The presence of a crack on a pressurized cylindrical shell structure leads to "complex stress and displacements fields resulting in nonlinear out-of-plane deformations" [1]. In other words, the single curved geometry and pressure differential causes a longitudinal crack to *bulge-out* or *protrude* from the original contour. This change in geometry of "bulging effect" significantly increases the stress-intensity factor (SIF) at the crack tips. The effects of this loading condition on composite laminae can trigger several types of failure mechanisms.

> *"One measure of the bulging effect is the* ***bulging factor****, which is the ratio of the SIF at the tip of a longitudinal crack in the fuselage to the SIF for the same crack in a flat panel. The damage tolerance design philosophy requires realistic stress state determination in the vicinity of cracks in airframe fuselages."*[1]

Bulging factor emerges as a result of the out-of plane deformations of the surface of a crack on a pressurized fuselage structure. The representation of this phenomenon becomes rather complex due to the biaxial and internal pressure load and structural configuration [1] (Figure 1).

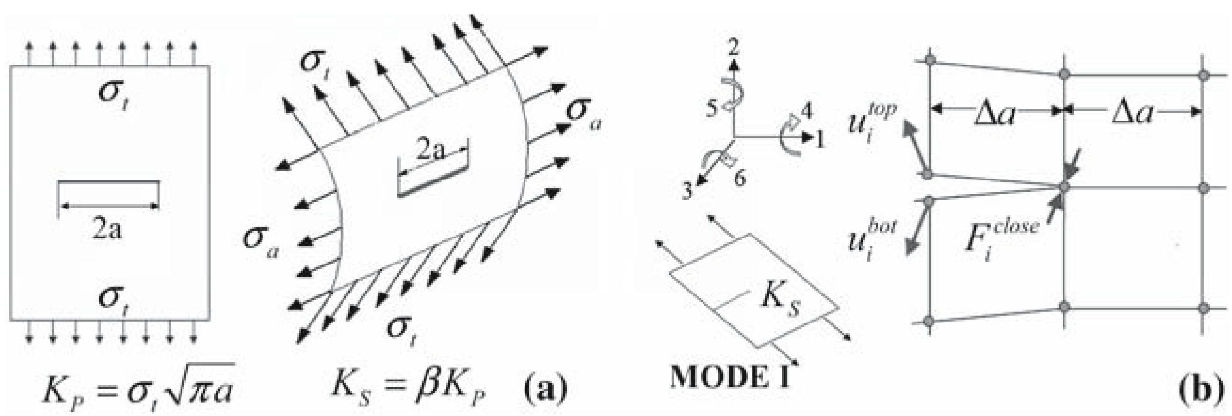

Figure 1 – (a) Comparison between a crack in plane stress condition and a crack on a curved shell; (b) mesh at the crack-tip for the Modified Crack Closure Integral (MCCI) technique; geometric parameters of the shell [3]

For the case of unstiffened shell structures, the bulging factor can be defined as the ratio of stress-intensity (SIF) of a curved shell to the stress-intensity factor of a flat panel:

$$\beta = \frac{K_{curved}}{K_{flat}}$$

References:

[1] Unites States of America. Federal Aviation Administration. Bulging Factor Solutions for Cracks in Longitudinal Lap Joints of Pressurized Aircraft Fuselages. Springfield, 2004. pp.1-3,10

[2] Lazghab Tarek, Fayza Ayari, Lotfy Chelbi. Crack growth in cylindrical aluminum shells with inner reinforcing foam layer. Springer, 2006. pp. 151.

[3] Bu, Jianxin “Three Dimensional erosion Geometric Effects on The Stress Intensity Factors of an Inner Crack Emanating from an Erosion in an Autofrettaged Pressurized Thick-Walled Cylinders”. Florida International University 1997. pp.12.