DEVELOPMENT OF ADAPTIVE AIRBAGS FOR EMERGENCY LANDING OF SMALL UAV

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1. Introduction

Currently, drones are used in a variety of applications and they are often equipped with expensive, specialized devices including e.g. high-resolution cameras, radars and LIDARs. Failures of avionic system, its sensors or engines as well as damages of other components of the UAV occur, what is the motivation for development of emergency landing system. In the case of possible crash with the ground, in addition to reducing drone destruction the emergency system should limit damages of objects on the ground or injuries of people around. One of the possible solutions is the use of parachute rescue systems. Unfortunately, such systems require relatively long time for deployment and increase of drag force which decelerates the falling UAV. As a result, the minimal altitude ensuring successful protection of drone after its failure reaches at least 10-15 m. In order to provide reliable solution, which will be efficient in case of low altitude failures, we propose the adaptive airbag system, further called Ad-Bag.

2. System development

The design of Ad-Bag system is a compromise between performance of the adaptive airbag, reliability of entire emergency system and costs of its production. In consequence, both adaptive as well as adaptable solutions are considered. The example of adaptive option can be real-time control of internal pressure with the use of precise gas release. Similarly, the application of optimal gas control for impact absorption was previously considered in reference to general concept of adaptive inflatable structures [1]. The main challenge in practical implementation of such solution is very short time of the impact absorption process and the corresponding requirement for very fast sensing and actuation. The adaptable alternative can be realized by activation of the proper release vents selected from the set of vents prepared for different crash scenarios. Selection of proper release vents should be based on actually predicted impact conditions. Similar technique was successfully implemented in the pneumatic shock-absorber designed for airdrop system [2].
In order to obtain high reliability, the Ad-Bag system is independent of main avionic system of drone and it includes two main subsystems:

- the electronic control system which is equipped with dedicated microprocessor system and a number of sensors used for detection of drone failure, prediction of impact condition and detection of the airbag contact with the ground,
- the mechanical executive system composed of airbag inflation subsystem and release vents activation system, which is responsible for proper adaptation of the system to actual impact conditions.

As a part of the project devoted to elaboration of the Ad-Bag system we have developed a dedicated airbag design method which includes application of simplified analytical models for optimization purposes, fully nonlinear dynamic FEM models solved by explicit solver LS-Dyna for precise airbag design (Fig. 1b) and procedures of experimental testing. The conducted simulations were validated and tuned during experimental drop tests. For this purpose, a drop test stand with the maximal drop height of 20 m was prepared. The stand

is composed of a vertical guiding system based on steel wires, remote control responsible for release of suspended object, and a base plate with piezoelectric force transducers for measurement of total dynamic vertical loads during the impact. The data acquisition system is based on LMS SCADAS platform and Vision Research Phantom v611 high speed camera. Video frame from exemplary drop test is shown in Fig. 1a.

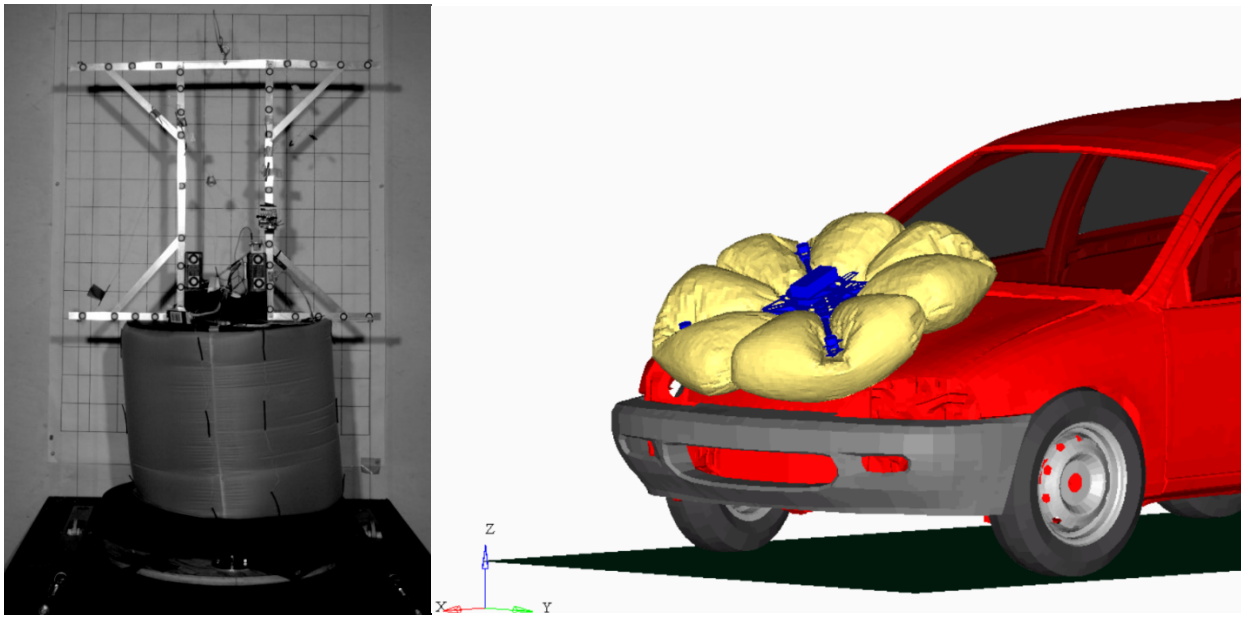

Figure 1. a) fast-camera image taken during drop test of exemplary airbag design, b) visualization of the numerical simulation used for airbag design with the use of Geo Metro detailed FE model.

3. Conclusions

As a response to limited application capabilities of emergency parachute systems the adaptive airbag system has been proposed in order to ensure safe emergency landing in case of low altitude failures of drones. The R&D activities have included design of the airbag, simulation of its operation, as well as experimental testing of the Ad-Bag emergency landing system.

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FE Model of the car: This model has been developed by The National Crash Analysis Center (NCAC) of The George Washington University under a contract with the FHWA and NHTSA of the US DOT. Authors would like to thank Mr. Jan Całka for his help with manufacturing of system components and preparation of testing stand.

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