ABSTRACT

The Dobson Space Telescope Project (DST) at the TU-Berlin develops foldable telescopes for micro satellite application. This technology will overcome the volume limits of secondary payloads and enable satellites of the 100kg class to carry 20inch (50cm) aperture optics. Using cost effective micro-satellites for 1m resolution imagery will cut down the price for the satellite to a tenth of existing super high resolution systems thereby initiating the long predicted remote sensing boom. In contrast to the James Webb Space Telescope DST does not use foldable mirrors which are not mature nor cost effective. Instead of this DST will fold the optical bench only. This will ease the volume limits of small spacecrafts. During the last 2 years the students of the DST Team formed a science network to develop foldable optics for micro-satellites. This work culminates in the construction of a scaled laboratory prototype. This prototype carries a deployable 14inch (35cm) f/9 Cassegrain telescope. After its completion at the end of this year it will be the world’s first optical telescope with automatic deployment and collimation.

1. INTRODUCTION

The Dobson Space Telescope Project [1] is a student initiative at the TU-Berlin. The aim of the team is to develop deployable telescopes for Microsat application. This technology will enable satellites of the 100kg class to carry 20inch mirror optics and make them to a serious competitor in the state of the art remote sensing market. The Project is part of the micro-satellites (TUB-Sat [2] family) activities at TU-Berlin. It is supervised by Prof. Briess the former project manager of the DLR BIRD [3] mission. Due to the high complexity of the topic external expert knowledge was acquired from the beginning. With the help of nearly a dozen professionals of various fields a science network was formed. This network can be seen in Figure 1.
2. MICROSATS FOR COST EFFECTIVE EARTH OBSERVATION

Since Spot1 hit the market in the early 1980’s the world has seen many commercial satellite remote sensing systems. Despite the hopes of the 90’s the market for Space Imagery is not very prosperous. Main reason for this is the end user price [4]. As long as an earth observation satellite costs about ten times more than a comparable reconnaissance plane most of the users will rely on aerial imagery. As a reaction to the aerial challenge there is a trend to use cost effective micro-satellite systems in mapping and High Resolution markets while the Super High Resolution market is reserved for the big and expensive systems.

Until now Microsats are limited in their capabilities to achieve super high resolution. The problem is that doubling the GSD of a system means in most cases an 8-10 times bigger telescope (volume, mass). In Figure 2 Earth Observation Systems and the limitations of micro-satellites can be seen. Todays most capable optical system based on a Microsat using solid telescope design is the British Topsat mission with a GSD of 2.5m.

3. THE NEXT STEP IN SPACE OPTIC DESIGN [5]

To overcome the constraints in terms of mass and volume and to make a GSD of 1m possible for micro-satellites a new approach in optic design has to be taken. The idea is to fold the telescope during ascend and to unfold it for observation. For space Application there are three types of deployable telescopes. The most challenging ones have deployable mirrors [6] but the technology is not mature and very costly. Telescopes with deployable structures and without collimation [7,8] are easier to handle but have limited optical capabilities. Telescopes with deployable structures and collimation like those developed at the TU-Berlin are the best trade off. They maintain the capabilities of classical solid telescopes but for a much lower price.

3.1 Optic Design

The DST telescope will be a simple straight forward design: on axis, two mirror, two lens corrector system. Despite the fact that this will limit the optical performance (smaller swath width, MFT degradation due to central obstruction, stray light problems) it is the only way to have a low cost deployable space telescope. The optic components can be built with very high precision and it might be possible to buy the whole mirror/corrector system off the shelf. In addition a less complex telescope design is much more stable and easier to collimate.
3.2 Deployment and Collimation [9]

Key element of the DST optic is the deployment and collimation mechanism. The hurdle of readying the telescope will be taken in two steps. The telescope will be unfolded first and collimated afterwards.

After the deployment of the booms the secondary mirror is about 1.1m depart from the main mirror but not exactly in the right position.

Secondly micro actuators will fine adjust the position of the secondary mirror and thereby collimate the telescope. In order to compensate thermal deformation of the telescope structure the collimation and focussing can be performed at any time during the mission to insure stable image quality.

3.2 Is a SHR Microsat feasible? [10]

Besides the challenging task to squeeze a 20inch aperture optic into the given space of secondary payload all other subsystems have to increase their abilities dramatically while shrinking in size and volume. A good way to do this is to rely on state of the art COTS technologies to benefit from the fast development cycles. A conventional Data Compression and Storage System for a SHR satellite alone can weight 30kg and be half as big as a Micrrosat [11] while a COTS system with the same technical abilities can be build up to 30 times smaller. In Table 1 the satellites requirements for 1m GSD based on DST technology can be seen. The DST team only develops the payload and relies on an existing bus. The Team therefore closely cooperates with the companies and institution involved in the design and construction of the BIRD Bus.

![Figure 3 DST in Orbit](image)

### Table 1 Requirements for the satellite Bus (1m GSD)

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Requirements</th>
<th>Achieved Today</th>
<th>By</th>
<th>Needed Improvements</th>
</tr>
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<tbody>
<tr>
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<td>BIRD</td>
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<td>Volume</td>
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<td>0.1m³</td>
<td>BIRD</td>
</tr>
</tbody>
</table>

* Depends on the duty cycle of the satellite
4. PROJECT DEVELOPMENT

The Project was started in November 2002 as part of the lecture satellite design at the TU-Berlin [12]. During the last two years it evolved to a dynamic and well known project. A mock-up was build and presented at the IAC2003 in Bremen. It contained a 3inch Newtonian telescope and was the world’s first optical telescope with inflatable structures. Due to its ability to produce real pictures it was also very helpful to find partners for the testbed development.

Figure 4 DST Schedule

The next important milestone is the completion of the optical testbed at the end of this year. It will contain a 14inch (35cm) f/9 Cassegrain telescope. It will be the first optical telescope with automatic deployment and collimation. Furthermore even this scaled version of DST is the largest telescope ever developed for micro-satellites.

5. CONCLUSION

With 7 TUBSat’s build directly at TU-Berlin and the DLR BIRD build at DLR Space Sensor Systems Institute in Berlin Adlershof the TU-Berlin is without a doubt the pace-maker of micro-satellites in Germany. The Dobson Space Telescope Project is based on this outstanding heritage. The innovative technology of foldable space optics developed at the TU-Berlin will reinvent space business. It will enable to use cost effective micro-satellites for state of the art remote sensing missions. This will cut down the end user price and thereby initiate the long predicted remote sensing boom.

[3] BIRD Homepage http://www.dlr.de/BIRD