Development of Numerical Simulation Method for Safety Evaluation of Launch Abort during Ascent Phase

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A Launch abort system (LAS) is installed to almost all manned space rocket (Fig.1), and its safety evaluation is quite important since safe return of astronauts is the primary function of LAS. However, it has been one of the most difficult questions how to evaluate and guarantee safe abort from catastrophic failure. NASA have been conducted a lot of researches on abort system safety using Simulation-Assisted Risk Assessment (SARA)[1] and applying the methodology to CEV development. Numerical simulation is one of the most powerful and key tools in SARA, therefore, its accuracy takes an important role for safety evaluation.

Fig.1 Launch Abort System of Apollo Spacecraft displayed at NASA Johnson Space Center

JAXA has started research on manned launch vehicle and launch abort system, and it is considered that simulation based safety assessment is one of the key technologies for LAS safety evaluation. SARA is one of the answer, however, further improvement is required and JAXA has started research on safety evaluation method for manned launch system. As the first step, launch abort during ascent phase was considered. During ascent phase, aerodynamic performance takes an important role, therefore, in order to evaluate aerodynamic characteristics precisely, Computational Fluid Dynamics (CFD) is applied since CFD can handle various phenomena if appropriate physical model is applied. This means that one of the important points is an appropriate physical modeling and its development, therefore, feasibility studies and validations cannot be avoided. Presently, the following two points will be reported.

1. Aerodynamic characteristic evaluation including control law.
   Both aerodynamic characteristic and control low are quite important for safe flight of LAS. As the present study, feasibility study has been carried out on CFD analysis with control low. In order to properly simulate actual controlled flight, 6 degrees of freedom (6DOF) simulation

was combined with control low (Fig.2). This methodology can be applied to various kind of failure evaluation, such as avionics and LAS propulsion system failures.

2. Rocket explosion modeling and its application to Loss of Clew (LOC) probability evaluation.
   It is considered that explosion hazard is the most dangerous hazard mode. Presently, numerical modeling of explosion was validated by comparing past explosion analysis results[2] and apply this methodology to rocket explosion simulation (Fig.3). Firstly, overall tendency on explosion hazard was evaluated on on-pad and transonic-flight condition. As the second step, LOC probability was evaluated under various conditions. 6DOF analysis was also applied to the simulations.

These two simulation techniques serve precise evaluation of LAS abort safety, however, it is clear that further investigations are required not only these two studies but also other simulation techniques such as parachute and splash down simulations. Development of these simulation methodologies will be started near future.

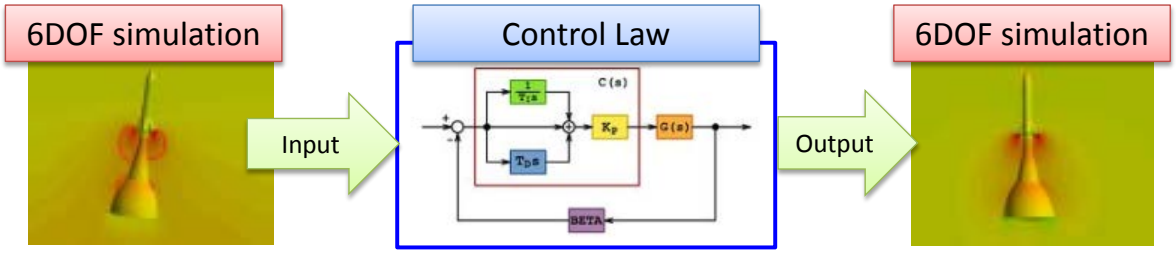

Fig.2 Schematic figure of aerodynamic simulation with control law

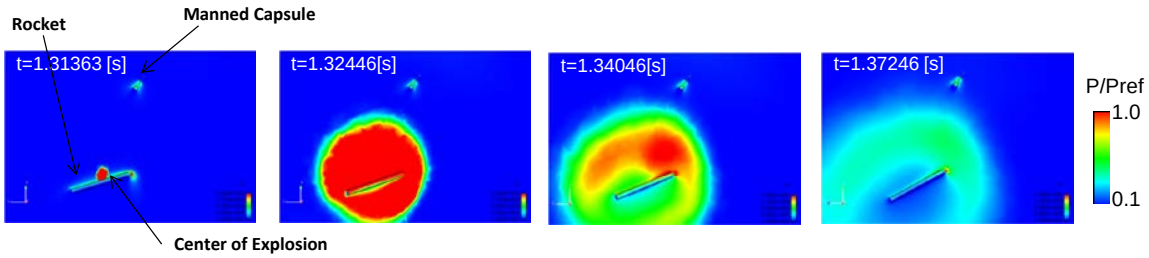

Fig.3 Manned capsule abort simulation from rocket explosion

References

[1] Lawrence, S., et al., "Simulation-Assisted Risk Assessment," 44th AIAA Aerospace Sciences Mtg., AIAA Paper 2006-0090, Reno, NV, 2006.

[2] Larcher, M., "Simulation of the Effects of an Air Blast Wave," JRC Technical Notes, PUBSY JRC41337 – 2007, 2007.