The velocity of the incoming air in the combustion chamber of the scramjet engine is very high ($M > 1$), and the residence time of the combustible gas in the chamber is on the order of milliseconds. In such a short period of time, the mixing and chemical reaction are completed, and therefore, it is very important to be stable with the flame. In addition, shock waves are generated in the supersonic flow field, and there are complex interactions such as shock/flame, shock/boundary layer, shock/turbulence in the combustion chamber. In summary, there are complex problems in self-ignition, partial flameout, re-ignition, shock and turbulent combustion in scramjet engines.

Supersonic non-equilibrium chemical reaction flow has been showing great complexity in numerical simulations due to the complicate physics-chemistry interactive phenomena. Especially, the space-time multi-scale essentiality causes significant numerical difficulty, for instance, rigidity or stiffness of the Ordinary Differential Equation (ODE). A modified uncoupled method, which follows the idea of Strang splitting and has proved to be simple and efficient for solving the reactive flow system, is applied with using unstructured finite volume discretization and detailed reaction mechanisms. In order to further improve the efficiency of the uncoupled method, a chemical reaction detection criterion is designed to adaptively turn off chemical reaction computation. Numerical tests have shown significant efficiency improvement and satisfactory accuracy of the presented method.