

Investigation into the Injury Severity of Unmanned Aerial System (UAS) Impacts on Non-Participating Public

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Background

Small unmanned aerial systems (sUAS) have increased in popularity, leading to some specific concerns about how they could present risks to people and property in their vicinity. One of these is the potential injury risk resulting from unintended impacts of a sUAS and the non-participating public. The Advanced Virtual Engineering and Testing (AVET) lab at the National Institute for Aviation Research (NIAR) was a research partner with Ohio State University, along with other universities, for the FAA's ASSURE Center of Excellence which investigated this issue. One responsibility of the project NIAR focused on was the accurate modeling of these sUAS impacts to the human head in dynamic finite element analysis. The speeds examined ranged from 25 to 71 ft/s. The simulation data was then used to help inform what could be expected and how to best optimize test matrixes for physical testing on anthropomorphic testing devices (ATD) and post mortem human subjects (PMHS).

Methodology

This was accomplished by conducting a series of numerical impact simulations utilizing validated sUAS models, a virtual finite element ATD (vATD) model, and the Total Human Model for Safety (THUMS). The data output from simulation and physical testing was examined through the use of current automotive and aviation injury criteria. These values helped assess the type of injuries predicted and provided a comparison of injury potential from one impact scenario to another. Impact orientations were evaluated with the simulations and ranked based on injury criteria results in order to define the optimum sequence for ATD testing. Another series of orientation studies were then simulated for the sUAS to THUMS impacts where the order of injury severity and worst cases were found for PMHS. This was especially helpful in predicting which tests in the matrix might cause skull fracture in the physical PMHS tests. This information also helpful in indicating a potential high level of injury, rendering the subject possibly unsuitable for further testing. Thus the analysis helped guide a final test matrix, ordered around injury severity and potential fracture.

Results and Discussion

The primary findings were the worst case orientations and ordered injury severity to be used in physical test matrix choices. In total, this included 109 ATD tests and 38 PMHS tests conducted. Examples of specific findings include the vATD simulations finding angled impacts to the forehead would be the worst case orientation. This was confirmed in the THUMS simulation with a HIC of 1331 and peak acceleration of 300.7g for angled frontal impacts of the quadcopter sUAS at 71ft/s. The THUMS also showed skull strains that accurately predicted skull fracture, which was then observed in PMHS testing for this test scenario. From ATD testing and vATD simulations, injurious neck loads were a concern with 26% of ATD test exceeding compression criteria threshold. However, THUMS simulations showed the less stiff construction on a biofidelic neck was not probable to experience injury. This was then also confirmed in PMHS testing.