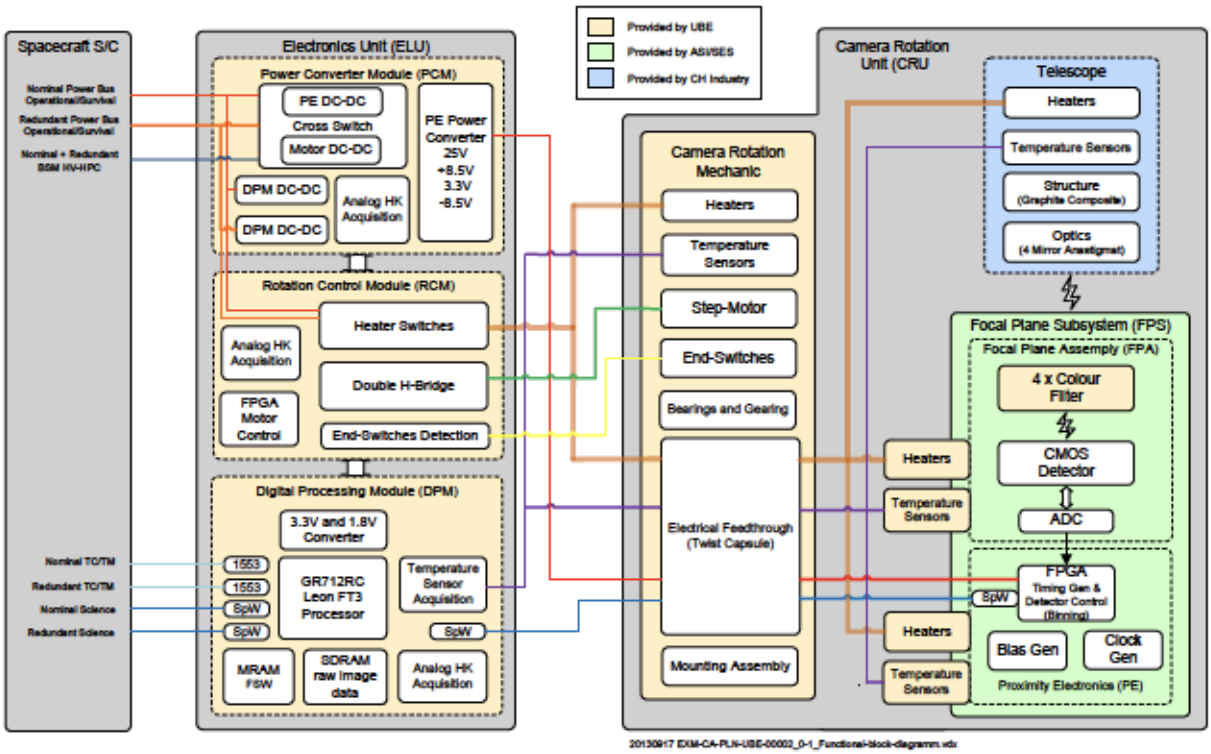


Figure 3: Functional Block Diagram

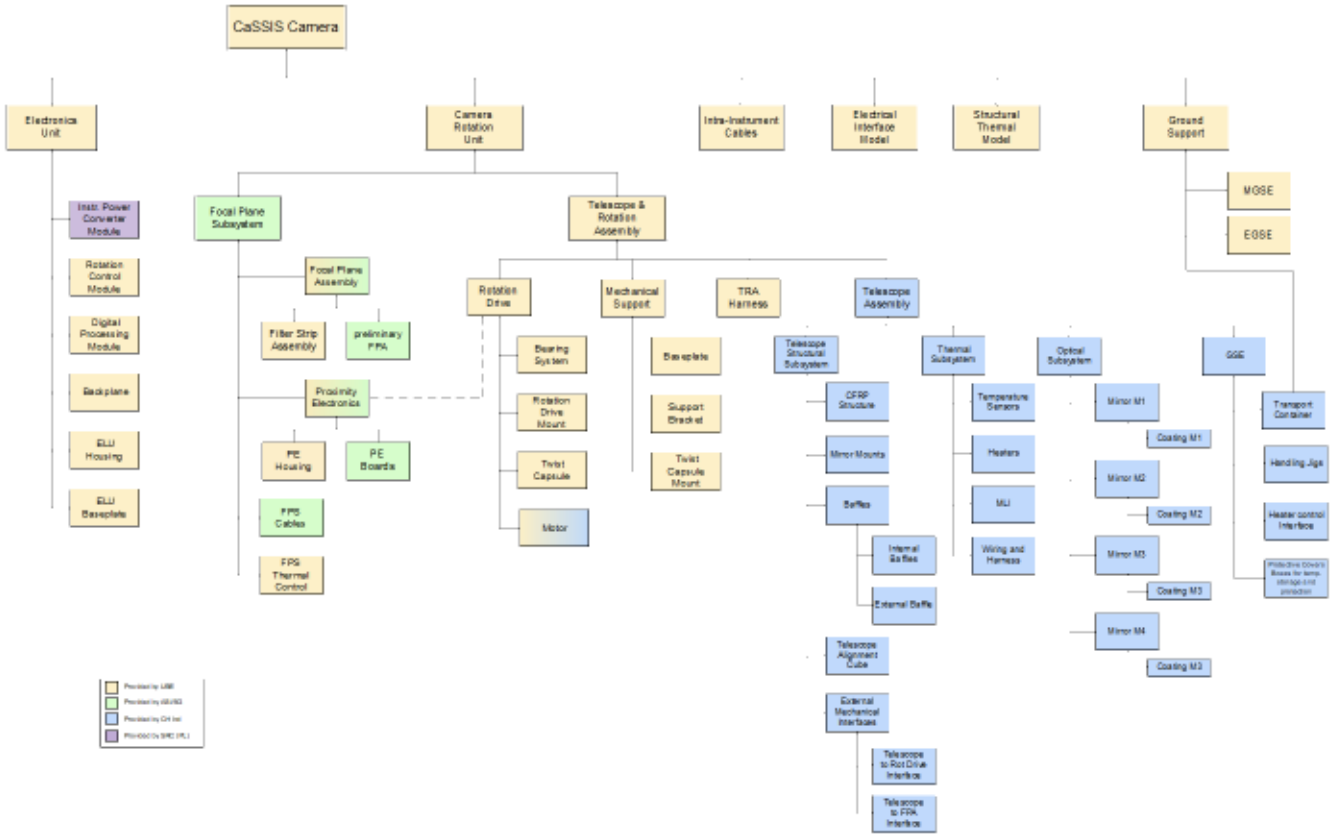


Figure 4: Hardware Responsibilities

6.2 State Diagram

Figure 5 shows the mode transition or state diagram. The modes of operation and their characteristics:

1. POWER OFF
    - survival heaters on
    - no power to the instrument

2. BOOT MODE
    - tart up
    - prepare for booting the defined FSW
    - or via TC let choose another FSW
    - or via TC can let the possibility for configuration and SW update
    - time synchronization
    - reduced HK

3. OPERATIONAL MODE
    - thermal control of the complete instrument, if necessary heat-up
    - when themperature is stabilized then the system is waiting for imaging commands
    - the Rotation Unit is switched on to turn the telescope in correct position
    - the motor can be turned to the end-switches for position initialisation

- the FPS will be switched on for the time of imaging sequence
- compress and send the remaining imaging data to the S/C PDHU
- low power standby when nothing to do
- background software update possible
- configuration of parameters
- LUT uploads can be performed
- Imaging modes can be loaded
- H/K of complete instrument (FPS only when it is switched on)

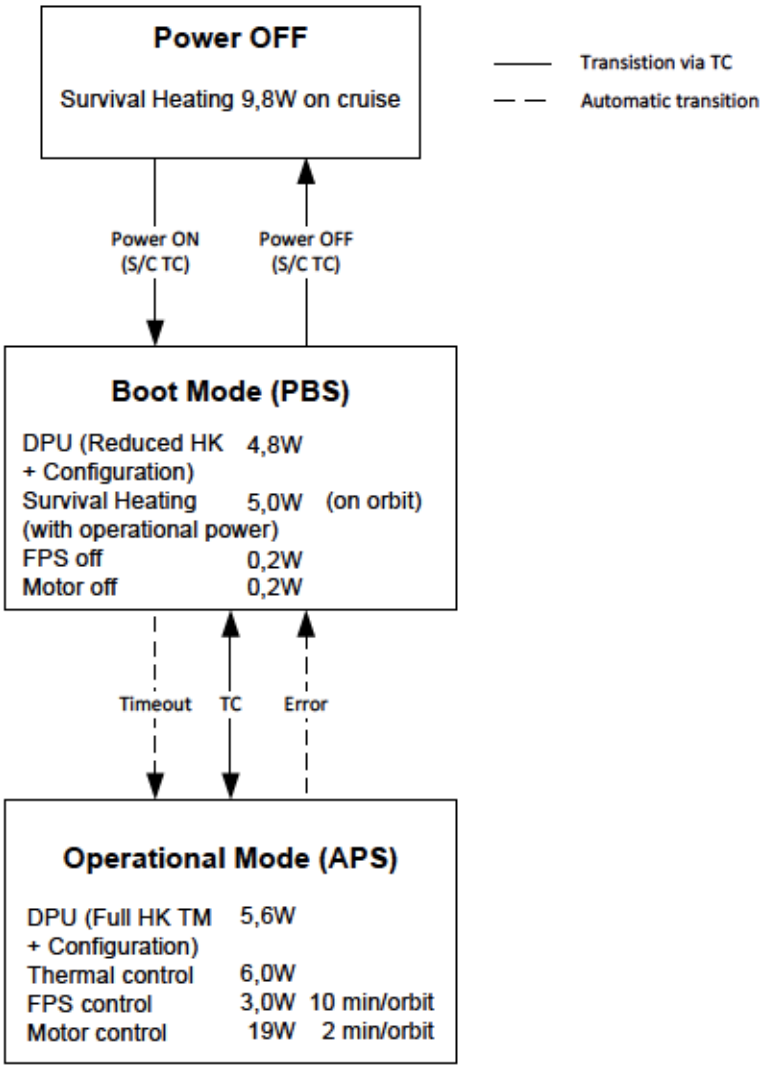


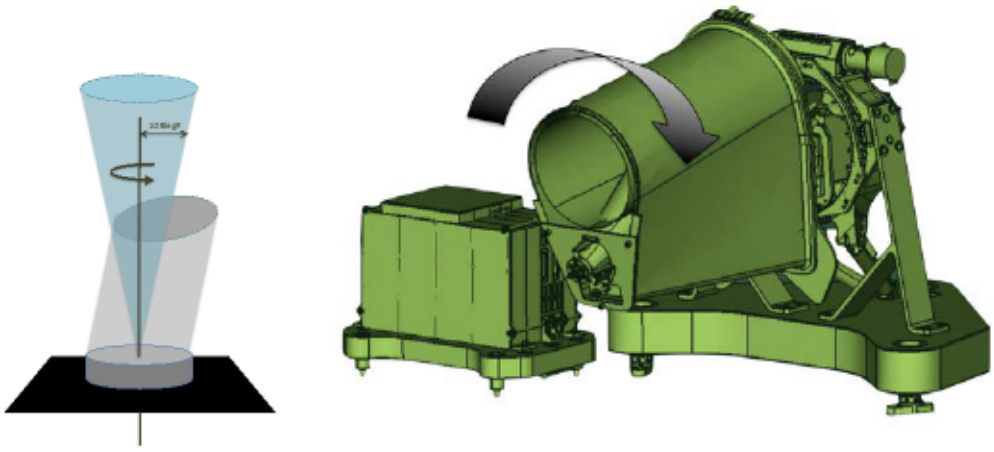
Figure 5: CaSSIS Mode Transition Diagram

The indicated power values are the exact calculated values without any margin.

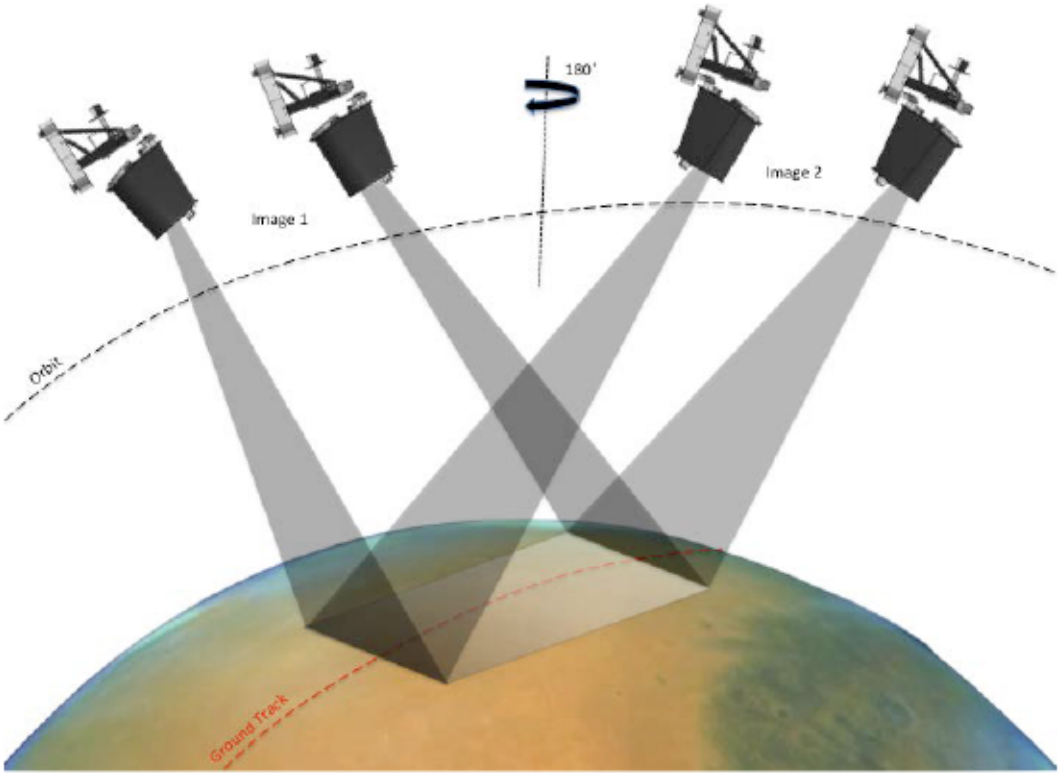
6.3 Operations

The EMTGO spacecraft plans a yaw strategy to keep the sun off spectrometer radiators, so CaSSIS must have a rotation drive to compensate for this motion.

CaSSIS also uses the rotation drive to acquire along-track stereo imaging, since the S/C will not point off nadir. The benefit of along-track stereo is that it ensures identical illumination angles for optimal stereo correlations. A stereo pair is acquired by first rotating the telescope to point ahead 10° to image, then rotating it 180° to point 10° behind for the second stereo view. The system is based upon re-use of the focal plane assembly of the SIMBIOSYS instrument for ESA's BepiColombo mission and uses a Raytheon Osprey 2k CMOS detector. The detector can be read-out extremely quickly with 14 bit digital resolution. The 10° look angle increases the pixel scale and atmospheric path length by only 1.5%, yet provides a slightly larger than 20° stereo convergence angle (accounting for planetary curvature). The proper yaw orientation for image acquisition is not precisely parallel to the groundtrack because Mars rotates, and this offset also ensures excellent overlap between the 2 stereo images (maximum mismatch is 3% of the swath width near the equator).



The instrument operational requirements are satisfied by creating a nominal concept of operations that includes one stereo image pair being collected per orbit. The maximum size of a stereo image that is possible to collect is approximately 2,048pixels by 20,480 lines, with a line rate of 450 lines per second . However, some orbits may include only a single non-stereo image or no images at all.
It is currently assumed that the maximum number of images per orbit is one complete stereo image pairs with the size described above, for a stressing case.


180°
Image 1
Image 2
Orbit
Ground Track

7 VERIFICATION

7.1 General

Unless specified otherwise herein, environmental test methods and tolerances shall be in accordance with the E-IRD [ESA-REF1].

7.2 Verification Methods

7.2.1 Inspection (I)

Inspection is an observation or examination of the item against the applicable documentation to confirm compliance with requirements.

7.2.2 Analysis (A)

Analysis is used in place of or in addition to testing to verify compliance with specifications. The techniques typically include an interpretation or interpolation or extrapolation of analytical or empirical data under defined conditions or reasoning to show theoretical compliance with stated requirements.

7.2.3 Demonstration (D)

Demonstration is an exhibition of the operability or supportability of an item under intended service-use conditions. These verifications are usually non-repetitive and are oriented almost exclusively toward acquisition of qualitative data. Demonstrations may be accomplished by computer simulation.

7.2.4 Test (T)

Test is an action that verifies an item's operability, supportability, performance capability, or other specified qualities when subjected to controlled conditions that are real or simulated. These verifications may require use of special test equipment and sensors to obtain quantitative data for analysis as well as qualitative data derived from displays and indicators inherent in the item(s) for monitor and control.

7.2.5 Similarity (S)

Similarity is the process of comparing a current item with a previous item, taking into consideration configuration, test data, application, and/or environment. The evaluation shall be documented and shall include the test procedures/reports of the item to which similarity is claimed, a description of the difference(s) between the items, and the rationale for verification by similarity. All on-orbit experience shall be documented and available for review. Use of the similarity verification method requires prior approval.

7.3 Acceptance Testing

Acceptance testing is testing performed on flight hardware that proves the produced units meet the design requirements under acceptance environments. In this section describe the acceptance testing to be performed, pointing the reader to the requirements verification matrix in section 4.5 to see which particular requirements require testing. Describe in broad terms the required sequence of tests—including partial or full functionality tests—but exclude planning information that is more appropriately included in the VV&C plan and test procedures. Identify if any acceptance testing is to be accomplished on orbit or at the customer's facilities.

7.4 Qualification Testing

Qualification is generally more environmentally stressing than acceptance testing and proves the design will survive its intended environment with margin. The item tested is not used operationally due to the higher stress levels it undergoes, and is typically called the Qualification Unit and is representative of the production unit(s) with respect to the characteristics being tested. Multiple qual units may be needed to test different aspects of the design. (Alternatively, a flight unit may undergo protoflight testing—a combination of qualification and acceptance test, and this subsection can be re-named Protoqualification Testing) Typical environmental stressors against which qualification tests are run include temperature, vibration, acoustics, shock, and humidity. This section should identify whether qualification testing is required, the item(s) to be tested, and the margins required. Describe in broad terms the required sequence of tests—including partial or full functionality tests, inspections between tests—but exclude planning information that is more appropriately included in the VV&C plan and test procedures.

8 PACKAGING

This section contains the requirements for packaging and preparing the specified item for delivery to the next level of integration. Example requirements could include marking, cleanliness, inspection, and so on. Sometimes the next level of integration is within Ball Aerospace. It also can contain storage requirements and shipping container requirements like use of nitrogen purge, vibration isolation systems, ESD protection measures, security measures, tamper indicators, inspection access, shock indicators, environmental protection, compatibility of shipping containers with clean rooms, container re-use, item monitoring, and so on.

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1510	Packaging and handling of the instrument shall follow the applicable requirements as specified in the CaSSIS to EMTGO Spacecraft Interface Control Document [UBE-REF1]					X							X					

8.1 Cushioning and Transport

Requirement ID	Description	Verification							Category			Level			Compl. Status			Comments
		N/A	Inspection	Analysis	Test	Review	Demonstration	Similarity	Qualification	Protoqual	Acceptance	Component	Subsystem	Spacecraft	Compliant	Partially Compliant	Non Compliant	(Document numbers of test reports etc)
CAS-CAM-1530	Proper handling fixtures shall be provided to help position the instrument during testing and for local transport.					X							X					
CAS-CAM-1540	Instrument flight hardware shall be accompanied by an authorized escort when shipped between suppliers, assembly facilities, test facilities or the launch site when unaccompanied transfer presents a significant cost or schedule risk to the project. *Information: Significant cost risk is when the cost to replace the lost item exceeds EUR 100'000. Significant schedule risk is when the time to replace the lost item jeopardizes the launch date. For the purposes of this policy, count-to-counter unescorted direct air shipment is considered as escorted shipment.*					X							X					