FOCUS-M
MISSILE EARLY WARNING SATELLITE SYSTEM

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ABSTRACT

Ballistic missile defence (BMD) comprises one of the major challenges in terms of future European security and defence policies. As one key element of BMD satellite based sensors provide the necessary surveillance capacity for early state detection of ballistic missiles (BM).

FOCUS-M was a study into a satellite based infrared (IR) missile early-warning system funded by the German Bundesamt für Wehrtechnik und Beschaffung (BWB). Based on an experimental phase with the German DLR satellite BIRD, the study allowed the collection of, in Germany, unprecedented spaceborne IR imaging data for incorporation into a missile early warning concept.

During the concept development different missions scenarios were investigated turning out a LEO Walker constellation of 28 satellites on moderate inclination as the most promising approach to fulfil the observation requirements with respect to the best costs ratio. Certain endeavours had to be undertaken to satisfy the strict requirements posed on the spacecraft (S/C) bus, firstly by the sensor payload and secondly by the mission profile. This paper comprises the outcome of the study for the LEO-based missile early warning concept Focus-M capable of providing all necessary features for permanent observation and surveillance on a global scale.

OBSERVATION REQUIREMENTS

For supporting the defence of military facilities and population centres on national and NATO territory as well as in out of area operations against any kind of BM a global surveillance capacity is demanded. Independent of the footprint dimensions of a single sensor the mission concept has to provide observation accessibility to an area of interest at any time. For further enhancement of data quality a stereo option has been implemented.

Different approaches like HEO, GEO, MEO and LEO configuration were investigated with the result that LEO systems can provided the global accessibility at the best cost ratio. This conclusion is mainly driven by the amount of instruments demanded to gain the required coverage at adequate resolution, spatial, temporal and spectral.

Figure 1: Focus-M System Coverage with 28 Satellites
THE MISSION

An essential security requirement for effective early warning is a continuous surveillance capacity above the area of interest. For uninterrupted observation the mission requires permanent nadir pointing of the instrument bore side leaving only one degree of freedom to the spacecraft motion profile. The changing orbital solar conditions and almost hundred percent duty cycle demands an efficient sun acquisition strategy. Therefore a yaw steering concept has been invented (Figure 2, top). While the bus will be steered around the yaw axis the solar generator assembly, which comprises a drive mechanism with a perpendicular axis to nadir, provides a second degree of freedom enabling the S/C to permanently remain the maximum solar incidence angle.

Another dominant driver was caused by the thermal concept as a dedicated radiator side is demanded to provide unobstructed radiation access to deep space. The implementation of both concepts yielded a non-symmetric S/C configuration. A momentum upload (torque profile Figure 2, bottom) as a result of non-symmetric solar pressure during orbital pass had to be compensated. Temporary this task will be accomplished by large reaction wheels. For total compensation the S/C must be twisted in the eclipse phase to inverse the load in the succeeding pass.

INSTRUMENT

For a full blown approach in terms of observation coverage a dedicated camera concept has been elaborated. The sensor is capable of covering the complete global sector bounded by the satellite horizon. With respect to the cone shaped field of regard (FoR, Figure 3, top) and related observation distances the sensor was subdivided into six cameras. The four similar outer cameras (AK) are designed for larger distances providing a smaller FoV in two directions compared to the two inner cameras (IK) which cover the remaining nearly rectangular centre volume around nadir.

This concept constitutes a well balanced sensor approach with respect to optical requirements, mass and thermal load. It is based upon a common instrument design (Figure 3, bottom) comprising only IR standard components (e.g. dewars and detectors).
cameras operate in linear scan mode and are capable of providing three aligned IR-channel for spectrometric discrimination. For maximum thermal and volumetric efficiency the cameras are assembled to two symmetric payload modules of three units each. The integrated thermal concept allows a common baffle for the bottom mounted primary radiators of the attached cameras. Beside this full blown approach the LEO concept provides a high degree of flexibility through the scalable field of regard. In relation to the coverage demands sensor and satellite can be adapted to actual requirements. As a pre-mission, based on the same camera concept, a sensor with reduced FoR (e.g. one camera) can be invented covering only a scene of interest (theatre) during its pass with hand over to a succeeding satellite of the constellation.

SPACECRAFT

The incorporation of the dominant drivers: nadir constrained operation, wide angle camera FoR and heat rejection capacity for IR channels, led to a S/C configuration as shown in Figure 5. For a cost efficient mission deployment the COSMOS launcher has been selected as primary alternative. The S/C design allows a storage of three satellites beneath the COSMOS extended fairing (Figure 5, left) and enables a mission deployment by not more than ten launches reducing the launch risk to a minimum. One single satellite comprises a

♦ mass of 330kg.

The solar generator is capable of producing

♦ 300 W (end of life)

while the heat rejection capacity is

♦ in the range of some Watt.
CONCLUSION/OUTLOOK

Focus-M constitutes a concept for provision of near-real time early warning capacity for initiation of missile defence systems and population warning with high temporal resolution on a globe scale.

The presented concept comprises an approach based on a maximum flexibility through scalability of the sensor system. While the constellation requirements are nearly fixed for a LEO-system the satellites and related costs are widely scalable with the observation requirements as a design feature to the customer. Furthermore, a pre-mission with theatre surveillance capacity could be based upon micro satellites which are directly related to the Focus-M demonstrator. With the generic camera concept the mission can potentially be expanded to the presented full blow approach in relation to raising observation requirements of the future (Figure 6).

For the 1st technology demonstration an even smaller micro satellite can be designed for verification of the IR-sensor concept and spectral data assessment at a minimum complexity.

![Figure 6: Potential System Expansion](image)

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