Small space debris are a high risk for the walls of Composite Overwrapped Pressure Vessels (COPV), by making small holes and causing the fuel leak. Commonly the self-healing materials are used to keep the mechanical structure strength, here the hermicity of the repaired portion is a stringent requirement, to prevent any potential fuel leak from the cryogenic tank in vacuum. The efficiency of self-healing of COPV is compared for protective walls composed of a combination of various layers, using strong materials such as Kevlar and Nextel; and self-healing commercial materials developed as bullet proof, e.g. the Ethylene-co-Meth Acrylic Acid (EMAA) and Reverlink™.

The small debris impact dynamic was detected and monitored with Fiber Bragg Gratings (FBG) sensors at very fast acquisition frequency up to 0.5 GHz (2 ns), measuring the variation of the total reflected signal by the FBG. The acquisition system is not expensive, based on commercially available products. To measure the total wavelength spectrum, the fastest available spectrometer can go up to 2 MHz acquisition (Micron-Optics), insufficient to detect the hypervelocity impact. The impact pressure evolution of the FBG, placed in middle layer, was compared with commonly used strain gauges placed a few layers further or on the back of the last layer. The measured impact time delay and relative intensity were compatible between the two sensing methods. Two types of FBGs were used; i) a thin central wavelength FBG with 0.5 nm spectral width and 1 cm length similar to those used as Wave Division Multiplexing (WDM) in telecom, this is generally used a sensor with the pressure impact proportional to the wavelength shift; ii) a chirped FBG covering about 40 nm reflectance range with length about 2.5 - 4 cm length; the position on the grating and the local wavelength are linearly related. A measurement of the complete spectrum of the FBG sensor before and after the impact gives important information in synergy with the fast signal measurements.

The performed FBG sensing method is an innovative approach, it provides many measured parameters. The hypervelocity impact dynamic is monitored with the change of the FBG reflected intensity, in time and value. The intensity after the impact is linearly proportional to the physical part left of the FBG. Since the FBG work by reflection, the spectrum of the two broken parts of the FBGs are measured after the impact and the localisation and amount of the destroyed part is deduced by comparison with the original spectrum. Moreover, the slow change of the residual strain and self-healing as well as their localization, are obtained by comparing the detailed reflectance spectra of the sensors, before the test, a few minutes after the test, one day after the test and a few weeks later, for slow evolution.

Some samples were characterized in details using the X-ray Computed Tomography at ESTEC, they permitted to confirm the results by observing the details of the healing and follow visually the impact trajectory.