ReDSHIFT: Revolutionary Design of Spacecraft through Holistic Integration of Future Technologies

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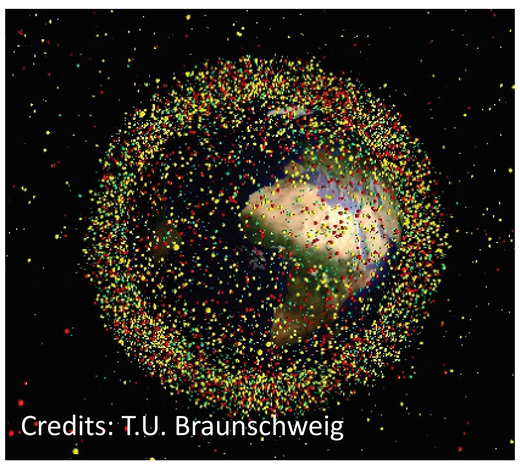
ReDSHIFT will address barriers to compliance for spacecraft manufacturers and operators represented by requirements and technologies for de-orbiting and disposal of space objects. This will be achieved through a holistic approach that takes into account opposing and challenging constraints for the safety of the human population, when debris objects re-enter the atmosphere, designed for demise, and for their survivability in the harsh space environment, while on orbit.
ReDSHIFT will take advantage of disruptive opportunities offered by 3D printing to develop highly innovative, low-cost spacecraft solutions, exploiting synergies with electric propulsion, atmospheric and solar radiation pressure drag, and astrodynamical highways, to meet de-orbit and disposal needs, but which are also designed for demise.
RedShift will design structures to enhance spacecraft protection, by fracture along intended breakup planes, and re-entry demise characteristics. These structures will be subjected to functional tests as well as specific hypervelocity impact tests and material demise wind tunnel tests to demonstrate the capabilities of the 3D printed structures. At the same time, novel and complex technical, economic and legal issues of adapting the technologies to different vehicles, and implementing them widely across low Earth orbit will be tackled through the development of a hierarchical, web-based tool aimed at a variety of space actors. This will provide a complete debris mitigation analysis of a mission, using existing debris evolution models and lessons learned from theoretical and experimental work. It will output safe, scalable and cost-effective satellite and mission designs in response to operational constraints. Through its activities, ReDSHIFT will recommend new space debris mitigation guidelines taking into account novel spacecraft designs, materials, manufacturing and mission solutions.

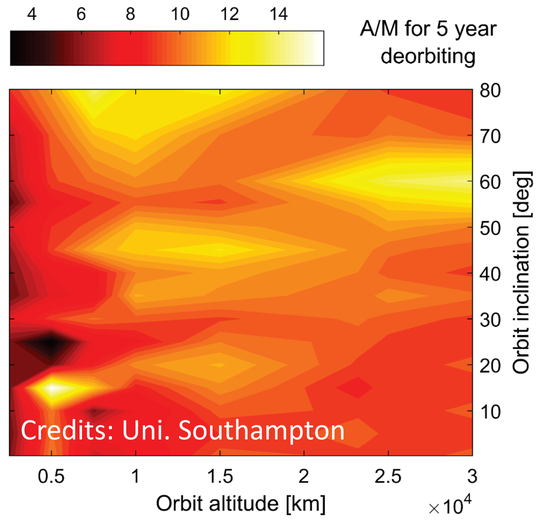
Critical analysis of environment, mitigation, guidelines


Credits: T.U. Braunschweig

We will critically analyse and revise the currently adopted and envisaged mitigation practices. The existing mitigation technologies, their applicability and actual application will be addressed. Long term debris simulation study will highlight the benefits and effectiveness of the current mitigation measures and serve as basis for improved mitigation scenarios. The international mitigation guidelines will be analysed from a legal/political point of view, identifying weaknesses that prevent their full applicability. ReDSHIFT will study means of improving the applicability of rules and codes of conducts and draft proposals for new, improved guidelines.

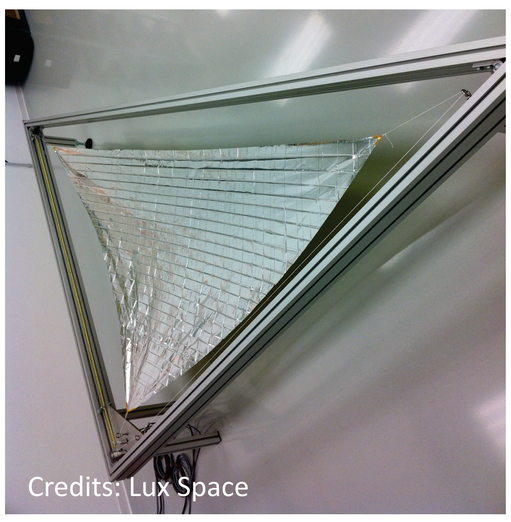
Dynamics of the circumterrestrial space from LEO to GEO

ReDSHIFT will characterise the dynamical structure of the whole circumterrestrial space from LEO to GEO using the tools of dynamical systems, celestial mechanics and astrodynamics. Stable and unstable regions in the phase space will be identified to trace the “de-orbiting highways” to reduce the residual lifetime of the objects in any orbital region. The most promising End-Of-Life de-orbiting technologies will be selected and the study of the complex dynamics of the composite spacecraft-device (attitude plus orbital motion) will be performed to optimise the performances of the de-orbiting device and the required manoeuvres.



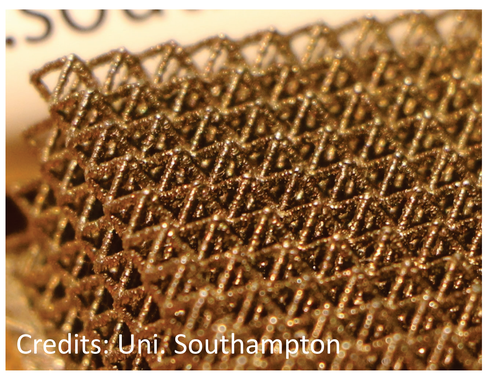
Design for demise and re-entry

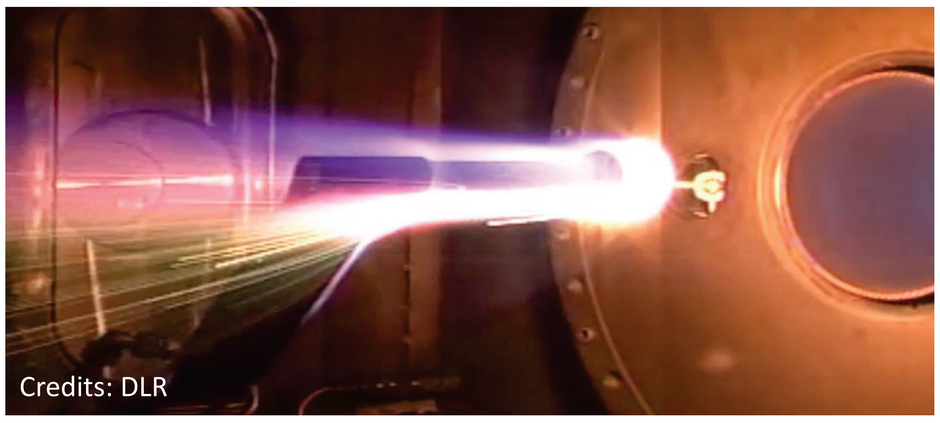
We will define the technology requirements and perform the preliminary and detailed system design of technologies for end-of-life disposal and spacecraft demise. The design will be optimised based on the choice of production technique by 3D printing (e.g., material, structure, etc.). It will comprehend: structural elements with predisposed load paths and strategic fault lines for controlled breakup, meteoroid and space debris protection systems, hinges with predetermined failure threshold for connecting structures to subsystems/components and deployment mechanism, demisable tanks, embedded sensors for satellite health monitoring, solar/drag sail module for end-of-life disposal for enhanced disposal.


Credits: Lux Space

Technology development: detailed design and 3D printing

ReDSHIFT will test the materials selected and the technologies designed against demise and protection criteria. First of all technical plans for the execution of the test will be decided. The test campaign will be initiated with tests that will reproduce re-entry conditions, radiation conditions and hypervelocity impact tests. From the results of these tests the developed technologies will be integrated into the design of one or several spacecraft. The final spacecraft will be manufactured and produced. The functionalities of the whole systems will be tested through environment (thermal, acoustic and mechanical) test campaign.


Credits: Uni. Southampton


Credits: DLR

Software tool and dissemination

One of the main products of the ReDSHIFT project will be a comprehensive software tool that shall implement the holistic vision of the project. A web-based version of the project will be also produced and made available to the public, to allow spacecraft operators to exploit the technical findings of the project to design a space mission according to the mitigation solutions found in ReDSHIFT. In the dissemination of the project results to the scientific community and the general public, particular care will be devoted to the dissemination of the new proposed mitigation procedures and measures in the appropriate high level technical, legal and political forums, exploiting the unique composition of the consortium partners.

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