Otter Pup Satellite Technical Description

The overall goal of the Otter Pup mission, is to demonstrate Rendezvous, Proximity Operations, and Docking (RPOD) technologies in Low-Earth Orbit (LEO) using a demonstration spacecraft. Starfish will utilize feedback and experience from this mission to develop an operational servicing spacecraft by 2024-2025 to be used for satellite life extension and defunct satellite and space debris removal missions. This development will enable the broad adoption of satellite servicing in the United States.

The Otter Pup spacecraft will be integrated onto the Orbit Transfer Vehicle (OTV) owned and operated by the space logistics company Launcher, and carried into orbit aboard SpaceX Transporter-8, from Cape Canaveral Space Launch Complex, no earlier than April 1, 2023. Transporter 8 will deploy the OTV at an altitude of 550km into a sun synch orbit.

The OTV carrying the Otter Pup spacecraft, will move from the deployed orbit, to the operational orbit of 475 km SSO, with an inclination of about 97.6 degrees. At that point the OTV will release the Otter Pup. Transmission will begin at that time, and cease approximately 1 year later.

After spacecraft commissioning, Otter Pup will rendezvous with the Orbiter OTV, perform proximity operation maneuvers around the Orbiter OTV, and then slowly approach and dock with the Orbiter OTV and then un dock from the OTV, repeating this temporary docking maneuver one or more times, and then the OTV and the Otter Pup will move apart and orbit independently. Atmospheric friction will slow the Otter Pup spacecraft and reduce the altitude of the orbit, until de-orbiting occurs approximately 18 months after launch.

The total wet mass is 38.8 kg, and total dry mass is 37.88 kg. The spacecraft has dimensions of 72.0 x 38.7 x 46.8 cm.

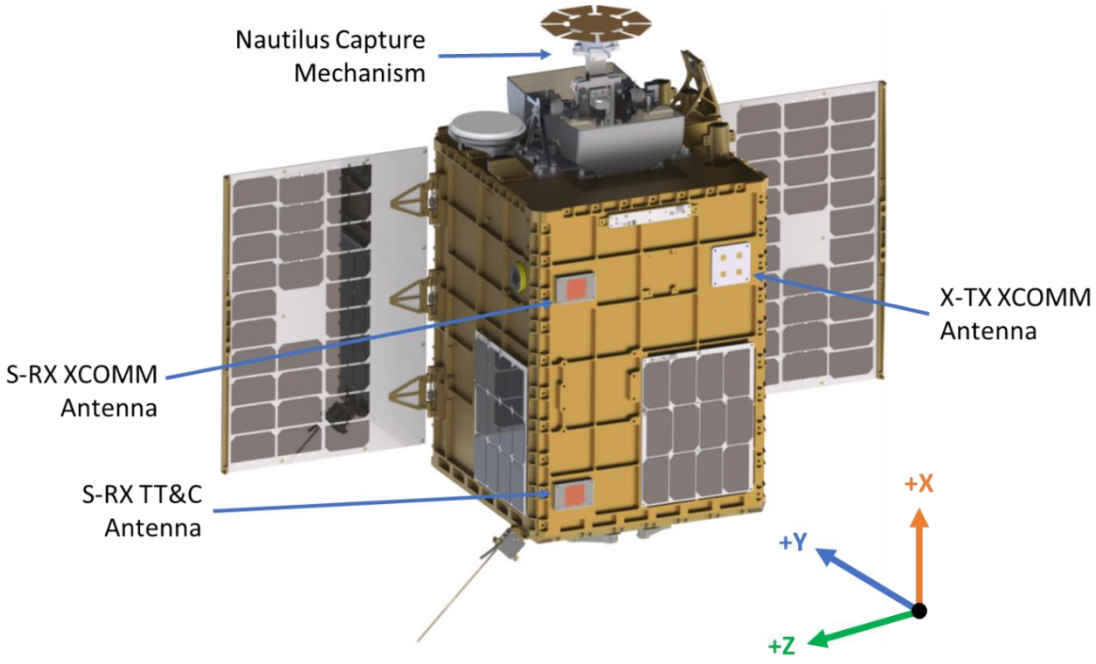

Figure 1 Otter Pup Overview 1

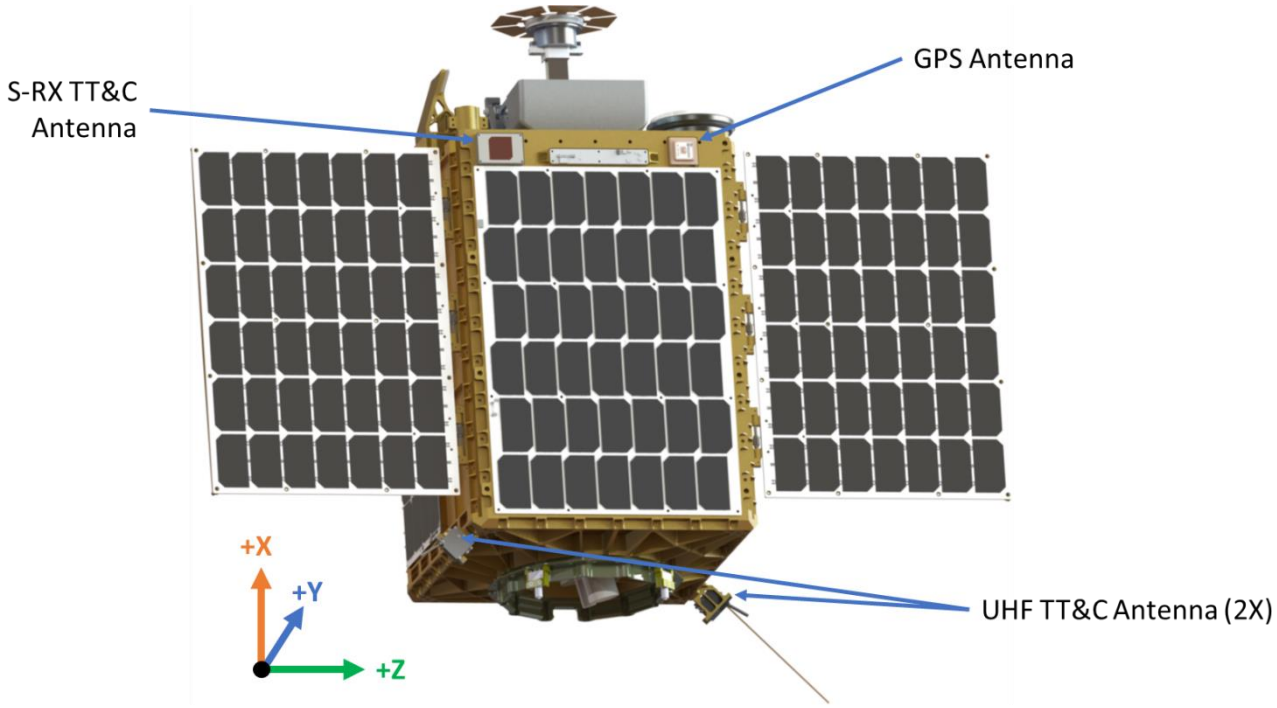

Figure 2 Otter Pup Overview 2

The spacecraft contains the following systems:

Communications System (COMMS): Two transceivers are used. For antenna placement, see Figures 1 and 2.

The Turva S-band/UHF transceiver supports TT&C. The two UHF antennas, and two S-band patch antennas, are placed at opposite ends.

The Gen4 X-band transceiver provides a high data rate payload data downlink. It is mounted in the interior of the spacecraft's -Y plate with the antenna mounted on the exterior of that same plate.

The GPS receiver is mounted inside the DPM, with its antenna mounted on a corner of the spacecraft.

Electrical and Power System (EPS): Power is generated by the 3 Main Solar Panels (MSP). Each MSP is comprised of 14 cells in series with 3 strings for a total of 42 cells per panel. The peak power generation of one MSP is 46 W. 3 keep alive panels serve as backup power generators in case of an uncontrolled tumble or clocking maneuvers. The spacecraft avionics are enclosed inside the Data Power Module (DPM) which is comprised of a flight computer with integrated IMU, GPS module, TT&C transceiver, two battery packs, charging module, power distribution module and a high voltage power board. An additional battery pack containing two Direct Energy Pack (DEP) is also used to further supply power to the payload, regulate the high loads which the MSPs generate and provide temperature monitor and heaters.

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Spacecraft Structure: Otter Pup is based on the standard Astro Digital Corvus-Micro+ bus. The spacecraft structure is comprised of six aluminum orthogrid plates, in which all components are mounted on the inner and outer faces. All structural panels are referenced against the body frame of the spacecraft. A main structural panel in the -Z axis, two side plates on the +Y axis, and a payload deck on the +X axis.

Propulsion System: The Exotrail ExoMG Nano is a Hall Effect Thruster (HET) developed by Exotrail SA. The system accelerates a xenon plasma using magnetic and electric fields for high efficiency thrust. Xenon propellant is substantially safer than traditional bipropellants/ monopropellants as it is non-toxic, inert, and found in relative abundance in the earth's atmosphere.

Attitude Determination and Control System (ADCS): Scheduling after separation will consist of autonomous de-tumble followed by a safe mode sun tracking mode. A magnetometer, sun sensors, gyroscope, reaction wheels, torque rods, and a star tracker are used to orientate the spacecraft.

Nautilus Capture Mechanism: Starfish Space's Nautilus capture mechanism, which is concealed in a protective shield for launch and Launch and Early Orbit Phase (LEOP), is actuated using EBAD Non-Explosive FC3 Frangibolts. These Frangibolts create no loose debris and are actuated in a set sequence to ensure proper deployment of the capture mechanism. An end effector will be connected to the end of the capture mechanism. This end effector will enable Otter Pup to dock with the Orbiter OTV from which it was deployed through electrostatic adhesion. An electromagnet will be integrated into the end effector and will be used as a backup option to the electrostatic end effector, to dock with the Orbiter OTV through magnetic attraction.

Illuminator and Argus Camera: To support capture, the +X face of the spacecraft includes a high-power light source–the AeroLEDs illuminator. The illuminator acts as a light source to help the camera detect docking surfaces in shadowed conditions. The Deep Space Systems Argus camera, also mounted on the +X face of the spacecraft, includes 2 stereo cameras for determining depth through stereo vision, and 1 center camera for docking alignment. The camera has on-board image evaluation. A mirror mounted on top of the center camera will assist the camera in viewing the end effector at docking.

CETACEAN Relative Navigation Software: The Starfish Space CETACEAN autonomous onboard relative navigation software determines the relative state between Otter Pup and Orbiter OTV using a combination of onboard sensors. CETACEAN provides position, velocity, attitude, and rotation rate information by integrating and combining several, new, and Commercial-Off-The-Shelf (COTS) spacecraft components. The Argus camera will integrate with CETACEAN to conduct stereo vision image processing for relative navigation.

CEPHALOPOD Guidance and Control Software: Starfish Space's CEPHALOPOD autonomous onboard guidance and control software uses novel astrodynamics that incorporate low thrust in order to make rendezvous and docking possible using exclusively electric propulsion. CEPHALOPOD processes relative navigation inputs from CETACEAN to generate optimized trajectories during proximity operations.