Research Project Resume

The project of a tethered vehicle can lead to a new technological solution for generating propulsion in space that is low cost, safe and free of pollution: characteristics that are becoming a necessary condition for the future viability of our Earth and Space. The necessity of an alternative to chemical propulsive systems for low-orbit satellites has become increasingly evident and a Tether System is able to provide adequate thrust or drag without the complications of combustions and with a minimal impact on the environment. In this way the purity of the external environment for science payloads will be enhanced, and beneficial operational impacts of reduced propellant exhaust on external systems and optics will be realized. An additional benefit outfitting a satellite with a tether severs the most critical and constraining dependency on Earth: propellant resupply. A tether on the satellite makes the vehicle itself essentially independent of propellant resupply from Earth. With a small investment in the vehicle virtually secured and free from concern over long resupply vehicle launch delays, the mission will be able to focus much more strongly on the program mission rather than on the satellite itself.
Past successful missions demonstrated stable tether deployments and fundamental feasibility of passive propulsion but did not measure tether boosts, nor propose a Tether System capable of re-entering payloads or deorbiting end of life satellites, in order to mitigate the growth of space debris, nor autonomously producing thrusts forces for maintain satellites at their project altitude, making them completely independent and free from Earth propellant resupply.

My research project is centered in demonstrating different configurations of Tether Systems to overcome the limitations of rocket propulsions, enable new classes of missions currently unaffordable or infeasible, and significantly advance the tether technology to an operational level, focusing on establishing a far deeper understanding of critical processes and technologies to be able to improve Tether Systems in the future. With my studies I will demonstrate the capability of the tether technology to provide robust, safe, propellant less propulsion both as de-orbiting and orbit-raising device and fully characterize the performance of an integrated tether propulsion system, for use on-board future satellites with minimum modifications.

The benefits in using Tether Systems are manifold. The value of a Tether System lies in the fact that it is able to develop *green energies* in total autonomy by exploiting physical principles: angular moment preservation, pairing between energy generation and thrust or vice versa between decrease in orbital energy and electrodynamic drag. For example, a) by releasing satellites from the International Space Station with passive systems without propellant and without discharge, the external contamination around the station is greatly reduced; b) equipping satellites with an electrodynamic tether ensures independence from the storage and use of propellant in orbit: in this way the themes of deorbiting, re-entry and reboost and, in general, passive propulsion can be addressed by a technology that is increasingly efficient as the time in orbit increases if compared to chemical systems.

Objectives that we want to achieve involve the Tether System requirement definition: Tether Systems need to be stable, with geometry such as to survive hypervelocity impacts with small debris (e.g., the choice of size and section of the tether, tape or cylindrical), able to follow, through a control system, predetermined reference trajectories for their deployment and able to provide enough forces to de-orbit or boost a satellite.
The main objectives are summarized as follow:

Table 1. Project Work's main objectives.

Tether System	***International Project***	***Objectives***
Momentum Exchange Tether	*Iperdrone.1*	1. Tethered drone deployment analysis, respecting ISS safety requirements. 2. S/W design: developing control laws for the pursuit of the reference trajectory, in order to satisfy the required ΔV for the de-orbiting.
Electrodynamic Tether (Deorbiting device)	*ET. PACK*	Contribution to the mechanical design of the *E.T. PACK* electrodynamic tape deployer (with laboratory activity in CISAS-SPARTAN facility).
Electrodynamic Tether (Reboost device)	*Internet in Space*	1. Development of current control strategies and therefore thrust for navigation and guidance of satellites maintained in their original orbit by Electrodynamic Tether Systems. 2. Developing a mass-efficient system that can generate the desired thrust for applications of great future interest such as LEO satellite constellations.

I hope that my investigation will lead to new green energy technological solutions for moving in space generating passive propulsion with a low cost, safe and free-pollution attitude; characteristics that are becoming necessary conditions for the future viability of our Earth and Space.