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Laser Swarm

Mid Term Review

Design Synthesis Exercise

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Abstract

In February 2010 the ICESat mission ended after 7 years of measuring ice sheet mass balance, cloud and aerosol heights, as well as land topography and vegetation characteristics using a space based Light Detection And Ranging (LiDAR) system. ICESat used only one of the possible approaches for LiDAR, namely the use of a high energy laser and a large receiver telescope. The other approach is using a high frequency, low energy laser and a single photon detector. The advantage of the latter approach is that it has a much lower mass, but it is uncertain if even a single photon per pulse reaches the receiver. One possible solution could be to use a swarm of satellites around the emitter, each equipped with a single photon detector. However, the technical feasibility of this concept has not yet been proven.

The baseline report provides an overview of the initial look into this concept. This document contains the requirements analysis, functional breakdowns, risk assessments and initial design options. A preliminary business assessment is also conducted at this stage. It provides the basis for the trade-off made later in the project to find the most feasible system, which incorporates this concept.

Contents

List of Acronyms

GLAS Geoscience Laser Altimeter System

LiDAR Light Detection And Ranging

RAMS Reliability, Availability, Maintainability and Safety

Chapter 1

Introduction

In February 2010 the ICESat mission ended after 7 years of measuring ice sheet mass balance, cloud and aerosol heights, as well as land topography and vegetation characteristics. To do all this, ICESat had only one instrument on board: a space based LiDAR system (Geoscience Laser Altimeter System (GLAS)), allowing for an unprecedented 3D view of the Earth's surface and atmosphere. The laser lifetimes, however, were severely limited because of manufacturing errors in one of the laser components.

ICESat followed only one of the possible approaches for LiDAR, namely the use of a high energy laser and a large receiver telescope. The other approach is using a high frequency low energy laser and a single photon detector. The advantage of the latter approach is that it has a much lower mass, but it is uncertain if even a single photon per pulse reaches the receiver. One possible solution could be the use of a swarm of satellites around the emitter, each equipped with a single photon detector. However the technical feasibility of this concept has not yet been proven.

This is the baseline report on the technical feasibility of this approach to achieve one or more applications of ICESat. It will mainly go into depth on the requirements, technical risks and define the initial design options. It will be the basis for the technical trade off to be made, which specifically requires the in-depth understanding of the subjects treated in this report.

Chapter **??** describes the functions and requirements of the system as a whole, whereas Chapter **??** shows the multiple budget breakdowns and resource allocation. In Chapter **??** the technical risks are investigated. Chapter **??** illustrates the different design options. Since sustainable engineering is an important factor, Chapter 3 is devoted to this subject. In Chapter **??** the return on investment and operational profit are discussed and finally in Chapter **??** the Reliability, Availability, Maintainability and Safety (RAMS) are studied.

Chapter 2

Preliminary Pruning of the Design Option Tree

Chapter 3

Approach With Respect to Sustainable Development

3.1 Production and Logistics

As a swarm of satellites is envisioned, most of which are likely to be identical, it is possible to produce them in series which is more efficient in terms of resources than one large satellites with a lot of unique components. This also implies that the number of different spare parts could be reduced. Smaller satellites could also use smaller facilities for production and testing.

Transportation can be split up in two parts: transportation to the launch site and the launch from the surface to its final orbit in space. On both occasions the system can again profit from its small size. If chosen to bring the satellite into orbit on different launches, they can piggyback on the rocket but also on the aircraft to the launch site (assuming main payload is built on the same location).

Spreading the swarm, i.e. piggybagging using different launches, has several advantages. First of all the amount of emissions is lower than in case of a dedicated launcher; secondly if the first satellite fails before the launch of the rest of the swarm, the others can be repaired and thus less resources are wasted.

3.2 Operations

Once in orbit, its influence on the Earth is very limited. The only real concern is the debris it leaves behind during launch and deployment, which can be dangerous to other satellites if the debris stays in orbit. However, the deployment mechanisms, which are solely responsible for the debris, are not included in this technical feasibility study. Later studies continuing on this feasibility study should keep an eye on it, since more satellites could mean more deployment mechanisms and hence more debris. One aspect that can be dealt with is the efficient use of resources. The swarm can be designed in such a way that if one of the satellites fails a replacement satellite can be sent, while the other still working satellites can be reused.

3.3 End of Life

Each satellite will be at the end of its life if it cannot perform its function anymore or if its onboard propellant is low. It is important that after the mission is over all satellites are removed from their orbit and burn up in the atmosphere so that they do not pose any danger to other satellites. Final decommissioning of the swarm will be more complex than for a regular satellite, since every individual satellite has to be decommissioned separately.

Bibliography