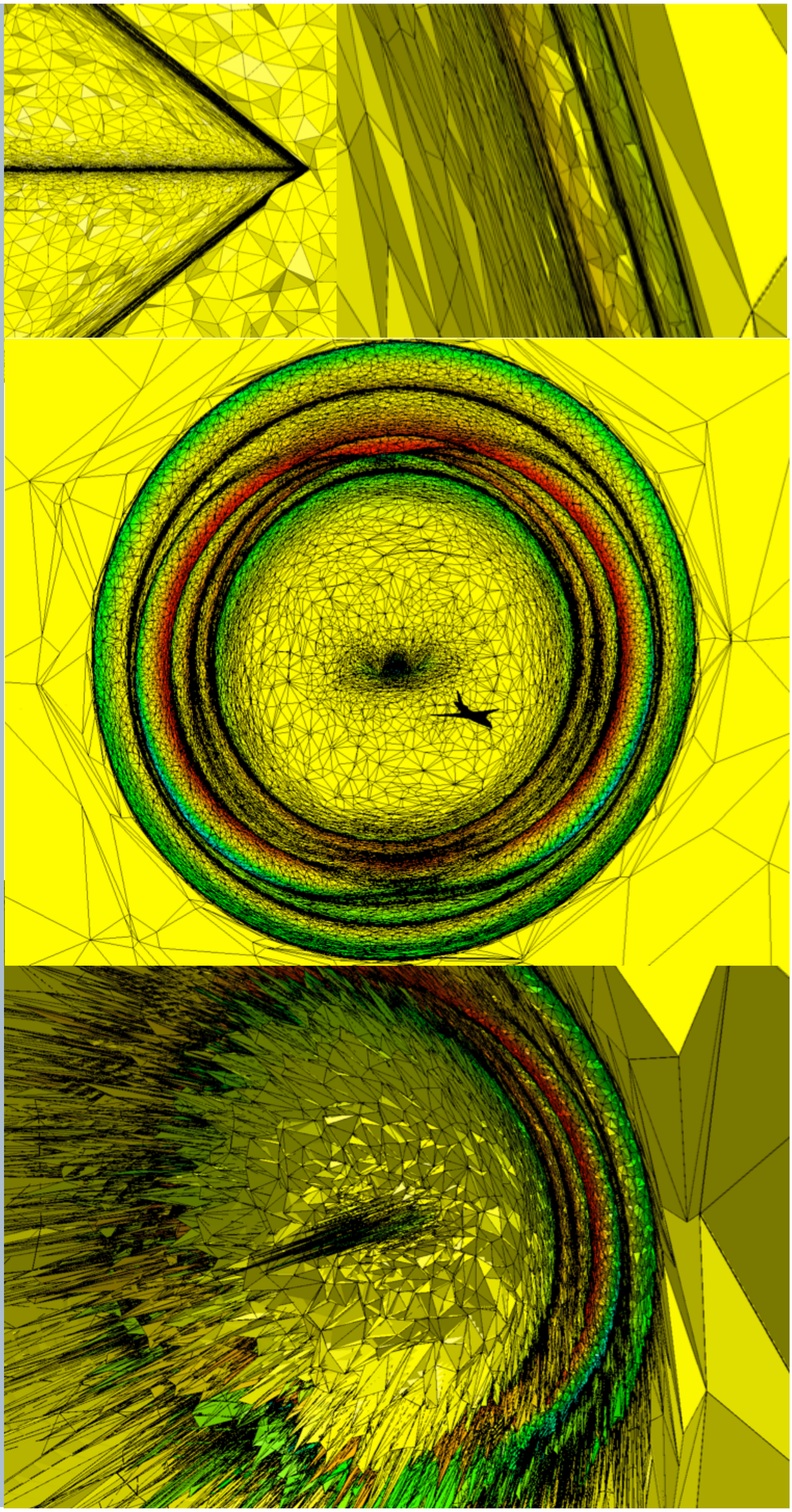
ANAMESH® software
Intelligent mesh

STICKING TO THE PHYSICS

The intelligent mesh is a powerful tool to reduce the cost of numerical simulations while preserving a desired level of accuracy.
The main idea is that, at fixed number of vertices, all meshes are not equivalent in terms of numerical efficiency. Indeed, some meshes will lead to smaller numerical errors than others.

Contrary to most of the currently available adaptation technologies, our mesh adaptation process is not based on a simple refinement/coarsening strategy depending on a purely local error estimation. Our strategy controls local as well as global numerical errors. Moreover, it does not only adapt the mesh in terms of number of vertices but also in terms of elements shape and orientation.

This method leads to meshes which can exhibit very stretched elements, generally in accordance with the physical phenomena at stake.

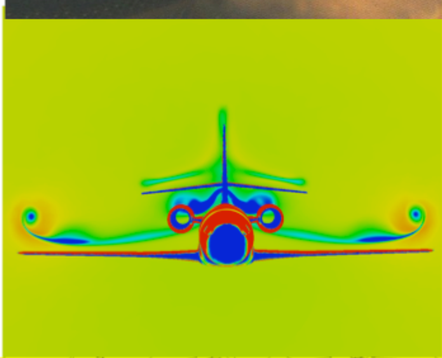


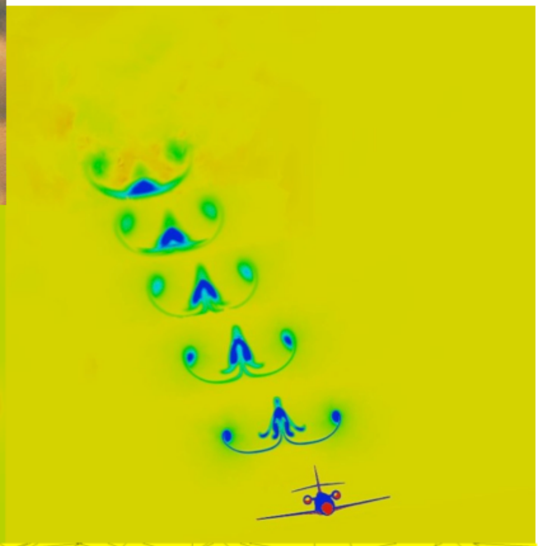
APPLICATION TO COMPRESSIBLE FLOWS

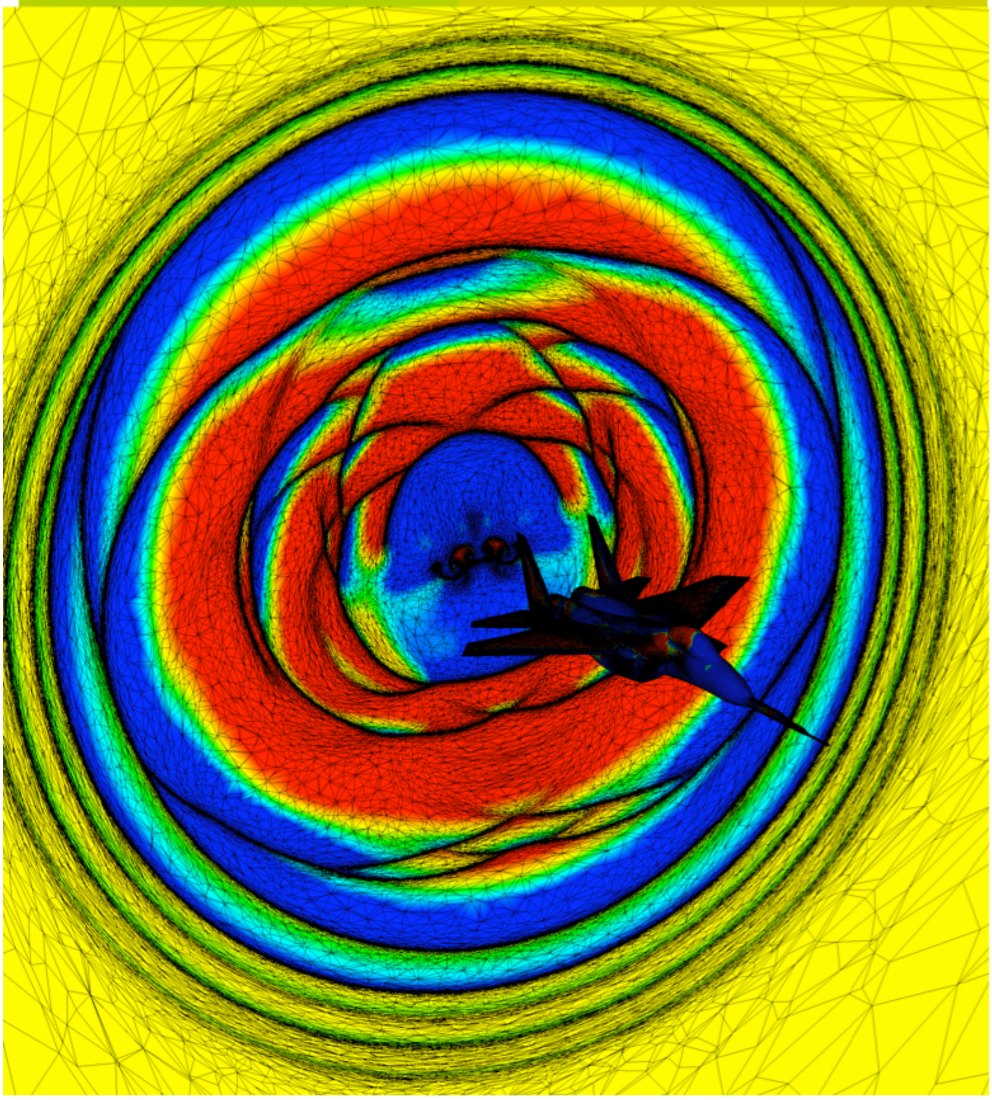
The intelligent mesh adaptation technology used in ANANAS automatically selects the optimal mesh minimizing the global numerical error for a prescribed number of mesh vertices or equivalently, will automatically select the mesh with the minimal number of vertices for a prescribed level of accuracy. Locally, elements size and orientation are adjusted to equally distribute numerical errors in all directions. Globally, an optimal distribution of vertices on the computational domain is guaranteed.

In the case of Euler compressible flows exhibiting shock waves, the adaptation process will generate tetrahedra which are very stretched in the direction parallel to shock waves, a direction in which the local error is relatively small and for which the discretization can be coarser. On the contrary, the process prescribes very small sizes for edges oriented in the direction perpendicular to shock waves, because local errors are expected to be bigger in this direction and hence a smaller mesh size is

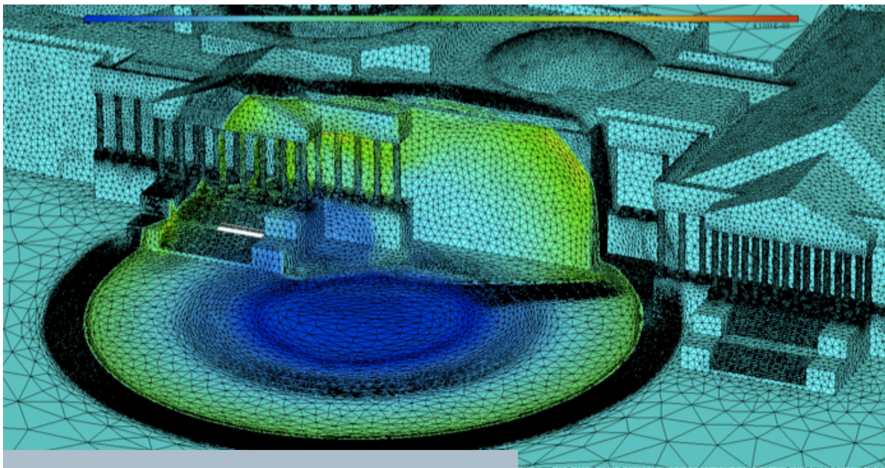
Wingtip vortices captured by mesh adaptation behind a Falcon aircraft

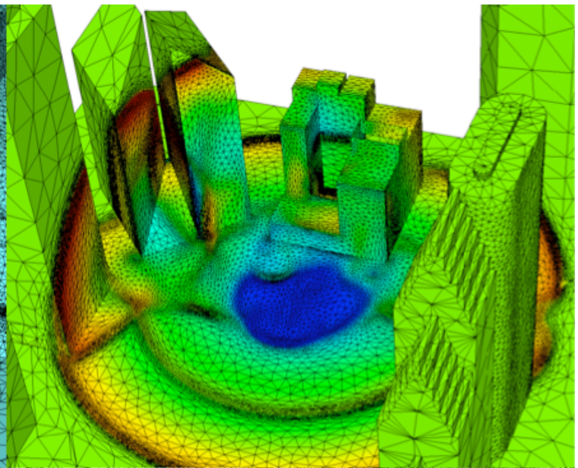






Highly-anisotropic intelligent mesh adaptation behind a F15 flying at supersonic speed. The plane is equipped with a GulfStream spike nose. Mesh elements are stretched along Mach cones behind the aircraft.

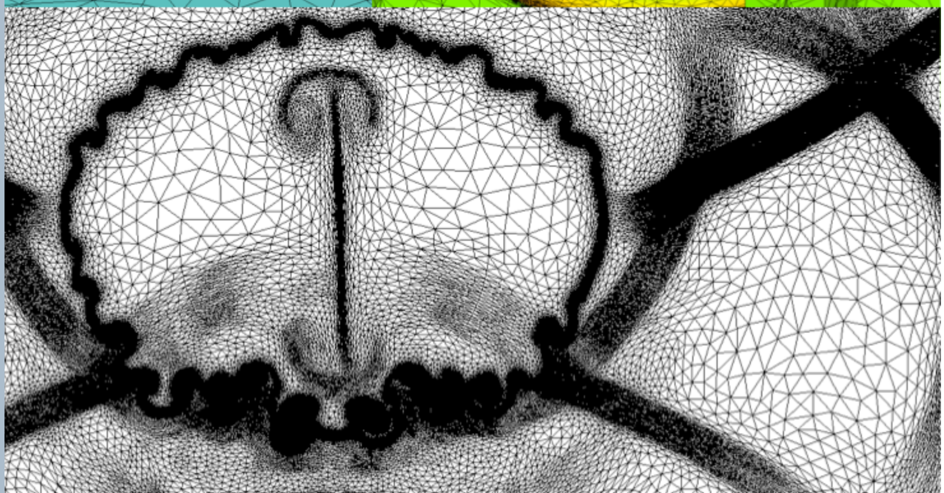




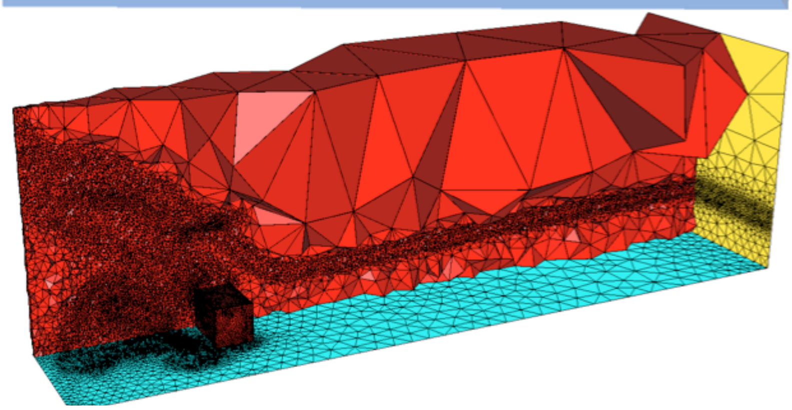
UNSTEADY SIMULATIONS

Extension of intelligent mesh to unsteady simulations is not straightforward and must be undertaken with care to maintain an acceptable computational efficiency.

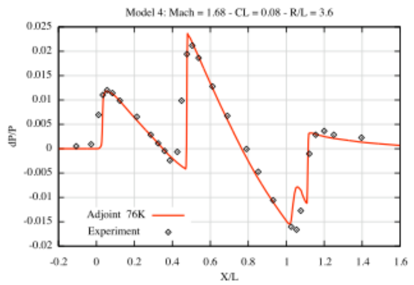
In this context, the adapted mesh is expected to follow time-evolving phenomena but adapting the mesh at each solver iteration cannot be considered for efficiency reasons. The transient fixed-point algorithm answers this issue by cutting the simulation time frame into N sub-intervals and generating N meshes. Each mesh controls the space-time numerical errors while the solution evolves in the associated time sub-interval. This leads to N striped-shape anisotropically adapted meshes guaranteeing the control of space-time errors during the whole simulation.



Unsteady intelligent mesh is specially suited for blast simulations: explosion in front of the Capitol, inside a city, Leveque «mushroom» shaped blast involving instabilities...



Dam-break simulation. A level-set function is used to represent the interface between water and air. The mesh is adapted on this function to accurately capture the interface and all its topological details.



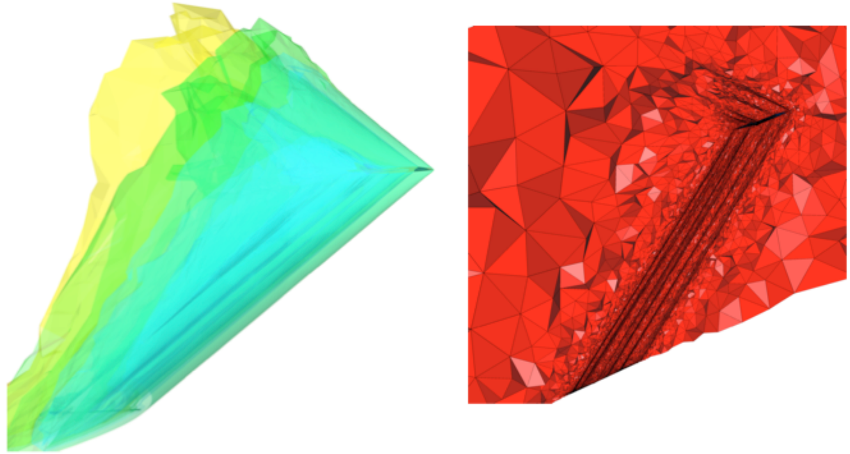
GOAL-ORIENTED INTELLIGENT MESH

Goal-oriented intelligent mesh adaptation has been designed to control numerical errors with respect to a given quantity of interest, rather than controlling the whole global error.

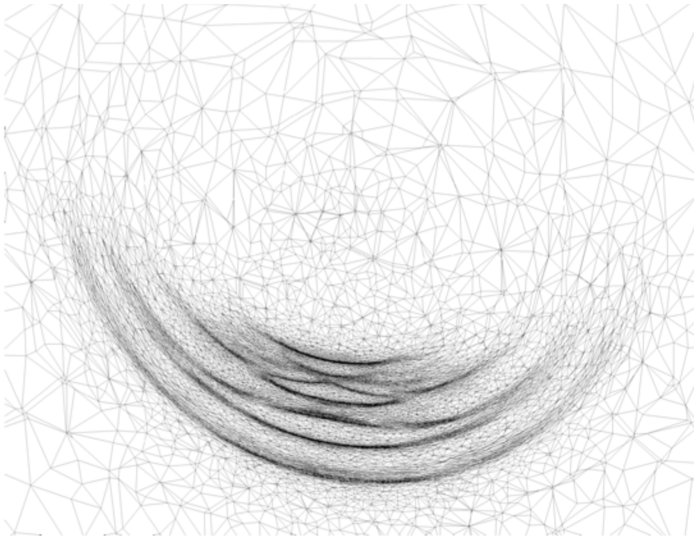
For instance, environmental regulations forbid supersonic aircrafts to fly above mainland because of the sonic-boom annoyance at ground level. Trying to reduce the pressure variation at ground level requires a very accurate computation of the sonic boom pressure variations several kilometers below the aircraft. Besides, the quality of the solution above the airplane does not matter.

Specific error estimations based on the adjoint theory enables to answer this demand. This process generates meshes which are adapted only in areas having an influence on the computational accuracy of the prescribed quantity of interest.

Goal-oriented intelligent mesh thus constitutes a major advance for simulations.



Goal-oriented mesh adaptation applied to the sonic-boom signature capture at ground level. Mesh adaptation effort is concentrated on shock waves propagating below the aircraft, because they are the only ones impacting the target functional, i.e the sonic-boom signature at ground.



Goal-oriented mesh adaptation applied to the capture of wake vortices behind a Falcon. Vortices are accurately captured several hundred kilometers behind the aircraft. Despite the weak intensity of vortices phenomena as compared to shock waves, the adaptation concentrates on the accurate computation of wake vortices.