1. INTRODUCTION
The challenge in the design of pressurized stratospheric balloons lies in increasing their capability to carry scientific load to high altitudes. The use of load-bearing tendons makes an improvement in this fashion. This new design, like a pumpkin balloon, creates additional stresses in the polyethylene envelope which can lead to its failure. Therefore, it is essential to better understand the mechanical behaviour of the polyethylene film under biaxial stress in order to provide a critical criterion.

The current approach is to maintain stresses barely above the elastic limit [1]. However, this has been shown to be very conservative and that plastic flow could be allowed to some extent [2]. Here, a new approach is employed by characterizing the deformation micromechanisms during biaxial deformation. This means determining a critical criterion based on microstructural parameters, independently of stresses and strains in the film.

2. METHODS
The material studied is a 60µm-thick linear low-density polyethylene (LLDPE) film. It is deformed under equibiaxial stress with a bulge test device. The setup can produce constant pressure and cyclic loading conditions in order to mimic the actual mechanical loads.

Raman spectroscopy has been chosen to follow in situ the evolution of the polymer microstructure at the molecular scale. This technique is particularly well-suited to time-resolved characterization [4,5] and has been employed during biaxial deformation of the film. The Raman spectrometer is using a laser with a wavelength of 785 nm and has a spectral resolution of 1 cm⁻¹.

3. RESULTS
From a deformation micromechanisms point of view, the limiting process is the fragmentation of the crystalline lamellae. This mechanism gives significant mobility to the macromolecular chains and thus fosters much localized deformation. It is a consequence of fine crystal slips that trigger the onset of yield flow. Raman bands are associated to a specific vibrational mode assigned to a characteristic chemical bond. Changes in a Raman band (position, width, intensity) are linked to changes in the environment of the corresponding bond. The band at 1418 cm⁻¹ is associated to the bending vibration of the CH₂ group in the crystalline phase and therefore is sensitive to the intermolecular interactions in the lamellae [3].

A shift in this band position has been measured and is correlated with the fragmentation mechanism. As a consequence, a critical criterion can be defined with this band position. Changes in other bands’ width and position are also monitored. These parameters will be discussed in respect to the deformation mechanisms.

CONCLUSION
A new approach using coupling techniques has been developed to define a critical criterion under biaxial stress for the pressurized balloons envelopes. Raman spectroscopy may be a suitable tool to characterize in situ deformation mechanisms and predict the occurrence of a fragmentation mechanism of the lamellae. Therefore, it is a way to limit the stress domain of the polymer envelope.

REFERENCES
5. M. Ponçot et al, “Complementarities of high energy WAXS and Raman spectroscopy measurements to study the crystalline phase orientation in polypropylene blends during tensile test”, Polymer, 80, pp27, 2015