Implementation of cleanliness and contamination procedures and validations on space missions

Degree programme: Master of Science in Engineering | Specialisation: Medical Engineering
Thesis advisor: Prof. Dr. Cédric Bessire
Industrial partner: Micos Engineering GmbH, Dübendorf

Contamination control in the space sector is of paramount importance for the success of most aerospace programs. During ground-based activities as well as exposure to the space environment, contaminants deposit themselves on all accessible surfaces of space systems and thus may impact vital space system functionalities leading to performance decrease or complete mission failure. The aim of this thesis is to implement contamination control procedures and validations.

Introduction

With no prospect of maintenance, satellites must perform at a level of reliability greater than 99 %. To guarantee these reliability levels and to avoid or mitigate any risk of damage during launch and in-orbit operations, spacecraft systems are governed by stringent requirements in terms of design, material and process selection as well as manufacturing, assembly, integration and testing. Moreover, the materials used on a spacecraft are exposed to harsh environmental conditions including vacuum, ultraviolet and ionized radiation, extreme temperature variations, environment-induced contamination, and others.

Contamination

Surface contamination is of great concern in the aerospace industry, because of its proclivity to cause crucial instrument failure. During ground-based activities as well as exposure to the space environment, contaminants deposit themselves on all accessible surfaces of space systems. With respect to high-profile remote sensing missions, contamination on optical payload surfaces is extremely critical since it may reduce signal sensitivity due to absorption. It can also increase noise due to scattering. The consequences are performance degradation or complete mission loss. Therefore, contamination and cleanliness control is essential for the success of most aerospace programs, requiring product assurance experts. Contaminants can take numerous forms and manifest themselves in a variety of states (solid, gaseous, or liquid). Generally, two main categories such as molecular (MOC) and particulate contamination (PAC) can be distinguished. By definition, particle contamination pertains to visible µm-sized (0.001 to 100 µm) foreign matter including dust, metals, ceramics, glass, hair and fibers. Molecular contamination, either organic or inorganic, conjures to sub-microscopic dimensions (0.1 to 3 nm) such as residues from additives, oils and greases, outgassing (release of volatiles from materials) and airborne pollutants.

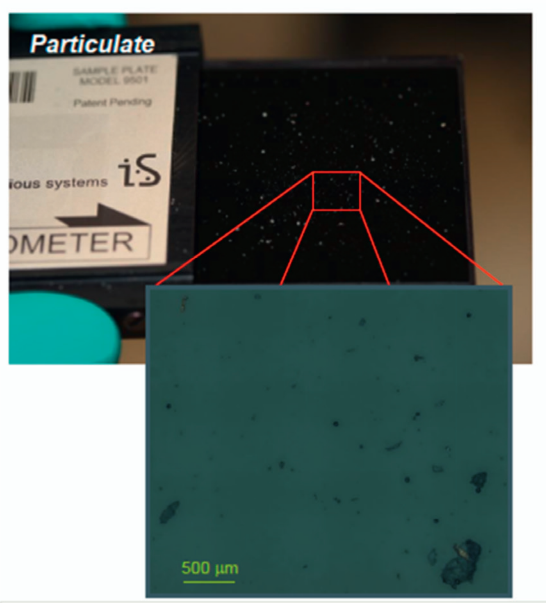

Figure 1: Particulate Contamination

Results

As a means of assuring cleanliness specifications, it is of high importance to prevent or mitigate any risk of contamination along the entire supply chain, including material choices, manufacturing process selections, transportation, storage and cleanroom assembly. Clean processes, monitoring, investigation, cleaning and validation technologies are all part of contamination control used for running space missions by Micos Engineering GmbH. The objective of this thesis covers not only the stringent control of the supply chain but also cleanroom capability monitoring, as well as MOC and PAC accumulation assessments of assembled space parts after various cleaning procedures. These procedures are experimentally validated and compared with project-specific cleanliness and contamination control plans as required by customers and applicable space standards.

Clara Katherine Carolin Vaerst