The early history of the BRITE project:
A somewhat subjective view

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This document describes the origins of the BRITE project. It is meant as a record on how the project evolved from its conception through the first years (2002 – 2006) when I actively contributed to shaping of the project.

Preamble: Prehistory

In 1996 – 1997, Dr. Kieran Carroll (the at Dynacon and University of Toronto) and I planned a small satellite mission. We were meeting at least once a week for s few hours to discuss what could be done in astronomy using very small payloads. We knew that the Canadian Space Agency was planning new projects and we were trying to design a novel, micro-satellite (<100 kg) for astronomy. At that time, astronomical satellites were rather large because of the perceived need for large inertia for stabilization. We considered 3 options for a mission to study variability of bright stars: (1) a very high-precision imager for small fields (<1 deg), (2) a precision imager for large fields (~25 deg), and (3) an UV wide-angle mission. Stabilization for small spacecraft masses was considered as the most difficult goal to achieve at that time: 15 arcsec mean error was considered as very ambitious for a micro-satellite. Option (1) was the most attractive for the Canadian community and eventually led to the MOST mission; option (2) resulted in BRITE, particularly after MOST demonstrated that the mean stabilization error for a micro-satellite can be by an order of magnitude better then originally estimated, while option (3) was (and still is) beyond technical capabilities of small spacecraft missions because of the lack of small-size UV detectors (or a high voltage for MCP).

Origins

In July of 2002, Dr. Robert Zee asked me over the phone if a nano-satellite could be used for astronomy; then we exchanged several e-mails which led to specific research plans. The team of Dr. Zee at the Space Flight Laboratory of University of Toronto Institute for Aerospace Studies (SFL-UTIAS) was working on an application for an NSERC grant in the Fall of 2002. At this time, SFL was close to launching its first nano-sat CanX-1 (2003), was preparing CanX-2 (launched 2008). An astronomy nano-satellite, which would be the most advanced and complex nano-satellite designed and built at SFL, would carry the designation CanX-3; this name is still occasionally used. More about the SFL nano-satellite program: https://www.utias-sfl.net/nanosatellites/ . Note that all this happened before MOST was launched one year later on 30 June 2003.

A nano-satellite for astronomy would have, by necessity, to concentrate on brightest stars of the sky. Statistics that I did in 1996 – 1997 showed that the bright-star sky is dominated by predominantly *intrinsically the most luminous stars*. Such high luminosity stars should be – on the average – the largest and most massive and thus should show the slowest variations permitting lower observing cadences and less demanding orbits than that of MOST. Therefore, what eventually materialized as BRITE was more than just "an idea of using nano-satellites for astronomy", but a very specific set of research goals aimed at the most luminous stars. The additional stress on studies of the brightest stars in the sky was related to generally poor photometric information on their variability which resulted from residual, unaccounted atmospheric extinction effects over large angular sky distances.

Most of the thinking and ideas which are implemented currently in BRITE can be traced to the period 2002 – 2005 and very strong involvement of a team from the Department of Astronomy & Astrophyscis of the University of Toronto (DAA, UofT). In this time frame, the nano-satellites built at this time by SFL had dimensions of multiples of 10x10x10cm cubes. CanX-3 was envisaged at first as a fully three-axis stabilized satellite with dimensions 10x10x30cm, with a lens having an aperture of about 3cm and a focal length >15cm; then this form was modified to a 15x15x15cm cube to evolve into the present 20x20x20cm box.

Early funding attempts and Proposal #1 (2004)

I was to be the co-signatory of the SFL grant proposal to NSERC for CanX-3 in 2002, but it was not submitted. Such a proposal was submitted by Dr. Zee in the Fall 2003, but the project was not funded. From the Spring of 2004, the fund-securing activities shifted from SFL to a team led by the undersigned at the DAA-UofT.

The project was advertised by the undersigned in 2004 during various meetings of the Canadian Astronomical Society and the Joint Committee for Space Astronomy (JCSA). Generally, there was a strong interest in the mission. But actual funding was not forthcoming and it took several years to see any concrete results.

In the Spring of 2004, the Science Team of BRITE met several times to discuss the science of the mission. The name "BRITE" (an acronym for BRIte Target Explorer) was then invented by Tony Moffat, in place of the less attractive "Bright Star Photometer" (BSP), which was used earlier[1]. The Team consisted of, at DAA: Slavek Rucinski (PI), Tom Bolton, Marten van Kerkwijk, Stefan Mochnacki, John Percy; at U. de Montreal: Tony Moffat; at McMaster U. (Hamilton): Doug Welch. The Technical Team was represented, at SFL: Rob Zee; at Dynacon: Kieran Carroll, Daniel Faber.

The results of the discussions in the Spring of 2004 was an unsolicited proposal to CSA for funding of one BRITE satellite. Informal discussions with CSA representatives led us

[1] Trying to be linguistically correct, I did not like the name. But I was convinced that it is a convenient and "catchy" one.

to believe that such a proposal had very high chances of acceptance because of the low costs (estimated at <$1.1M for the satellite). The resulting Proposal #1 was dated June 1, 2004. BRITE was envisaged as a single, one spectral-band satellite, either a Triple Cubsat (10x10x30cm) or a 15cm Cube, 3-axis stabilized to 1 arcmin.

The proposal to the CSA was shared with Dr. Werner Weiss at the Vienna University Observatory in June 2004. Dr. Weiss was a member of the MOST team from the start of this mission in 2003 and was very much aware of the activities related to the BRITE initiatives. In September 2004, a workshop on nano-satellites for astronomy was organized in Vienna.

In evaluating the BRITE proposal, the Canadian Space Agency turned for advice to Joint Sub-Committee on Space Astronomy (JSSA; now called slightly differently: Joint Committee on Space Astronomy) in June 2004. JSSA suggested that a Technical Feasibility Study funded by CSA be done to study (1) an optical design of a lens system which could feed a CMOS detector, (2) dark current properties of CMOS detectors, (3) vignetting effects in the CMOS detectors due to their poorly documented f/ratio limitations. This resulted in a CSA funded Concept Study that I led.

Concept Study (2005): CMOS detectors and Preliminary Optical Design

The Concept Study "CMOS Detectors and a Preliminary Optical Design for BRITE" was done to study properties of CMOS detectors and then red and blue optical systems which would feed such detector; the CSA contract: 9F007-046080/001/ST. At that time, I had a very strong conviction that CMOS detectors are better than CCD's because they are addressable memory chips (and not read sequentially as CCD's): One could envisage separate raster windows read at different cadences, with some rasters with rapid readout used for stabilization of the satellite and some rasters used to integrate stellar images for photometry. This detector could be fed by a single optical system (with perhaps a larger lens) serving both duties; such a system would avoid a separate tracker.

Properties of CMOS detectors were poorly documented at that time. The main difficulty of working with the CMOS's are connector wires in front of the detector: The sensitive parts are located deep inside; in some CMOS detectors the light goes through tiny micro-lenses capturing light from the front face of the detector. These additional optical complexities set limits on the f/ratio of the optical system; they forced us to think about a strictly telecentric design which was finally adopted for the BRITE's. By 2004/2005, two separate satellites with either a red or a blue system of lenses were already envisaged, so Ceravolo Optical Systems was contracted within this Concept Study to provide two designs fulfilling such needs. It should be noted that the blue design is the same as the one finally adopted for the currently built blue BRITE's; the red system is slightly modified in details.

The study showed that CMOS detectors have entirely sufficient sensitivity for BRITE application and show reasonable dark current levels at room temperatures. On the

negative side, they normally have low discretization-level A/D converters (typically 12 bit) and have poor angular properties resulting in vignetting-like limitations for large opening angles. Some detectors tended to show fringing in the red part of the spectrum.

Proposal #2 (2005)

Armed with the results of the Concept Study, as above, we applied again for CSA funding in May 2005. The proposal #2 was signed by the Science Team very similar to that of Proposal #1 (Rucinski (PI), Bolton, van Kerkwijk, Mochnacki, Zee, Moffat, Welch), augmented by Dr. Jaymie Matthews (U. of British Columbia). In addition to several improvements to the proposal, the important item was an explicitly addressed collaboration with the team in Austria which was going to apply for funds to the FFG Agency in 2005. At this time, still a single satellite was considered, but keeping an option for two satellites each with a separate spectral band if sufficient funds would become available.

Although well received and considered very inexpensive, the proposal was again not accepted, citing changes in the administrative structure within the CSA. No definite decision was made. The matter remained open-ended.

2005 – and later

While administrative changes kept on taking place at the Canadian Space Agency, we learned in the early Spring of 2006 that the first Austrian BRITE had been funded by the University of Vienna PI: Werner Weiss), with a second successful funding application from Gratz University of Technology (PI: Otto Koudelka) soon after. Thus, while the BRITE project definitely originated in Canada, we were confronted with a situation that it could be successfully realized abroad, but not in Canada. While it was a great success for SFL, I felt that the efforts of astronomers are not properly recognized in Canada. In this situation, I decided to resign as the PI of the project, remaining a member of the Science Team. I was frustrated and felt that I cannot cope with administrative obstacles. My resignation was not noticed by anybody – as I should have expected. At this point, BRITE could die as a scientific project in the country of its origin; fortunately, Dr. Tony Moffat accepted the PI duties from 2006 onwards.

In the following years, meetings of the whole or part of the Canadian Science Team took place frequently adjacent to the MOST Science Team meetings. Of particular note are the meetings in June 2006 in Halifax and in December in Sacacomie, near Montreal in December 2006, where many technical details were discussed and solidified. In particular, following extensive studies of Dr. Stefan Mochnacki, it was decided to use a CCD detector rather than a CMOS detector.

In our subsequent attempts to obtain CSA funding, it was assumed that the Canadian BRITE's will eventually somehow materialize. Thus, the applications were stressing the collaborative nature of the project with several satellites forming a Constellation, originally planned to consist of two Austrian and two Canadian. After intensive effort of

the Canadian team, particularly of Dr. Rob Zee, funding for the Canadian complement of the Constellation was indeed granted in 2011, already after a third partner joined the project in 2010.

The Polish connection

When the Austrian BRITE's were accepted for funding, I felt that Poland with its rapidly improving economy could join the Constellation. When the Canadian part of the project appeared to be in limbo (from 2006 until 2011, but with standing promises to eventual funding), I started pushing my colleagues & former students in Poland to follow the Austrian example. I found a somewhat skeptical audience for my suggestions. A notable exception was Dr. Janusz Kaluzny from the Copernicus Astronomical Centre in Warsaw. His colleague, Dr. Alex Schwarzenberg-Czerny was able to obtain a promise of funding for two BRITE satellites at the end of 2009; the funds had a rather unrealistic provision attached that they must be used within 3 years which does not take into account – now widespread – difficulties with finding a launch facility. The good news about the Polish BRITE's came to the MOST/BRITE teams during their meeting in San Jose in December 2009. This way, the present six-satellite BRITE Constellation was born.

The documents available in:
http://www.astro.utoronto.ca/~rucinski/BRITE/

- BRITEprop1_2004.pdf
- BRITEprop2_2005.pdf
- CMOS-optical_2005.pdf
- Early_history_BRITE.pdf
- successful_MOST_proposal_1997.pdf (scanned, size: 51 Mb!)