FLEX & Sentinel 3: A tandem to monitor vegetation

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Future mission concepts, ESA Programmes: Future Missions (Sentinel, EE and Meteorological Programmes)

Mission FLuorescence EXplorer (FLEX): Single satellite with FLORIS payload flying in formation with Sentinel 3 mission in a Sun synchronous orbit (height about 815 km).
Payload FLORIS: Pushbroom hyperspectral imager observing the vegetation fluorescence and reflectance (spectral range between 500 and 780 nm at medium spatial resolution) and producing 2D Earth scene images in High Spectral Resolution and Low Spectral Resolution spectral channels.

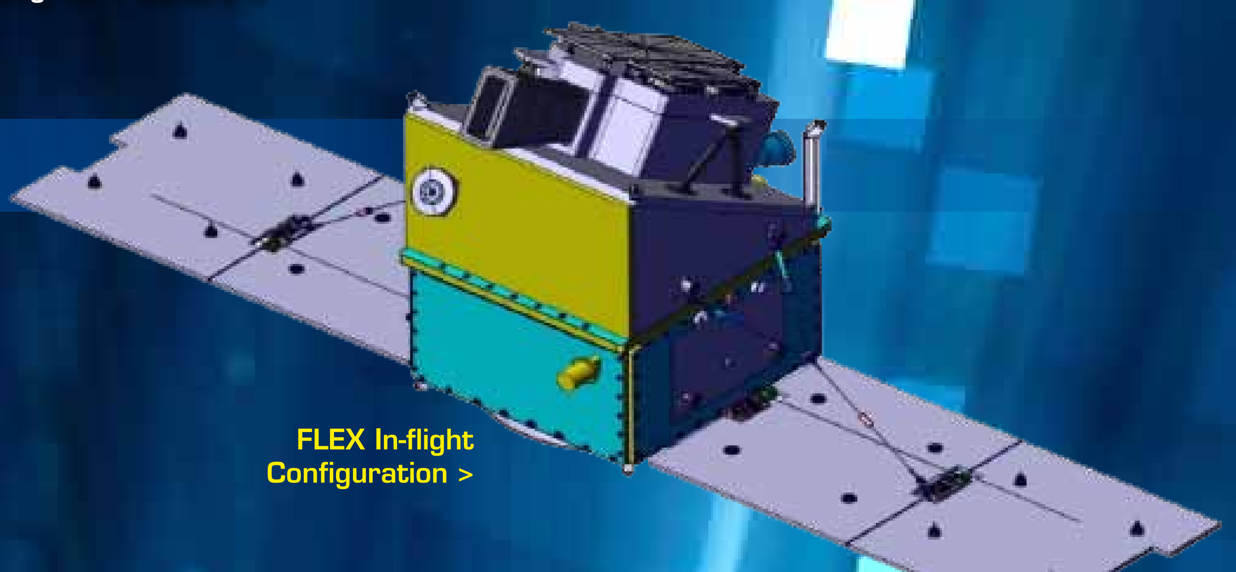
The flying formation is imposed by:

Temporal co-registration between FLEX: observations and the OLCI (other visible reflectance) and SLSTR (surface temperature data) Sentinel 3 observations : 6 sec goal, 15 sec target

Satellite inter-distance by insuring the ground swath covered by FLEX to be entirely contained within the ground swath of the nadir-looking OLCI camera 4

Synchronization of FLEX and Sentinel 3 orbit control manoeuvres

Non-simultaneous communications or selection of a ground station in Antarctica without any RF interference



FLEX In-flight Configuration >

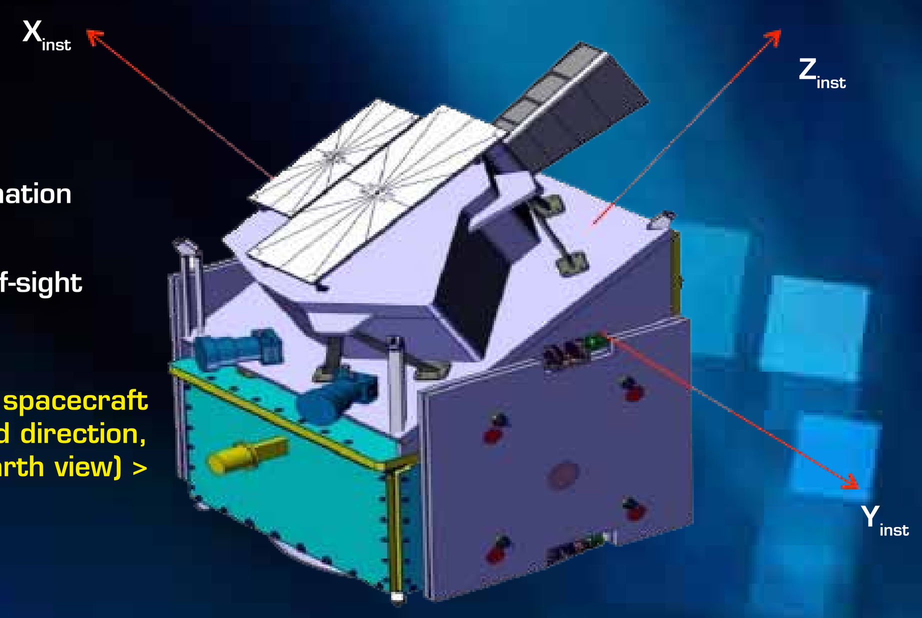
SATELLITE CONFIGURATION

Based on TAS Proteus 150 platform product line heritage designed for single-instrument LEO observation missions and mastered through various past programs.

Deployed configuration

Constant roll angle of 60° optimizing the illumination of the solar arrays

Additional 30° tilt to align the instrument line-of-sight with the nadir direction



FLORIS Instrument on spacecraft (Xinst=cold space, Yinst=speed direction, Zinst= Earth view) >

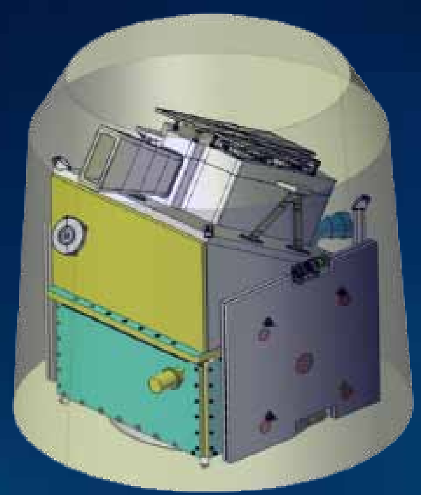
Yaw control

Yaw angle adjusted to maintain the slit perpendicular to the ground track in observation arcs

Yaw guidance applied to optimize the solar array illumination outside observation arcs

Safe mode

The satellite points its solar arrays toward the sun and performs a slow spin around the Sun axis.



Mass Launch and Launcher Compatibility

Maximum mass of 485 kg

VEGA/VESPA launcher maximum payload mass of 600 kg with 78 kg adapter: separated satellite mass of 522 kg

Satellite compatible with VEGA/VESPA

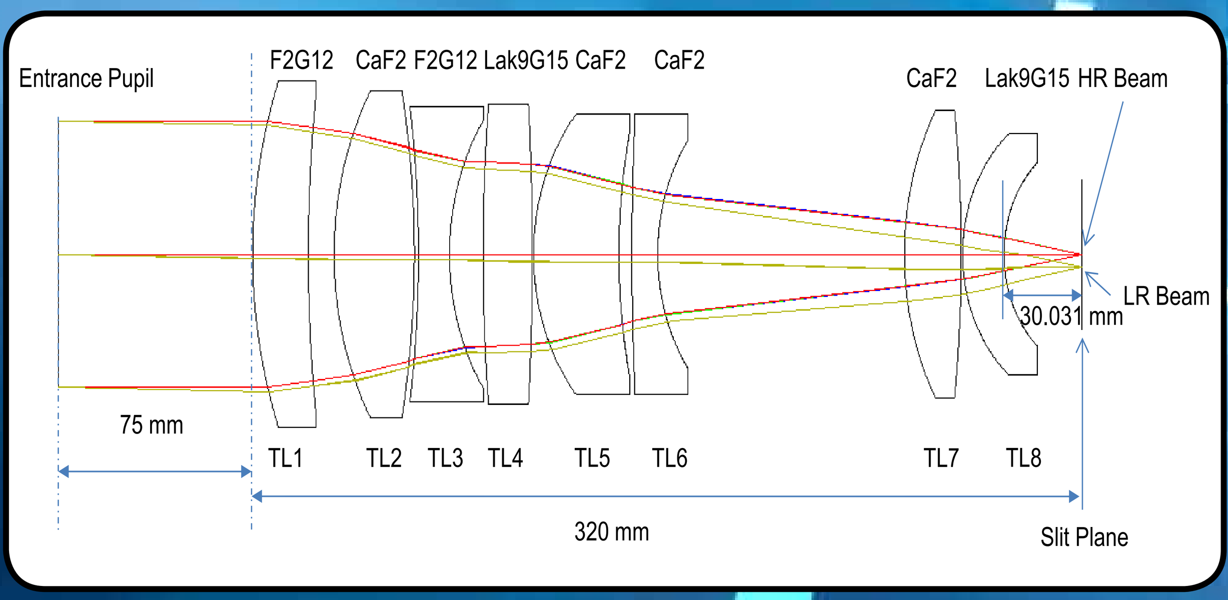
< FLEX inside VEGA/VESPA Fairing

	Telescope	High Spectral Resolution Spectrometer	Low Spectral Resolution Spectrometer
F#	3.1 in the spectral band 677-780 nm 6.5 in the spectral band 500-740 nm	3.1	6.5
Spectral Range		670– 780 nm	500 – 740 nm
Pixel pitch		28 μm in the spectral direction 84 μm in the spatial direction	28 μm in the spectral direction 84 μm in the spatial direction
Spectral Sampling		0.1 nm/30 μm	0.6 nm/30 μm
Magnification		1	-1
Grating period (1) / Grating grooves density (2)		(1) 1450 Grooves/ mm (0.093 nm/pixel on the focal plane)	(2) 500 lines/mm
Beam incidence angle on the grating		38.2°	17.4°
Diffracted beam characteristics		-1 order Diffraction angles between 21.3° (at 677 nm) and 30.9° (at 780 nm)	1st order Diffraction angles between 33.2° (at 500 nm) and 41.9° (at 740 nm)

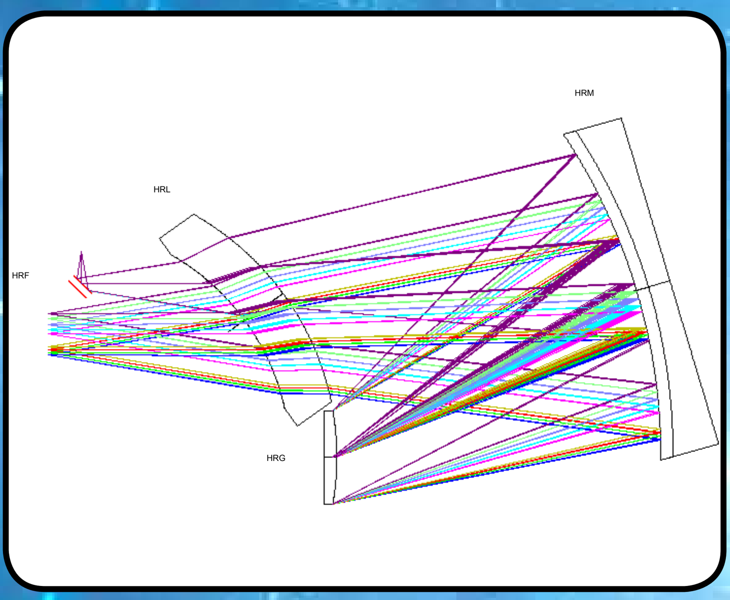
FLORIS INSTRUMENT

A compact opto-mechanical solution with all spherical and plane optical elements is proposed. A dual Babinet scrambler is placed in front of the telescope in order to reduce the polarization degree of the incoming light and a dioptric fore-optic images the ground scene onto a double slit. Two spectral resolution grating spectrometers in a modified Offner configuration with unitary magnification disperse the radiation onto two detectors.

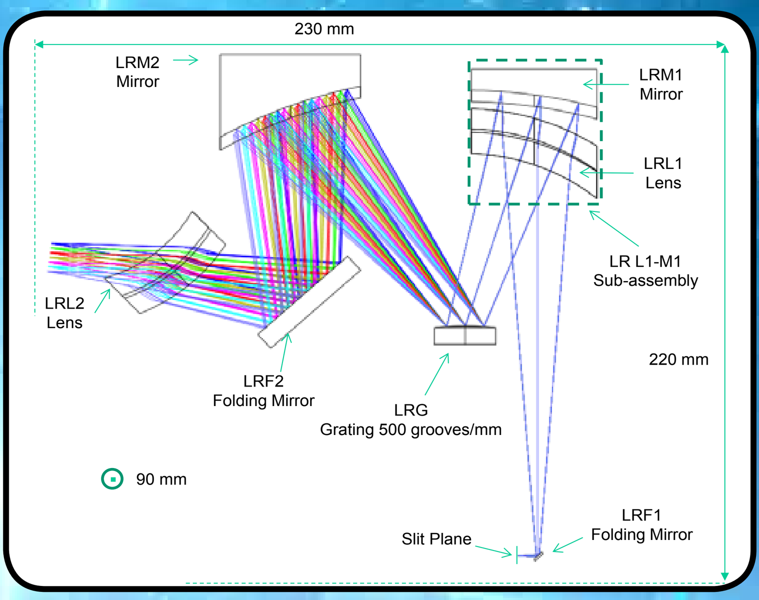
A common Petzval objective with eight spherical lenses is used for the Telescope as fore-optics between the two spectral channels.
The High Spectral Resolution Spectrometer is based on Lobb's theory of concentric designs for grating spectrometer. It is composed of a flat mirror (HRF), an Offner relay (concave spherical mirror HRM + convex spherical mirror + concentric spherical lens HRL). Grating structure (HRG) is added on the surface of the convex spherical mirror.
The Low Spectral Resolution Spectrometer is based on the same family as the High Spectral Resolution Spectrometer with a standard 2 mirrors Offner configuration with two additional spherical lenses.



Telescope optical lay-out



High Spectral Resolution Spectrometer optical lay-out

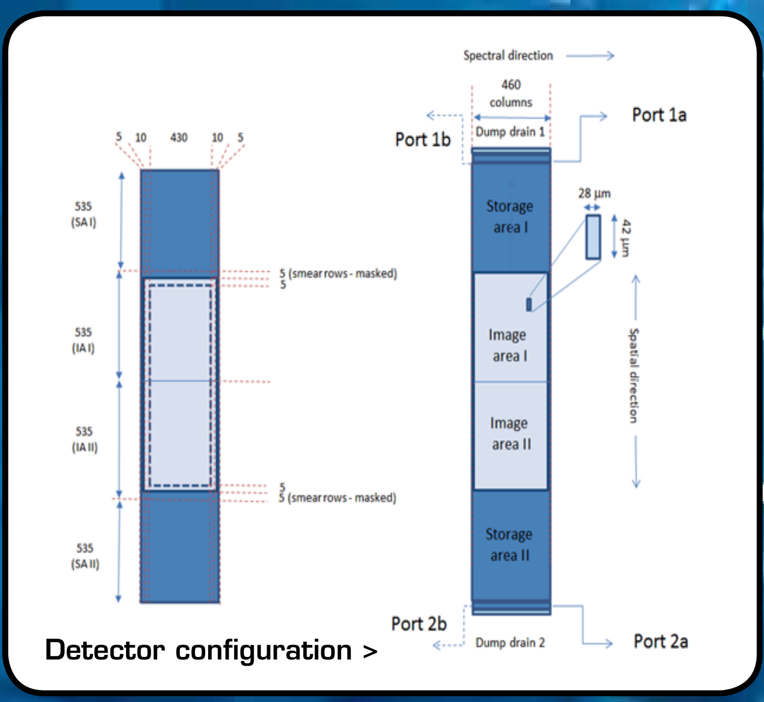


Low spectral resolution Spectrometer optical lay-out

Detector Configuration

Three identical CCDs - backside illuminated, split frame transfer, radiation tolerant with 2 double output ports- are used for the acquisition of 147 km swath and 40 nm spectral range for high spectral resolution spectrometer (240 nm for low spectral resolution). Further columns and rows are used as margin for alignment and for smearing and dark current signal corrections. 3 MHz readout frequency for port allows download of all pixels at 45 msec pixel reading time. Two ports with similar gains for each transfer serial register are used to select the best direction of the transfer signal to mitigate the possible CTE degradation.

A dumping gate has been implemented to skip part of swath during the diagnostic mode and the cover of the two O2 absorption bands (677-697 nm and 740-780 nm) is ensured by adequate separation of two adjacent detectors along the spectral direction in the high spectral resolution spectrometer.



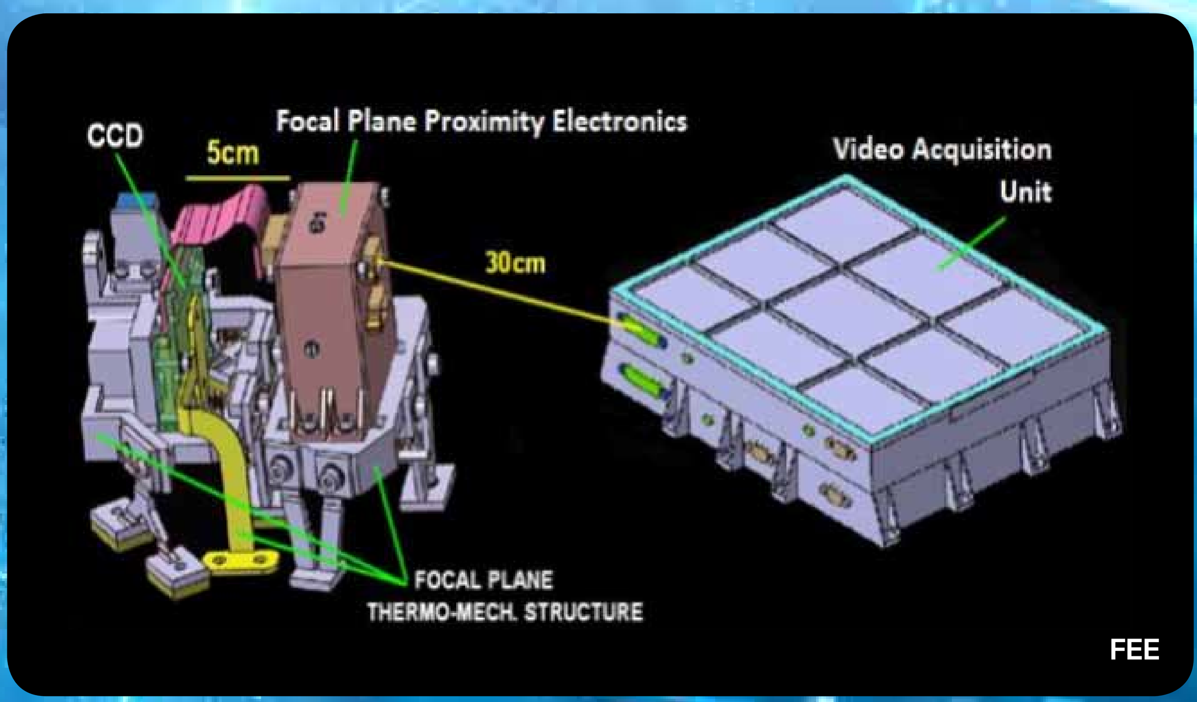
Detector configuration >

Electronics

Front End Electronic (FEE): Three non-redundant units, linked to ME

Focal Plane Proximity Electronics (FPPE): pre-amplification and CCD bias conditioning

Video Acquisition Unit (VAU): gain/offset drift compensation, bias and clocks generation/driving, FEE TM/TC and digital processing/serializing



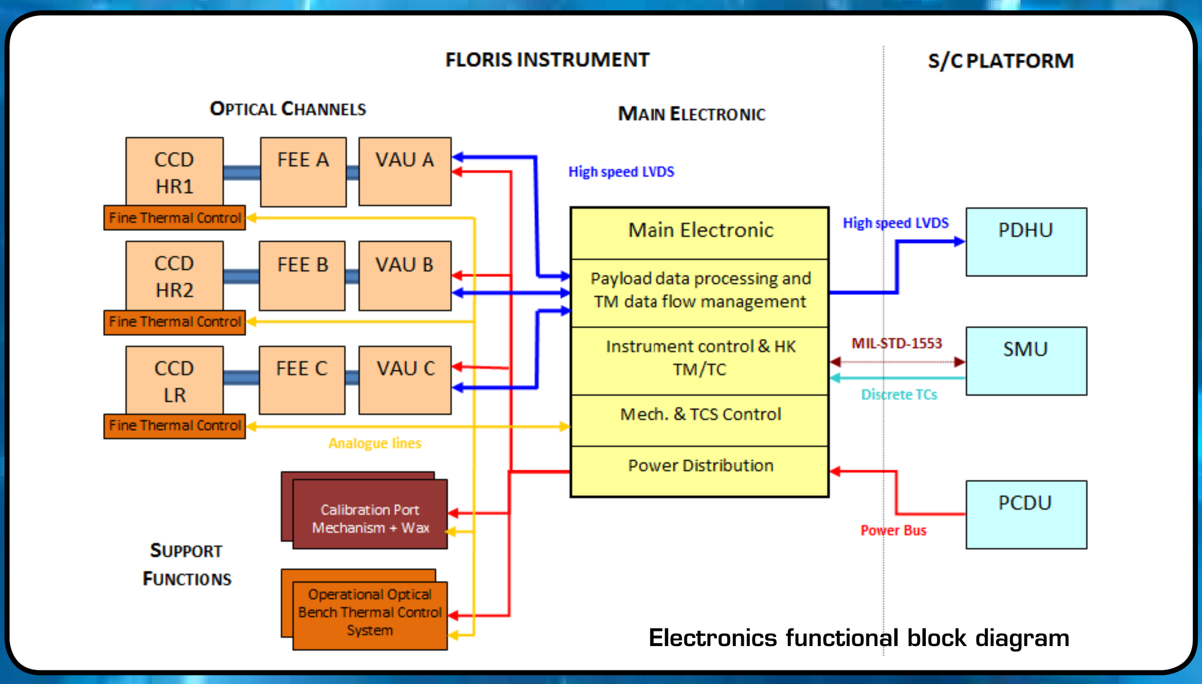
Mechanical and Thermal Equipment

High thermal insulation & stability: Titanium optics and supports for aluminium optical bench and baffle

Redundancy: three similar redundant mechanisms (entrance port + diffuser + solar port) for calibration unit

Cooling and thermal efficiency: two white painted radiators for the detectors; VAU's mounted on the upper side of instrument

Mechanical stability: iso-static mount concept with three titanium bipods at 120 degrees



Electronics functional block diagram

Main Electronics (ME): One redundant unit; Linked to PDHU, SMU and PCDU platform units

Payload data processing and TM data flow management

Instrument control and HK TM/TC

Mechanisms and TCS control

Power distribution

The opto-mechanical design is robust, stable versus temperature, easy to align, showing high optical quality with excellent corrections (by design) of transverse aberration and distortions (keystone and smile).

PLATFORM ARCHITECTURE

Mechanical and Thermal Equipment

Identical to Proteus 150 product Line

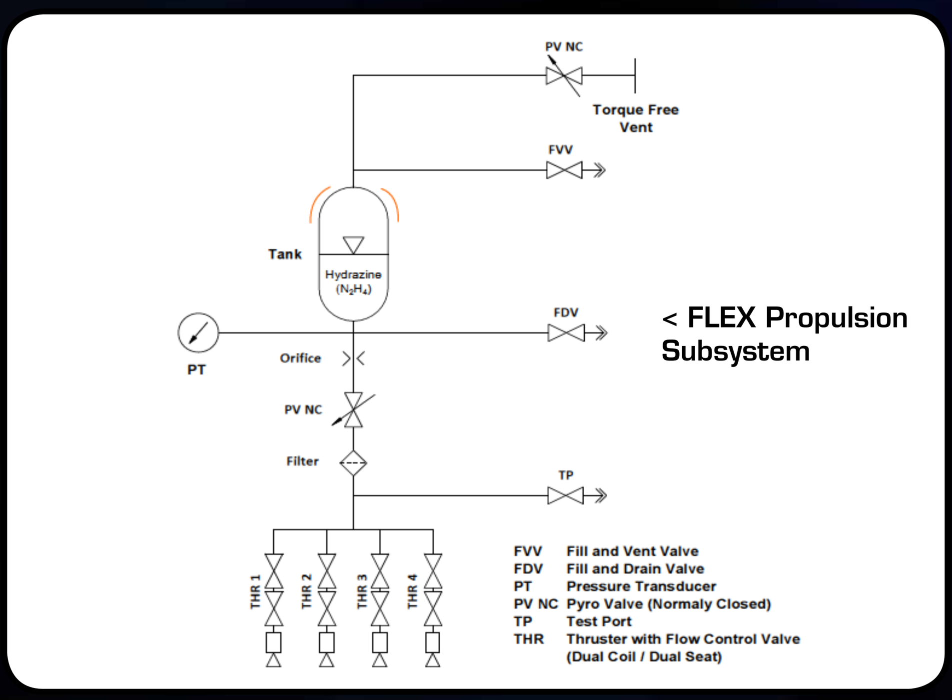
FLORIS instrument own qualified thermal control

Exclusively passive dissipative thermal hardware

Propulsion

Monopropellant propulsion subsystem ensuring in-orbit control and de-orbitation, with tank capacity of 28kg and 4 x 1 N thrusters.

4 thrusters configuration for large manoeuvres or diagonal pair of thrusters for small manoeuvres and contingency case.



< FLEX Propulsion Subsystem

Avionics

FLEX avionics architecture has identical ground-to-space interface and operational concept as Sentinel 3 but in a more compact way.

Satellite Management Unit in charge of:

Ground interfaces (TM/TC) and S-band communications management

Mode management

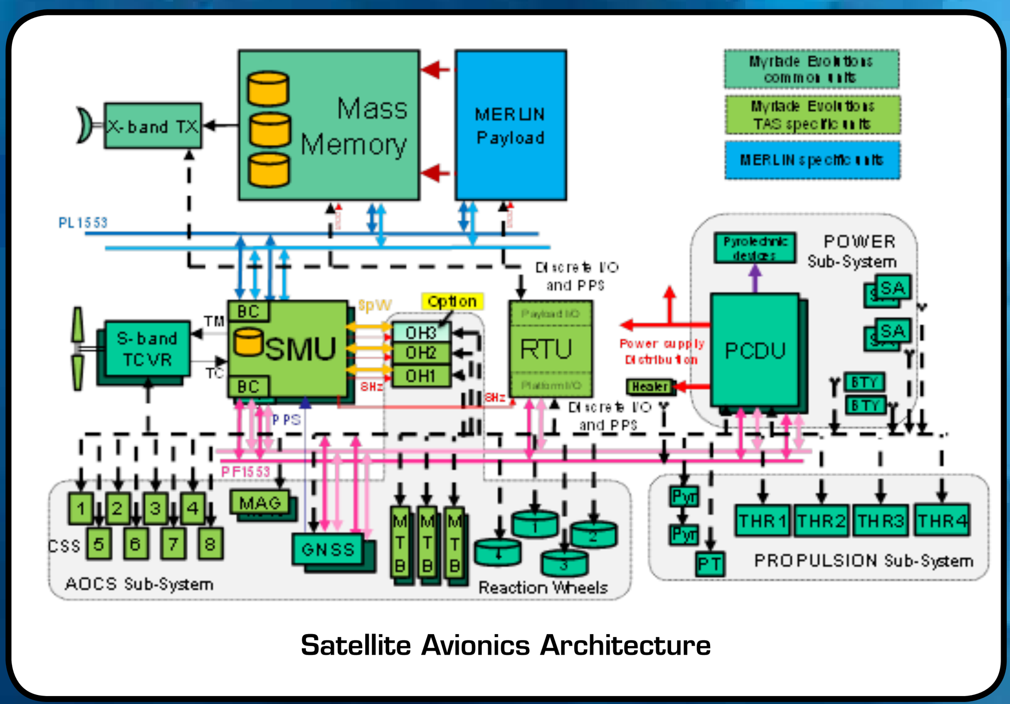
System FDIR

AOCS and Thermal Control applications

Payload Data Handling Unit management

Two 1553 buses for command and control communications (one for platform units and one for payload module units)

On-board computer to route telecommands to the instrument Main Electronics using PUS format



Satellite Avionics Architecture

Qualification will be performed at equipment and main element levels in order to ensure additional confidence in system level tests and to master the development and schedule of both instrument and satellite.

Instrument Phase B2/C/D starts by mid-2016, System/satellite Phase B2/C/D by second quarter of 2017 and launch scheduled by December 2021.

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