Development and validation of a confined RP modelfor HRAM event simulations in fuel tanks

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Abstract: *In the event of impacts of high speed/high energy projectiles in liquid filled tanks, the container may suffer large hydrodynamic loads that could possibly rupture the entire structure. This impact scenario is referred as Hydrodynamic Ram (HRAM) in the literature. To design an aircraft fuel tank that resists such HRAM events is a particularly difficult task due to structural optimisation constraints that already exist in aeronautics (weight, range, etc). HRAM events are generally characterized by four stages: the shock stage, the drag stage, the cavity growth and collapse stages. The ballistic projectile first penetrates the container and creates a shock wave that propagates in the liquid. Then a cavity bubble is created in the wake of the projectile. The growth and collapse of this bubble induce large hydrodynamics loads on the container structure that are hardly measurable during complex and expensive experiments.*

A solution would be to use full-3D on linear numerical simulations (projectile, fluid and container) to determine the loads and/or subsequent structural damage. However such numerical simulations of the container response and failure under HRAM conditions still prove to be very challenging. Another option relies on the use of analytical models in order to estimate the hydrodynamic loads occurring during HRAM events. The present work describes such an alternative method which is here used to determine the "key parameters" that are necessary to perform physically justified full-3D numerical simulations. Hence, recent experimental results where the evolution of the bubble created in the wake of a tumbling projectile was observed (which seems to be

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comparable to the ones observed in other fields, e.g. underwater explosion) led to propose to use Rayleigh-Plesset like equations to determine the influence of different physical phenomena (cavitation, compressibility, etc) on ballistic bubbles dynamics (and subsequent hydrodynamic loads).