

SPACE DEBRIS SYMPOSIUM (A6)  
Space Debris Removal Concepts (6)

Author: Mr. Xavier Roser

Thales Alenia Space France, France, xavier.rosier@thalesalieniaspace.com

Ms. Carole Billot

Thales Alenia Space Espana, France, carole.billot@thalesalieniaspace.com

Mr. patrice couzin

Thales Alenia Space France, France, patrice.couzin@thalesalieniaspace.com

CONCEPTS AND TECHNOLOGIES TRADE AND ROAD-MAP FOR AN EFFECTIVE ACTIVE  
DEBRIS REMOVAL OF LAUNCHER STAGES & HEAVY SATELLITE.**Abstract**

The paper reports a wrapped and synthesis of Thales Alenia Space performed works on active debris removal of large debris such as launcher stages and launcher stages, left in the LEO orbit. This synthesis encompasses, ESA, CNES and in-house funded system and technologies studies, which have been performed since 2010. The paper addresses: technologies aspects, removal concepts and compare the different options taking into account cost and financing schemes. The system concepts encompasses: - Removal strategy: raising the orbits toward high LEO graveyard orbits, performing direct-re-entry or bringing the debris on a rapid decay orbit significantly below 25 years. - Capture strategy: flexible links (harpoon, anchoring, nets), semi-rigid (robotic arms, docking type system, tentacles) and related capabilities in term of debris configuration, tumbling. - Chaser vehicle concept encompassing: 1 debris dedicated vehicle developed in large serie to reduce its cost and launch in grape on medium size launcher, Multi-debris dedicated vehicle transferring the debris or transferring de-orbiting kits to the debris. - Type of propulsion used or combined: chemical, electrical, powder. The technologies analyses encompasses: the control aspects (Rendez-Vous, dynamics aspects with capture mechanisms, composite dynamics), the capture system mechanisms. The type of targets is also addressed showing the dependability of the solution to different targets: large satellites with wide flexible appendages requires more complex solution than stages. For instance, stages with inertia properties compatible with a spin stabilisation can be de-orbited by a rigid mounting kit; an unstable configuration requires more complex solution. The different concepts are analysed in terms of technology readiness and needed development, risks and cost per debris assuming different de-orbiting strategy but also effectiveness in terms of collision risk mitigation of the type of debris de-orbited. From these analyses a road-map for ADR is drawn addressing, removal strategy, technology and vehicle development aspects and also raising the legal and international issues related to an efficient debris removal strategy.