WATER-II MISSION CONCEPT: Water Extraction mission based on WATER-I and OSIRIS-REx. B. Albers[1], B. de Winter[1], B.H. Foing[1,2], K. Molag[1] [1]Vrije Universiteit Amsterdam, de Boelelaan 1105, 1081 HZ Amsterdam, the Netherlands (bram_albers@hotmail.com, dewinterbram@hotmail.nl), [2]ESA ESTEC, Keplerlaan 1, 2201 AZ Noordwijk, the Netherlands (Bernard.Foing@esa.int).

Introduction: With the arrival of the OSIRIS-REx at Bennu and Hayabusa 2 at Ryugu and the first results published by OSIRIS-REx with the detection of hydroxyls in possibly clay minerals of Bennu. A group of students from Vrije Universiteit Amsterdam propose a follow up mission based on the WATER-I (Water-Rich Asteroid Technological Extraction), OSIRIS-REx and Hayabusa 2 missions. The WATER-I was a mission designed in the a Introduction to Planetary Science course in the BSc program of Earth Science at the Vrije Universiteit Amsterdam, the Netherlands. This abstract summarizes the WATER-II Mission proposed by a student team for OSIRIS-REx at Asteroid Bennu special session at LPSC50. Their mission, WATER-II will revise the WATER-I [1] with the gathered information of OSIRIS-REx and will aim to harvest water from a carbonaceous asteroid.

Background: Asteroid mining can become realistic and important in the near future. Significant terrestrial reservoirs of potassium, phosphorus and platinum-group elements (PGE's) are becoming less economical viable to extract. Because the importance of these elements in the modern society, it could be an relevant and economical interesting option to look at asteroid mining. At this moment the main economical problem is the amount of fuel needed to launch space missions. This would not make mining asteroids worth investing. Because of the recent discovery by OSIRIS-REx of water on Bennu, making fuel out of water could be an option for making asteroid mining missions more efficient. Additionallly Space Agencies could use asteroids as "fuel stations" for further scientific exploration of the solar system and beyond. Devoting another mission to a near-Earth hydreous C-Type asteroid will give more insight to the possibility of using water in C-type asteroids as fuel. The OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, and Security - Regolith Explorer) [1] will be a sample return mission that is approaching a near-Earth Astroid and aims to return samples from a pristine carbonaceous asteroid. Our proposed mission, WATER-II, is inspired by aspects of the OSIRIS-REx mission. The WATER-II will return samples from a C-type asteroid and tries to return to earth on self-produced fuel from mining water. The WATER-II objective will be to harvest water from a water-rich asteroid, and using this water in an regentive fuel cell (RFC) system. [2] Within the RFC system, electrolysis will split the water in oxygen and hydrogen, producing hydrogen in the fuel cell. The electricity could als been used for propulsion insteed of using it for electrolysis. This type of propulsion is durable but does not have the power for fast traveling. Therefore the electricity could be used for making hydrogen. Hydrogen fuel propulsion has lot more power than electricity. For the WATER-II mission, the produced fuel will be used to return to earth. Once the technique has been shown successfully, larger scale operations could be designed and launched.

WATER-II planning and objectives: WATER-II will combine OSIRIS-REx mission objects and planning with new methods of water mining and processing this water into return fuel. The mission is divided in five stages. 1) Finding suitable asteroid. 2) Arrival at Asteroid and remote sensing. 3) Asteroid capture, optical mining and sampling. 4) Water processing in RFC Fuel 5) Sample return to earth. While OSIRIS-REx has discovered hydroxyls in probably water-bearing clay minerals, Bennu is not large enough to host water. WATER-II has to search for an asteroid that could host water. Based on OSIRIS-REx with added time for mining and water processing, the mission will take 3,5 years when discovered a potential target. The complete WATER-II mission profile which aims to bring the capsule back to Earth safely on self-produced hydrogen fuel is as follows:

01/2027: Launch with new generation of rockets.
07/2029: Detailed survey target asteroid
07/2030: Approach targeted asteroid and asteroid capture/water mining/fuel production
07/2031: Start return to Earth
01/2034: End of mission

After the sample return of OSIRIS-REx in September 2023, WATER-II will be launched in 2027. This will happen with the new generation of rockets. The spacecraft will orbit the asteroid and will start with detailed remote sensing and measurements. Cost of the WATER-II will be almost comparable with OSIRIS-REx. However additional cost for the development of the RFC system, and the bigger solarpanels for powering RFC must be taken into account.

Spacecraft: Based on NASA missions APIS and OSIRIS-REx the spacecraft will have a launch weight between 9000 and 10000 kg. The estimated dry weight will be 6000 kg . Two solar panels, with a combined area of 15 m^2 will deploy during the travel to the asteroid and will power the spacecraft and the electrolysis. During the flight to the asteroid, power is captured and stored in the spacecraft. When the spacecraft approaches the asteroid, it will change direction and will enter an orbit around the asteroid. Using the OCAMS POLYCAM [3] from OSIRIS-REx the spacecraft could target accurately the asteroid. When stable in the orbit, the spacecraft will start to observe the asteroid. The spacecraft will use OCAMS MAPCAM [4] from OSIRIS-REx or ONC camera [6] from Hayabusa 2. A laser altimeter from OSIRIS-REx[5] will make 3D maps of the asteroid. The scientific payload holds three spectrometers, which are used to analyze the surface composition of asteroid targets. Cosmic rays interacting with the asteroid surface up to a depth of a few meters produce X-rays, gamma-rays and neutrons. These can

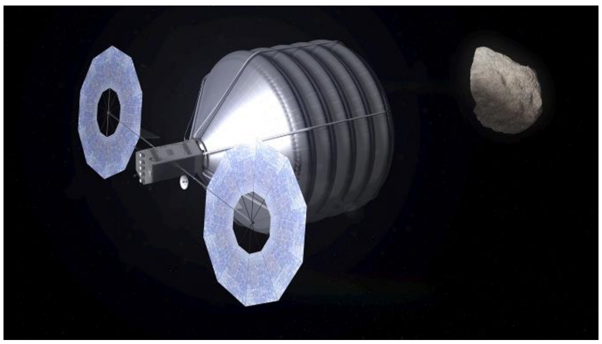

Figure 1, Artist impression of Asteroid capture system, developed by NASA for Asteroid Redirection Mission (ARM). Source: nasa.gov

be analyzed by x-ray, gamma-ray and neutron spectrometers to detect elemental compositions of the surface. Since neutron emission is influenced by hydrous compounds, neutron spectrometry can be used to detect water abundances [7]. The water is extracted from the asteroid by optical mining. The asteroid is enclosed by an instrument that resembles NASA's APIS (Asteroid Provided In-situ Supplies) [8, 9]. Sunlight is concentrated into a high-energy beam that is pointed at the asteroid within the capsule. As a result, volatiles, including water, evaporate from the rocks, but stay inside of the instrument. Water condenses within and can be collected and used in the RFC-system. The RFC-system will produce hydrogen and oxygen through a solar powered electrolyzer.The fuel cell within this system will yield energy to power the electrolyzer, future mining facilities and communication devices. As well, hydrogen and oxygen will be ignited in a propulsion tank as fuel. During the optical mining the WATER-II mission will deploy a sample machine. This procedure can be done in two ways. Hayabusa 2 shoots a projectile into the asteroid and ejected material will be stored and brought back to earth. OSIRIS-REx is using the TAGSAM, a sampling arm that releases a burst of nitrogen gas. The sampling arm would after the burst pick up samples that are ejected from the asteroid. WATER-II will have the opportunity to wait for results of Hayabusa 2 and OSIRIS-REx to determine the best solution. A return capsule similar to the OSIRIS-REx SRC (Sample Return Capsule) will be used for the WATER-II mission. This capsule relies on heat shields and parachutes to fly the instruments back to Earth.

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Glossary:

OCAMS POLYCAM: OSIRIS-REx Camera Suite Long-Range Telescope to locate the asteroid from two million kilometers
OCAMS MAPCAM: OSIRIS-REx Camera Suite Medium-Resolution Mapping Camera
ONC camera: Hayabusa-2 Optical Navigation Camera.

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