RECENT ADVANCES IN ADJOINT-BASED DESIGN OF SHOCK MITIGATION DEVICES

Shane Torbert[1], **Rainald Löhner**[1] **and Fernando Camelli**[1]

[1]George Mason University, Fairfax, VA, USA

Key Words: Design, Shock Mitigation, Blast Damage, CFD, Adjoints

Assuming that the amount and the location of the explosive, the location of critical damage areas (windows, facilities) and the design constraints for protective structures are given, one can recast the design of the shock mitigation device as an optimal shape design problem. Of all the possible optimization techniques, those based on the solution of the adjoint equations have the least computational cost. Over the last 3 years we have developed techniques that combine unsteady Euler and adjoint Euler solvers in order to obtain, with just one run, the sensitivity (design objective gradients) on all surfaces. This has led to considerable insight into the effectiveness not only of surface changes but also the addition of porous media as blast mitigators.

This paper reports on recent advances in these techniques. The most important of these center on storage requirements. Adjoint solvers (which integrate from the end of simulation time to the beginning, i.e. backwards in time) require the solution of the (forward) flow field in time. This implies having to store vast quantities of data to disk. By using checkpointing and data compression techniques, one can reduce these requirements by two orders of magnitude without increasing CPU costs appreciably. This has led to the possibility of computing cases that were hitherto prohibitive in memory and diskspace. Figure 1 shows a typical example (design of a vestibule). This case grid contains $O\left(2.1 \times 10^6\right)$ elements. The forward run was integrated for $O(6500)$ timesteps. Guided by the adjoint, the geometry was modified, leading to a reduction of the peak pressure on the building door of more than an order of magnitude.

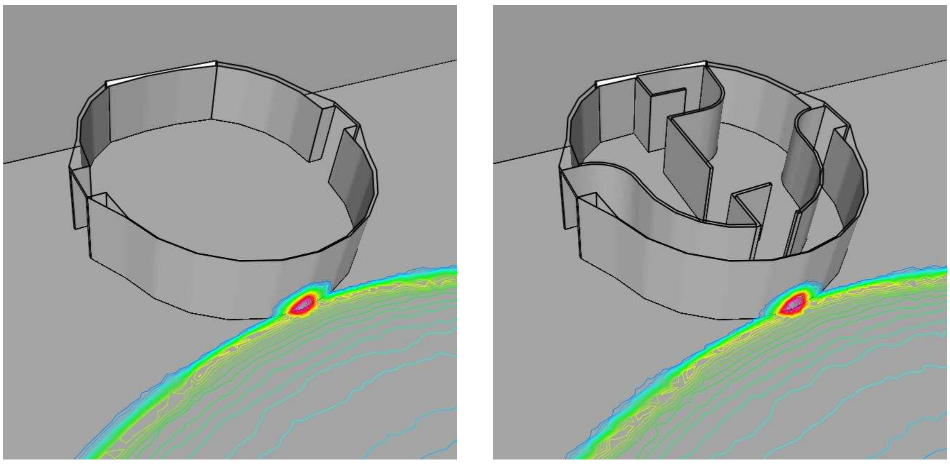

Figure 1 Vestibule Problem: Initial and Final Configuration