@BUS THRUSTER ORIENTATION MECHANISM DELTA DESIGN

Alain Blanc[(1)], Fabrice Champandard[(1)], Jean Michel Lautier[(2)], Yann Michel[(3)]

[(1)]TAS, 100 Bd du Midi, BP 99 - 06156 Cannes la Bocca, E-mail : alain-vincent.blanc@thalesaleniaspace.com
[(2)]ES , Postbus 299 - 2200 AG Noordwijk, The Netherlands, E-mail : Jean-Michel.Lautier@esa.int
[(3)]CNES, 18 avenue Edouard Belin – 31401 TOULOUSE Cedex 4 ,E-mail : yann.michel@cnes.fr

ABSTRACT

The Thruster Orientation Mechanism was developped and qualified in the frame of the project STENTOR initiated by CNES 10 years ago to launch a French technological satellite. TOM acquired a successful In flight heritage on Eutelsat 10, on Immarsat4-F10, on Immarsat4-F2.

TOM is a standard baseline product for Thales Alenia Space Plasmic Propulsion Subsystem and EUROSTAR platform.

The function of the TOM is to allow the in-orbit positioning of the plasmic thrust vector by ± 12 degrees rotation around two perpendicular axes. TOM is equipped with two motors.

Due to performance evolution (TOM equipped with 2 PPS 1350 motors) and @BUS mechanical environment, a delta design of the TOM has been performed. The main challenging delta design driver was to strenghten the mechanism structure but to conserve thermal and lifetime qualification status.

Thales Alenia Space is in charge of the development, delta qualification and delivery of two flight models of a Thruster Orientation Mechanism (TOM) for AlphaSat.

The paper presents the delta design of the TOM, the delta qualification test sequence and the obsolescence issues on a initial off the shelf product

1. @BUS WORKING HYPOTHESIS

The major inputs which are the basis of the TOM delta design are the following one's :

- The baseline at Thruster Module Assembly is the use of two PPS1350-G
- The @BUS mechanical environment specified at TOM interface is higher than the environment specified in the frame of the STENTOR qualification.

2. TOM FUNCTION

TOM is used : to optimise propellant resources, to limit the number of electric thrusters on a platform, to perform advanced Altitude and Orbit manoeuvres,

3. TOM ARCHITECTURE

TOM has a standard architecture of Electric Propulsion Pointing Mechanism (EPPM), composed of the following elements :

- a mobile plate or radiative plate
- a gimbal assembly
- a structure made of five feet
- 2 linear actuators
- 2 switches giving the zero-reference position
- a hold-down and release mechanism

4. SUB ASSEMBLIES NOT MODIFIED

One of the delta design driver was to conserve lifetime qualification status. As a consequence, the linear actuators and the gimbal assembly are the same.

Minor design improvement have been performed to take into account lessons learnt of previous Flight Models assemblies.

This design evolution have been implemented in order not to overpass qualified loads under the mechanical environments specified in TOM @BUS specification :

- Actuator ball bearings are not loaded during launch phase
- Loads applied on gimbals' ball bearings are under ball bearings qualification status.

Linear actuator

The two actuators are equipped with two ball bearing from ADR, and a roller screw from SKF. They allow to fulfil the actuation of the mobile plate in the whole specified angular range.

Proc. '13th European Space Mechanisms and Tribology Symposium – ESMATS 2009', Vienna, Austria
23–25 September 2009 (ESA SP-670, July 2009)

Gimbal assembly

The gimbal assembly is equipped with two pairs of face-to-face ball bearings from ADR on each perpendicular axis. It ensures the mobile plate guidance about both orthogonal axes

5. DELTA DESIGN EVOLUTION PERFORMED

The main delta design driver was to strengthen the mechanism structure to comply with @BUS requirement.

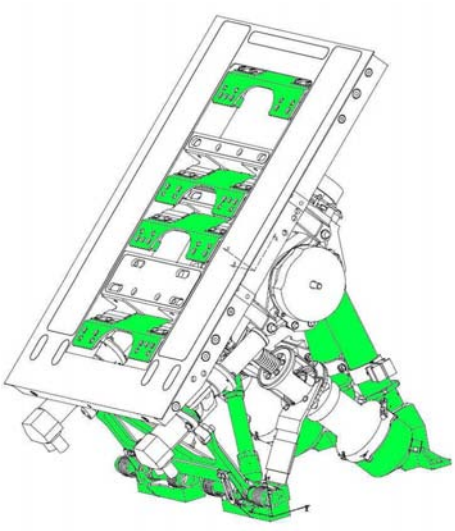


Figure 1. TOM @BUS, front side impression

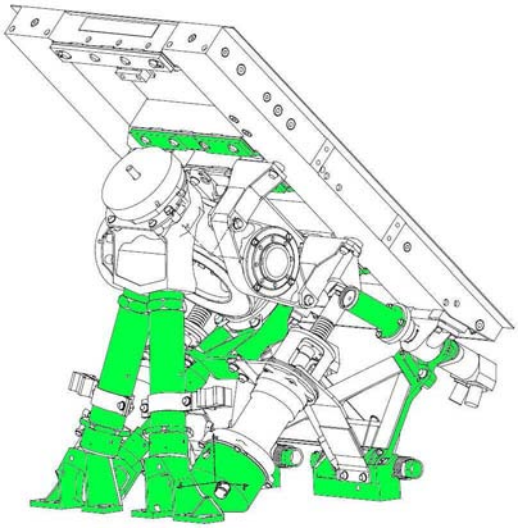


Figure 2. TOM @BUS, rear side impression

Two types of structural major evolution have been performed :

Structure

The structure provides the launch frequencies of the TOM in locked configuration, and the on-orbit frequencies of the TOM in unlocked configuration

The structure is constituted of five feet (one bipod and one tripod) reinforced. The four associated brackets have been modified : they support the base of the bipod and tripod and constitute the four only mechanical interfaces with the satellite structure.

Hold-down and release mechanism (HRM)

The HRM device aims to secure during launch the electric thrusters in a stowed configuration.

Reinforcement performed of HRM linked to the use of PPS1350-G

6. TOM OBSOLESCENCE

Optical switch from CODECHAMP

An optical switch is implemented on each gimbal joint axis to indicate the TOM reference position. Both optical switches are mainly composed of two parallel printed circuits boards (one transmitter and one receiver) inside of which rotates an engraved disc made of glass.

The transmitter and the receiver are two major components of optical switch. They were not any more manufactured by OPTEK / USA. Due to obsolescence, these components have been replaced.

Qualification of the TOM will be fully performed with a qualification optical switch model on each axis.

ESA alert

OAN coating has been replaced.

Due to an alert on Fenwall thermistor, they are replaced by BETATHERM thermistor.

7. TOM @BUS MAJOR PERFORMANCE DATA

- Angular range : ±12° around each axis
- Resolution step better than 0.005° (0.0027° on each gimbal axis and 0.0019° on combined axis)
- TOM mass : 14.5 kg
- In Orbit Lifetime : 15 ans

8. TOM @BUS DEVELOPMENT PHILOSOPHY

Delta qualification test plan includes all the mechanical environment test to demonstrate that the reinforcement performed can fulfil the @BUS requirement

Thermal qualification status

Thermal design and analysis have been performed to not overpass qualification status. TOM @Bus calculation temperatures are covered by qualification status. As a consequence, no thermal vacuum cycle is necessary at TOM Delta Qualification Model level.

Life test qualification status

Two complementary life tests have been performed :

- The first one in ambient pressure and thermal conditions.
- The second one, with a small motion profile : in vacuum and ambient temperature.

Considering :

- TOM @BUS need for mechanical life cycles
- Test qualification performed (no wear out failure appears on TOM, comfortable motorisation margin all along life tests)
- Analysis of lubrication behaviour (thermal and vacuum influence),
- Oil loss calculation

we demonstrate that qualification heritage performed in the frame of STENTOR covers @BUS need.

Delta Qualification Model (DQM)

The below flow chart summarises the qualification test sequence.

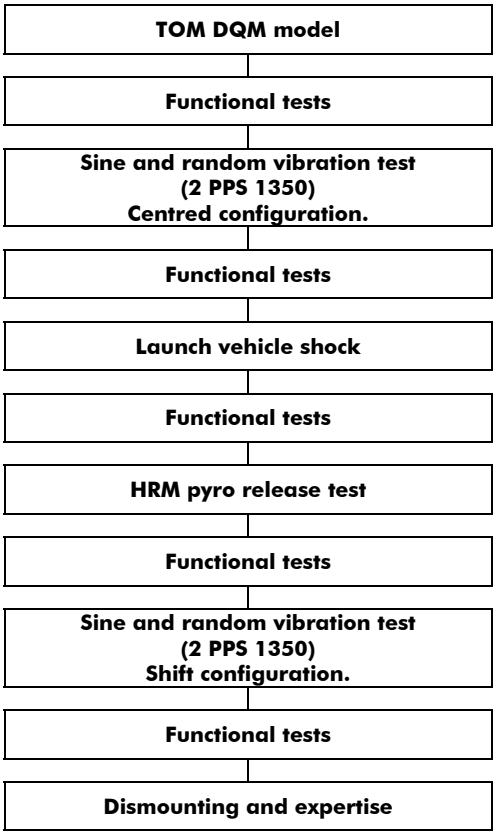
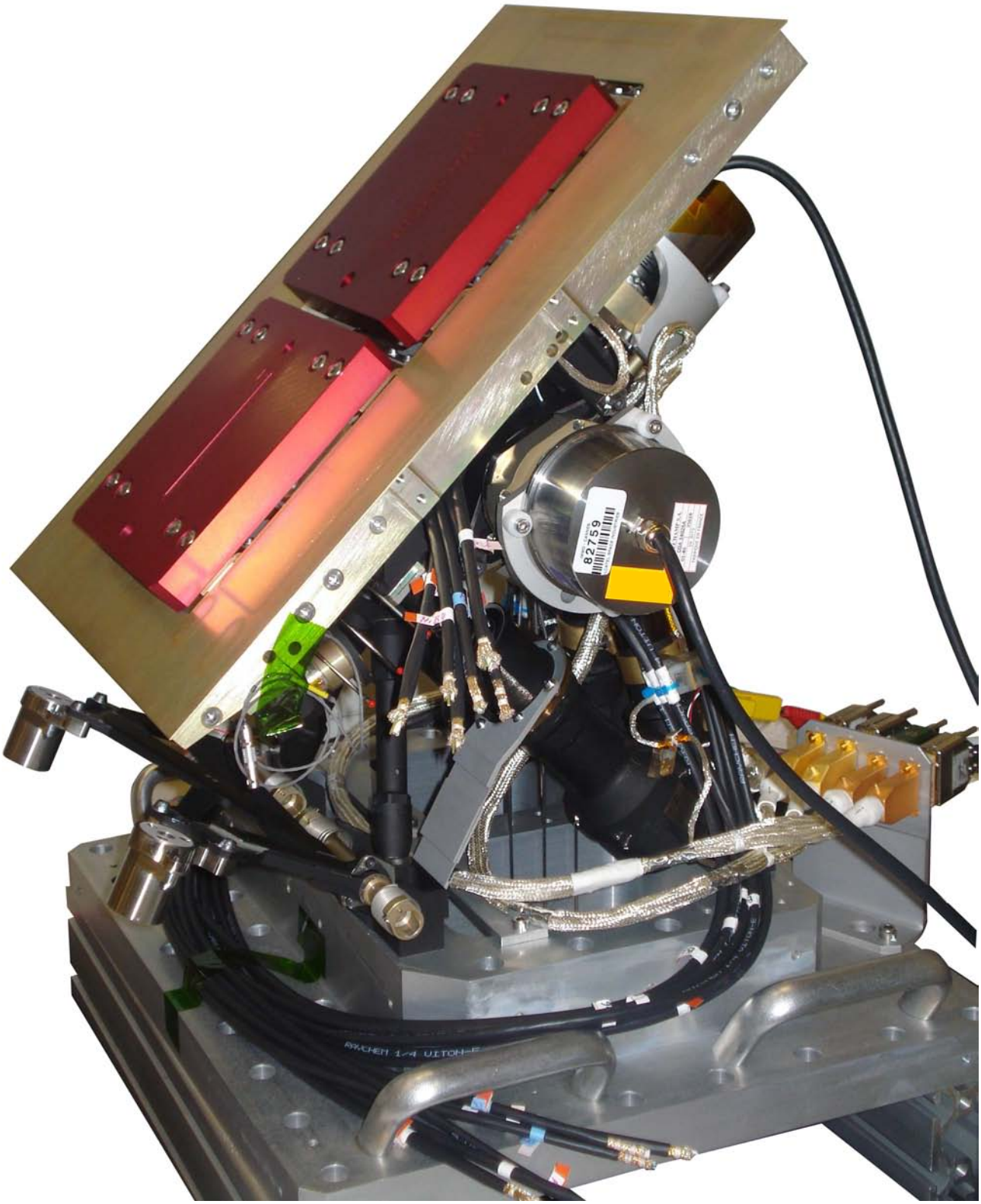


Figure 3. TOM @BUS DQM Test sequence


82759