TEST APPROACHES FOR THE MECHANICAL QUALIFICATION OF THE SMALL SATELLITE BIRD

Swen Ritzmann*, **Maik Hartmann***, **Dr. Bernhard Heym****

*Astro- und Feinwerktechnik Adlershof GmbH
Albert-Einstein-Strasse 12, 12489 Berlin, Germany

** DLR, Institute of Space Sensor Technology and Planetary Exploration
Rutherfordstr. 2, 12489 Berlin, Germany

ABSTRACT

The BIRD mission was designed by the German Aerospace Center for hot spot detection and the measurement of vegetation conditions. To keep the instruments in accurate calibration, high demands were required to the structure. For this reason, a structure development was needed for the BIRD qualification.

The test requirements for the qualification were adapted from KOSMOS specifications first, than from PSLV specifications. For more flight like tests, a dynamic analysis of the flight configuration for BIRD was performed; in consequence, the qualification levels could be reduced. BIRD passed all mechanical qualification tests successful.

1. INTRODUCTION

The Bispectral Infra-Red Detector satellite, BIRD, has been developed by the German Aerospace Center to demonstrate the scientific and technological values of a remote sensing small satellite mission, considering low budget constraints. The scientific aims

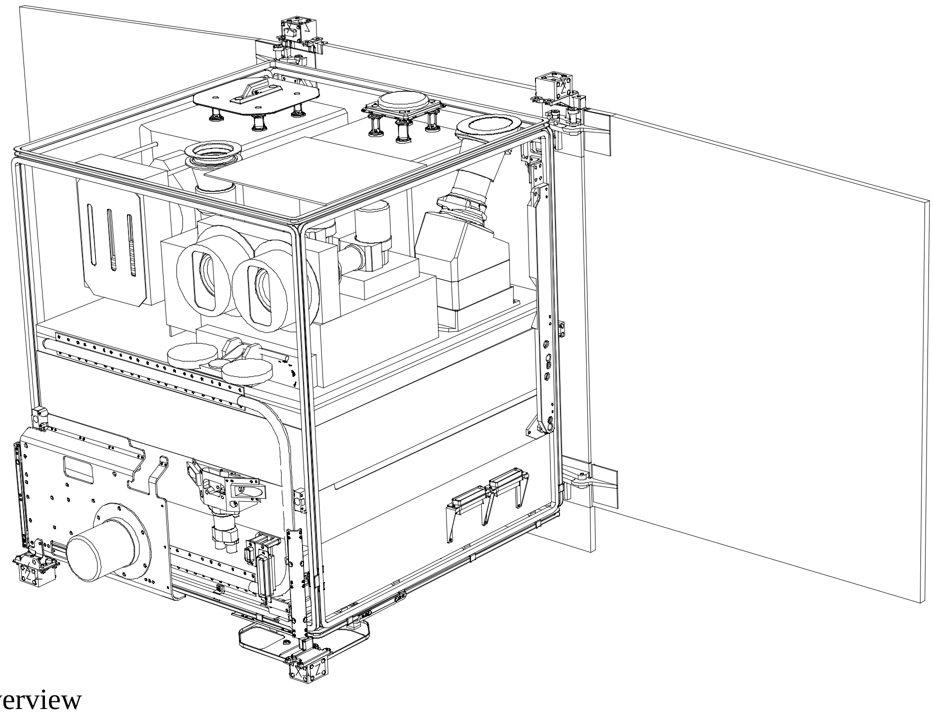

Fig. 1:
BIRD S/C Overview

cover hot spot detection, for example forest fires, volcanic activities and burning oil wells, but also the measurement of vegetation conditions and changes.

One of the participating companies for the BIRD project is the Astro- und Feinwerktechnik Adlershof GmbH. Instructed by DLR, this company is responsible for the mechanical testing in the DLR centre in Berlin. Additionally, Astro- und Feinwerktechnik Adlershof GmbH is supplier for instruments and structure elements.

A new generation of infrared sensors was chosen to operate in medium and long wavelengths (MWIR and LWIR instrument). The Wide Angle Optoelectronical Stereo Scanner (WAOSS, MARS96 mission) was added for the visible range. These three optics shall be co-aligned to cover the same ground swath without distortion.

For mechanical tests of BIRD, a Structural Thermal Model (STM) was built and used in different qualification tests, following the stages of launch negotiations.

2. LAUNCHER INTERFACES

The launch opportunity first planned for BIRD was a KOSMOS launch for CHAMP in July 2000. While the satellites stand on a special framework, the separation system has been engineered by Swedish Space Corporation for BIRD/KOSMOS requirements, using the experience from a former development. It consists in four bearing assemblies, held by hooks and cable.

BIRD is now planned to get launched in summer 2001 as one of two piggyback payloads by a Polar Satellite Launch Vehicle (PSLV), designed and fabricated by the Indian Space Research Organisation (ISRO). PSLV requires its own separation system for small satellites, a circular, spring-loaded ball-lock system.

3. BIRD S/C MECHANICAL REQUIREMENTS AND QUALIFICATION

The structural design concept of BIRD follows several guide-lines:

- withstanding different launcher environments
- compact shape for different launcher space, modular design
- geometric requirements defined by ready made components and standards
- payload as interchangeable platform on bus interface with high accuracy

Exemplary, one of the mechanical demands to the spacecraft should be explained: The payload has to be assembled on the bus structure avoiding interfering forces on 10 support points at least; the load capability may be 12kN in any direction (30kg, 400m/s_), the mounting direction shall be from below. The solution: 18 tension bolts fix the platform by friction (facing shear-forces) with safety factor 2; the flatness deviation is less than 30µm over all 18 support points (to avoid sensor de-calibration). The bolts are fitted through the complete bus structure to the bottom. The bearing structure is designed to give similar shear stiffness for all 18 support points to divide forces equally to them.

Different interface adapters, separation systems and responses from the other satellites change the dynamic behaviour and in consequence the loads for the BIRD S/C.

The mechanical qualification of BIRD S/C was performed with the STM. It was not practicable to plan the qualification tests for all scheduled missions. This was verified by the different mission profiles for KOSMOS/CHAMP and PSLV.

The qualification for KOSMOS/CHAMP requirements was not performed according to the KOSMOS User Manual. For the flight configuration (Fig. 2), a coupled load analysis gives new requirements. The calculation results in higher loads up to 200 Hz, but lower loads above. To simulate the structure impedance of the flight configuration, the force notching was used for shaker testing. With the semi-empirical method, the force limits on the test interface were calculated. It was found, that the input on the shaker was notched by this limits during resonance.

The requirements for the STM Qualification according PSLV specification were discussed with the Indian specialists before testing, especially the differences between the BIRD shaker test (Fig. 3) and the flight configuration loads. The discussed topics for the qualification tests were:

- Test level for quasi-static load test performed as sine burst test
- Sine vibration level and notch limits
- Random vibration spectrum

To verify the strength of the BIRD structure, the required loads for the sine burst test were decided to 11 g. This quasi-static loads simulate the low frequency modes of the flight configuration. The shaker test with a sine sweep produces high loads for the resonance of the structure. The stiff shaker interface do not simulate the structural impedance of the flight assembly. Notching with 12 g for C/G of BIRD was necessary, to reduce the levels to real loads. The low levels for random vibration up to 250 Hz and the higher levels above for the simulation of the acoustic loads have not required any changes.

The system test with the PSLV C3 EB Assembly (Fig. 4) has confirmed the test requirements. The first modes of the coupled structure were measured for 20 to 40 Hz with up to 10 g on BIRD C/G, which corresponds very well with the notch level.

The first mode of BIRD on shaker was different from the coupled modes and cause four times higher loads. Alternatively, the sine vibration test can be cut before resonance.

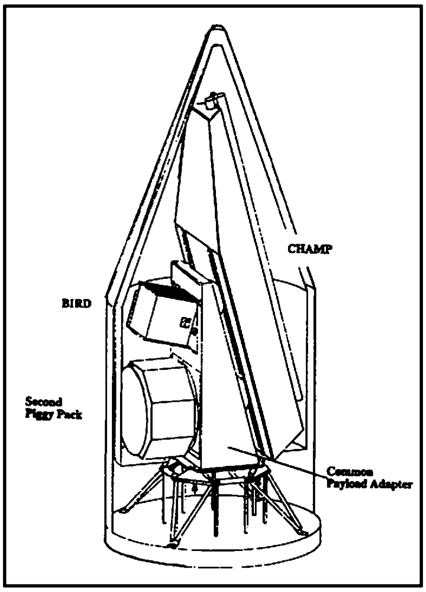

Fig. 2: KOSMOS/CHAMP Flight Config.

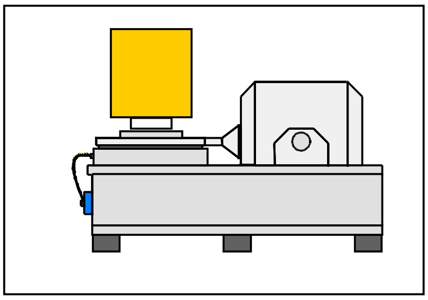

Fig. 3: BIRD on Shaker

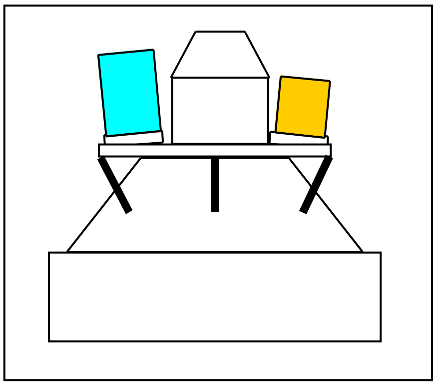

Fig. 4: PSLV C3 EB Assembly Flight Configuration (schematic, without main S/C)