I. INTRODUCTION

Future applications will bring unmanned aerial vehicles (UAVs) to near Earth environments such as urban areas, causing a change in the way UAVs are currently operated. Of concern is that UAV accidents still occur at a much higher rate than the accident rate for commercial airliners. A number of these accidents can be attributed to a UAV pilot’s low situation awareness (SA) due to the limitations of UAV operating interfaces. The main limitation is the physical separation between the vehicle and the pilot. This eliminates any motion and exteroceptive sensory feedback to the pilot. These limitations on top of a small field of view from the onboard camera results in low SA, making near Earth operations difficult and dangerous. Autonomy has been proposed as a solution for near Earth tasks but state of the art artificial intelligence still requires very structured and well defined goals to allow safe autonomous operations. Therefore, there is a need to better train pilots to operate UAVs in near Earth environments and to augment their performance for increased safety and minimization of accidents.

In this work, simulation software, motion platform technology, and UAV sensor suites were integrated to produce mixed-reality systems that address current limitations of UAV piloting interfaces. The mixed reality definition is extended in this work to encompass not only the visual aspects but to also include a motion aspect. A training and evaluation system for UAV operations in near Earth environments was developed. Modifications were made to flight simulator software to recreate current UAV operating modalities (internal and external). The training and evaluation system has been combined with Drexel’s Sensor Integrated Systems Test Rig (SISTR) to allow simulated missions while incorporating real world environmental effects and actual UAV sensor hardware. A block diagram of this setup can be seen in Figure 3.

To address the lack of motion feedback to a UAV pilot, a system was developed that integrates a motion simulator into UAV operations (Figure 2). The system is designed such that during flight, the angular rate of a UAV is captured by an onboard inertial measurement unit (IMU) and is relayed to a pilot controlling the vehicle from inside the motion simulator. Efforts to further increase pilot SA led to the development of a mixed reality chase view piloting interface as seen...
in actual or realistic environments. This is compared with other brain imagining modalities such as fMRI that require large specially designed rooms and minimal movement by the subject during tests [5].

Behavioral analysis showed that the chase view interface improved pilot performance in near Earth flights and increased their situational awareness. This was shown by a more efficient flight path (ie. tighter turns around corners) and more accurate positioning over targets. fNIR analysis showed that Chase view subjects’ average oxygenation levels was significantly lower than Onboard subjects. This signifies that Onboard view subjects were using more mental resources to conduct the flights. This result is most likely attributable to the narrower viewable angle and rolling of the environment in the onboard view, which require more cognitive processing by the subject to construct an accurate working mental model of the environment and the aircraft’s position in it.

Real world flight tests were conducted in a near Earth environment with buildings and obstacles to evaluate the chase view interface with real world data. The interface performed very well with real world, real time data in close range scenarios.

The mixed reality approaches presented follow studies on human performance and cognitive loading. The resulting designs serve as test beds for studying UAV pilot performance, creating training programs, and developing tools to augment UAV operations and minimize UAV accidents during operations in near Earth environments. More details of this work can be found in [6], [7], [8].

REFERENCES