THE IDEA OF A STUDENT BUILT LUNAR ORBITER. S. Tietz[1], Sascha.Tietz@gmx.de.

Background: In the last decade a large variety of student built satellites has been developed, launched and operated by students from all over the world. Most projects started with a cubesat of just 10 by 10 by 10 centimeters and a total mass of 1 kilogram. These picosatellites can be developed, built, launched and operated in a very short timeframe of around two years, which makes them a very valuable hands-on expericene add-on for undergraduate and graduate courses in all fields related to aerospace engineering. This educational process can be further improved by a collaboration of different courses or even different universities.

One example for the cooperation of a large number of universities is the the European Student Space Exploration and Technology Initiative (SSETI) [1], which was initiated by the Education Office of the European Space Agency (ESA) in fall 2000. The idea of SSETI is to create a network of students being capable to develop, launch and operate a student build microsatellite. The first SSETI mission called SSETI Express was designed to be a technology demonstration and in-orbit test bed for hardware to be used on later more sophisticated SSETI missions like the European Student Earth Orbiter (ESEO) or the European Student Moon Orbiter (ESMO). The 60 kilogram SSETI Express microsatellite was launched on October 25th 2005 from Plesetzt (Russia) only 21 months after the project kick-off in January 2004.

Most of these student built satellites are considered to be educational projects and are rather doing technology demonstration than producing scientific outcome. Their impact on other missions is therefore usually restricted to further missions at the same university. Nevertheless, the overall technology level of student built satellites increased rapidly since the first cubesats at the end of the 1990s. Inspired by the “It’s the mission that matters” slogan of this years Small Satellite Conference [2] in Logan, UT and a presentation of the National Aeronautics and Space Administration (NASA) about the idea of an American Student Moon Orbiter [3], a group of students from different universities discussed the idea of starting a microsatellite project similar to SSETI in the the United States, but with a more mission driven approach.

Idea: Nearly ten years after the first student built satellites, these missions conduct only technology demonstrations which seems to be a rather unsatisfactory approach. The reason these missions have been limited to technology demonstrations is that cubesats and nanosatellites are usually too power and volume restricted to perform scientific missions. The conclusive idea is therefore to focus on microsatellites which should be able to achieve science objectives. Nevertheless, education would still be a primary goal of such missions. But in contrast to earlier missions additional scientific outcome will be provided. Doing science with student built spacecrafts would also open the opportunity to include more students with scientific background, like planetary sciences or astronomy. These students would have the chance to work on a mission and possibly even provide an instrument, which is usually not possible on professional science missions. The general philosophy is that engineering students would develop, build and operate a spacecraft to achieve scientific objectives outlined by the scientific student community.

The Project: Following the notions mentioned above, the project should be entirely run by students. In the beginning a group of students from different universities, probably supported by their professors, will discuss the primary goal of the project. Such discussions could, for example, result in a decision to build a spacecraft as a technology testbed for Low Earth Orbit (LEO) or to launch several cubesats. Another idea for a more science driven student mission could be a lunar orbiter developed, built, launched and operated by students with science experiments provided by students, universities or other educational institutions. This would be a very interesting opportunity of student contribution to the current NASA plans for the return to the Moon and the large interest of the science community for lunar missions. It would also encourage students, because they would be part of a real space endeavor instead of providing only an in-orbit technology testbed. Furthermore, both engineering and science students would have the opportunity to work together in a close cooperation. This partnership and their hands-on experience over the whole project life cycle would make them a well trained workforce for companies and other institutions working on future missions.

After defining the primary goals, the students will have to define management and project structure according to these goals. This includes the selection of the project management, its responsibilities, the team and subsystem selection process, etc. A small group of experienced students from different universities could then conduct a first feasibilty study, which should result in a set of preliminary requirements and a guideline of how to reach the primary goals. It is highly recommended to include a number of science related students in this early process in order to facilitate a more science driven approach.

Later the project management is appointed and an announcement for the student community is prepared, which should result in a number of teams interested in joining the project and the ideas of their contribution. Based on this information the teams for the different subsystems and tasks can be selected. The details of this selection process should be defined by the initial group of students, but considering the overall project goals. The final large group of students then starts to define the mission objectives, requirements and schedule for the project. It is very important for the ongoing motivation of the students to avoid unnecessary work, because they have to contribute to this project in addition to their studies at the university. The project management should therefore try to implement a streamlined workflow, for example by excluding documentation which is not necessary for reaching the primary project goals.

In this paper, only the idea of science driven student lunar mission is presented because the project started only six weeks prior to this workshop and is still in the first phase of the process described above. The following information should therefore considered to be only one concept, which may not reflect the final concept.

Mission Description: The preliminary mission design could be very similar to the other microsatellite mission to the Moon. After being launched as a secondary payload into a highly elliptical, low inclination Geostationary Transfer Orbit (GTO) and finishing the in-orbit verification, the spacecraft would use its onboard propulsion system for Trans Lunar Injection (TLI) and Lunar Orbit Insertion (LOI) before it reaches its final orbit around the Moon. To reduce the amount of propellant needed for maintaining the orbit, a stable elliptical polar orbit might be the better option than a circular Low Lunar Orbit (LLO). This would also decrease the amount of delta v needed to reach the final orbit.

Over the next couple of months, different options for the transfer to the Moon (using either chemical or electrical propulsion) and different final orbits will be analyzed before the final decisions will be made. Furthermore, the interests of the science student community need to be considered as well, because their scientific goals and objectives are the purpose of the mission.

The overall mission duration varies depending on the transfer time to the Moon, but it is desired to provide at least enough lifetime at the final orbit around the Moon to conduct all science experiments.

The Spacecraft: As explained earlier in this abstract, the spacecraft should be developed, built, launched and operated entirely by students. This results in a number of constraints for the design of the spacecraft. One constraint is that the mission must be low cost. This is possible using subsystems which have already been developed in the last couple of years for previous cubesat and nanosatellite missions of the student community. On the other hand, a higher amount of redundancy and testing is required to ensure the reliability. Another important concern is safety which may drive mission design considerations. For example, propulsion systems using toxic fuels should be avoided due to safety concerns. Finally, one of the biggest conctraints is the launch of the satellite as a secondary payload. Since the actual launcher will be determined rather late in the project, a variety of secondary payload standards like ASAP5 and ESPA should be supported. This would result in overall dimensions of approximately 0.7 by 0.6 by 1.0 meters and approximately 180 kilogram total mass for ESPA. The detailed design of the spacecraft will start as soon as the mission and requirements are further specified.

Conclusion: Inspired by their experience in building and operating spacecrafts in the last decade and the Small Satellite Conference this year, a group of students expressed their interest in taking the next step towards a science driven space mission. They are currently trying to define this step and a project to achieve it. Some preliminary ideas have been expressed in this abstract and will be further analyzed in the future. One part of this process is to find interested partners from government, academia and industry to achieve the mission goals. Their contribution and influence need to be discussed in the future, but ultimately this mission should still be a student project.

References: [1] Website of the Student Space Exploration and Technology Initiative *http://www.sseti.net*. [2] Website of the Small Satellite Conference *http://www.smallsat.org*. [3] Clearwater, Y. et al. (2007) *SSC07-XI-9*.