Incorporating UAV Generated Deliverables into HVE® Simulation Software

Gregory Gravesen
Northwest Crash Analysis, LLC
Duane Meyers
Great Lakes Crash Analysis, LLC

ABSTRACT

It's a well-established fact that demonstrative evidence is a critical component with effectively presenting a case to the trier of fact. Studies have demonstrated the combination of verbal and demonstrative evidence is six times more effective than a verbal delivery alone. In addition, many jurors have an expectation for some type of forensic evidence and analysis. This has often been referred to as the "CSI Effect." Regardless if the CSI Effect really exists, a National Institute for Justice Report stated there is a belief that a broader "tech effect" exists that influences juror expectations and demands.

In order to be an effective expert witness, crash reconstructionists should be cognizant of the proper use of demonstrative evidence and technology when presenting their findings to the finder of fact.

HVE is a powerful tool for the crash reconstructionist, allowing the user to simulate and model various types of collisions. HVE users have the ability to incorporate different types of backgrounds and environments into their simulations. This ability provides the users flexibility and the control to produce a highly effective work product. Once the collision is modeled, the results of the simulation may be visualized in an output file using the Playback Editor, producing highly accurate, physics based computer generated movies.

Over the last 20 years, technology has allowed collision investigators to improve their ability to accurately measure the geometry of 3-dimensional environments of traffic collisions. This technology includes laser based systems, total station technology, photogrammetry, terrestrial scanners, and now Unmanned Aerial Vehicles (UAVs).

The intent of this paper is to provide a basic description of the deliverables generated from professional mapping UAV systems and how to incorporate them into HVE simulations.

INTRODUCTION

Professional mapping UAV systems are capable of producing highly accurate results in a minimal amount of time. The basic workflow of UAV mapping systems generally consist of three stages: flight planning, data processing, and the outputs or deliverables.

One such system is produced by the *SenseFly* Company. It has both fixed wing (eBee) and a multi-rotor system (eXom). The system starts with creating the flight plan. This can be done from the office in advance of the flight or on location using their proprietary software (eMotion 2 and eMotion X). Once the flight plan is uploaded to the UAV and two-way communication is established, it flies the mission autonomously and allows the user to regain control or change flight parameters at any moment (See Figures 1 and 2). The UAV takes a series of photographs based on the longitudinal and lateral overlap values specified during the flight planning.

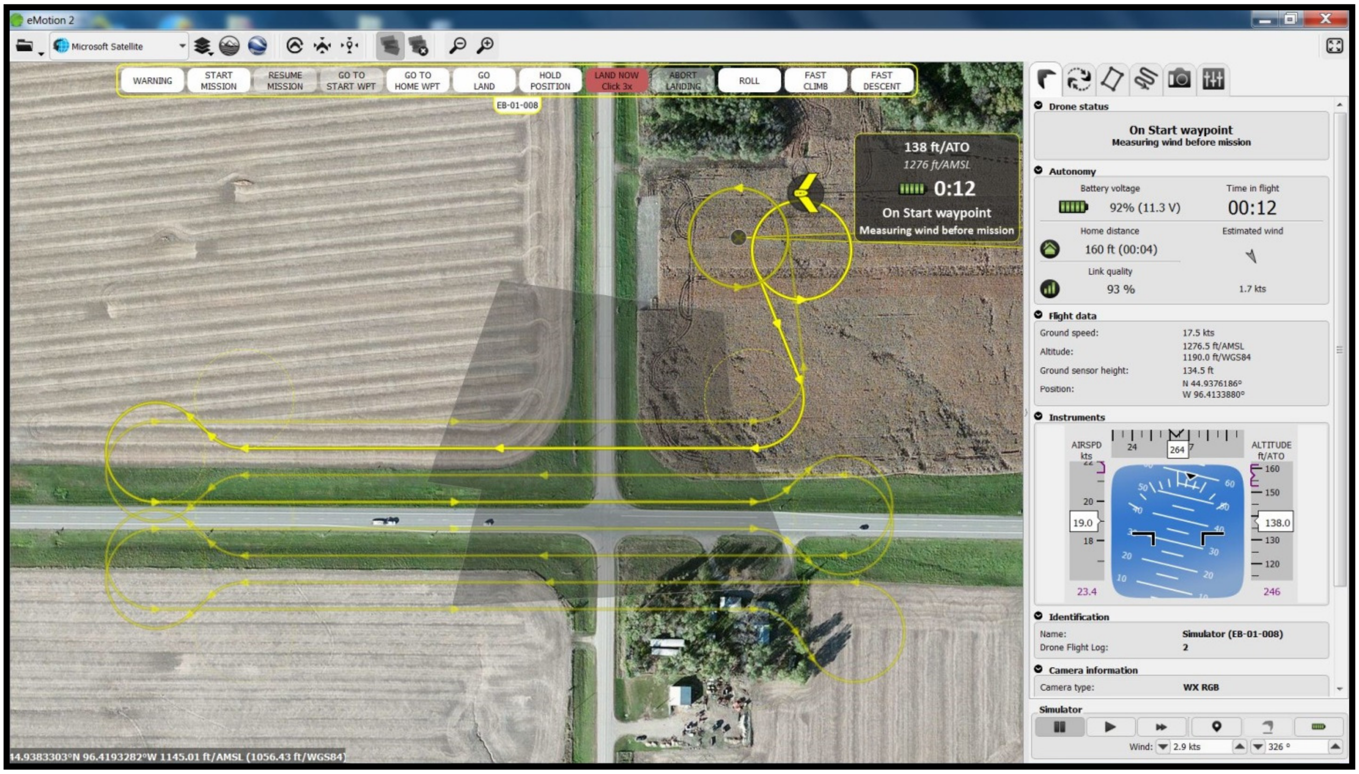

Figure 1 This is a screen capture of Sensefly eMotion 2 flight management software.

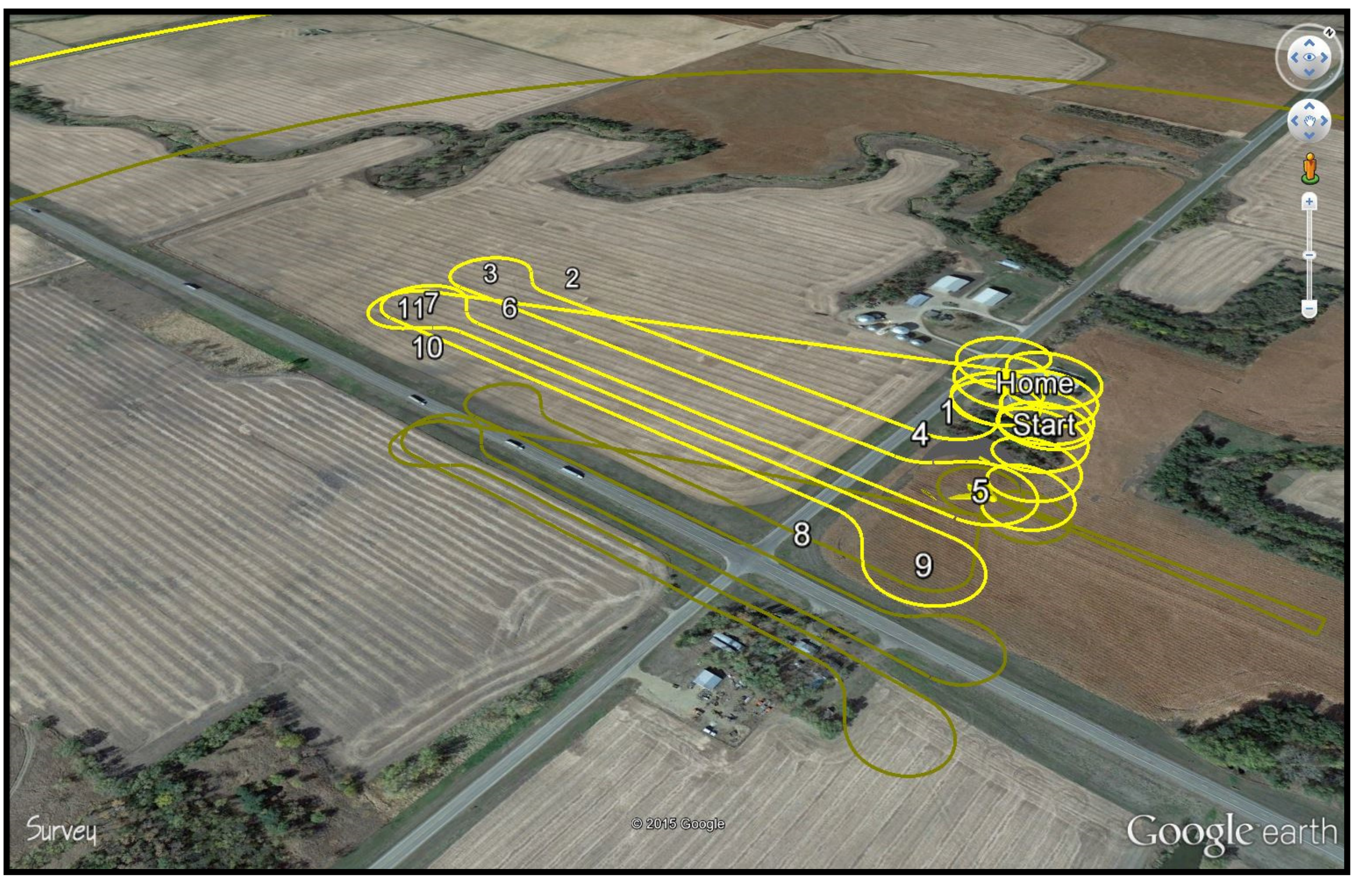

Figure 2 The eMotion 2 generated flight plan observed in 3D within Google Earth.

Once the mission is completed, the flight plan data and photographs are processed by the SenseFly software. When the processing is completed, the results are then used to create a *Postflight Terra 3D* project (by Pix4D). Postflight Terra 3D is photogrammetry software designed for mapping platforms. Postflight Terra 3D applies photogrammetric principles using these aerial images to produce highly precise mapping and modeling outputs.

There are three main types of deliverables created by professional mapping UAV systems that are useful in the creation of HVE environments and backgrounds: orthomosiac images, 3D point clouds, and textured meshes.

An orthomosiac image consists of a group of several overlapping, geo-referenced, aerial images that have undergone the process of ortho-rectification. Ortho-rectification is defined as the process of correcting the geometry of an image so that it appears as though each pixel were acquired from directly overhead. Ortho-rectification uses elevation data to correct terrain distortion in aerial imagery. The ortho-rectification process results in a mosaic image that is free of distortion (See Figure 3).

A point cloud is a large set of data points that are defined by X, Y, and Z coordinates. The point cloud is often intended to represent the external surface of an object. A point cloud contains elevations of natural terrain features, in addition to vegetation, trees and other environment features. Some common file formats for point clouds include .pts, .las, .xyz, .laz, .ply, .e57, and many more.

Figure 3 This orthogonal image is a mosaic compilation of several photos taken by the UAV system.

A mesh consists of vertices, edges, and faces that use polygonal representation, including triangles and quadrilaterals, to define a three-dimensional environment. These meshes are generated based on the calculated point cloud data and are textured based on the associated imagery. Some common file formats for the textured meshes include common CAD formats such as .ply, .fbx, .dxf, and .obj.

METHODOLOGY

There are numerous methods that can be utilized to create HVE environments and backgrounds. These methods usually include the use of various computer aided drawing (CAD) and modeling software. There are two industry standard computer programs that can easily incorporate the deliverables generated by UAVs and produce HVE environments; *IMS Map360* (Leica Geosystems) and *Rhinoceros 3D* (Robert McNeel and Associates).

There are many CAD programs that can import an image which can then be manually scaled by the user if there are known dimensions between objects visible in the image. However, the accuracy of the manual scaling is dependent on the user's ability to select the specific point in the photo that was used to take the manual measurement. In addition, the method used to take these manual measurements (i.e. tape measure, etc.) can also introduce some error into this manual scaling. The geo-referenced images generated by the UAV have a corresponding world file with a .prj or .tfw file extension. The corresponding world file for a geo-referenced image describes the location, scale and rotation of the image. IMS Map360 easily imports both the georeferenced image and world file generated by the UAV system (See Figure 4).

As a result, the image is automatically scaled based on the geo-referencing information and is not subject to potential human error due to manual scaling.

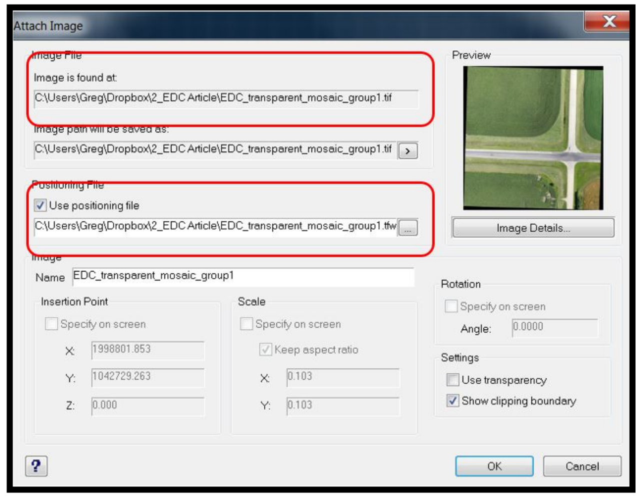

Figure 4 IMS Map360 dialog box for inserting an aerial image and corresponding positioning file.

Once the image file is imported into IMS Map 360 and automatically scaled through geo-referencing, it can be cropped according to the user's preference. The image can then be moved to local coordinates where the origin can be selected. The local coordinates for the upper left and lower right corners of the image can then be calculated for purposes of importing into HVE. This is particularly useful for a 2-dimensional collision or trajectory analysis. It should be noted default HVE coordinate entries are limited from -4,000 to 4,000 values. The geo-referenced coordinates are too large to enter into HVE unless the image is moved to a local coordinate system. In addition to cropping, IMS Map 360 allows the user to adjust the brightness, contrast and fade of the image.

3-Dimensional point clouds are easily generated from the ortho-rectified images within a Postflight Terra 3D project (See Figure 5). Programs that can function with point clouds can take immediate advantage of this stage in the process.

.

Figure 5 Example of a UAV generated point cloud.

For purposes of an HVE environment, we import the point cloud data into IMS Map 360® to create 3D line work or meshes. The line work represents topographical features as well as lane lines, pavement edges and other objects of interest. Since Rhinoceros 3D® CAD software is so useful to create a 3D mesh and export to a Virtual Reality Modeling Language (VRML) file format, we utilized it after the line work was created in IMS Map 360®. Surfaces followed by meshes are finalized in Rhinoceros® to create a detailed and geometrically accurate environment model

The following graphics (See Figures 6-8) demonstrate several stages of the development of a 3-dimensional model that can be imported into HVE. The user has several options available to deliver a useable environment model.

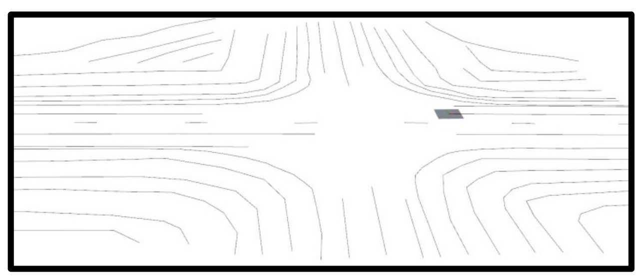

Figure 6 IMS Map360 topographical lines

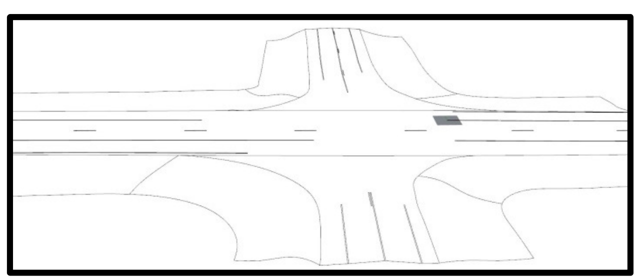

Figure 7 Rhinoceros topographical lines

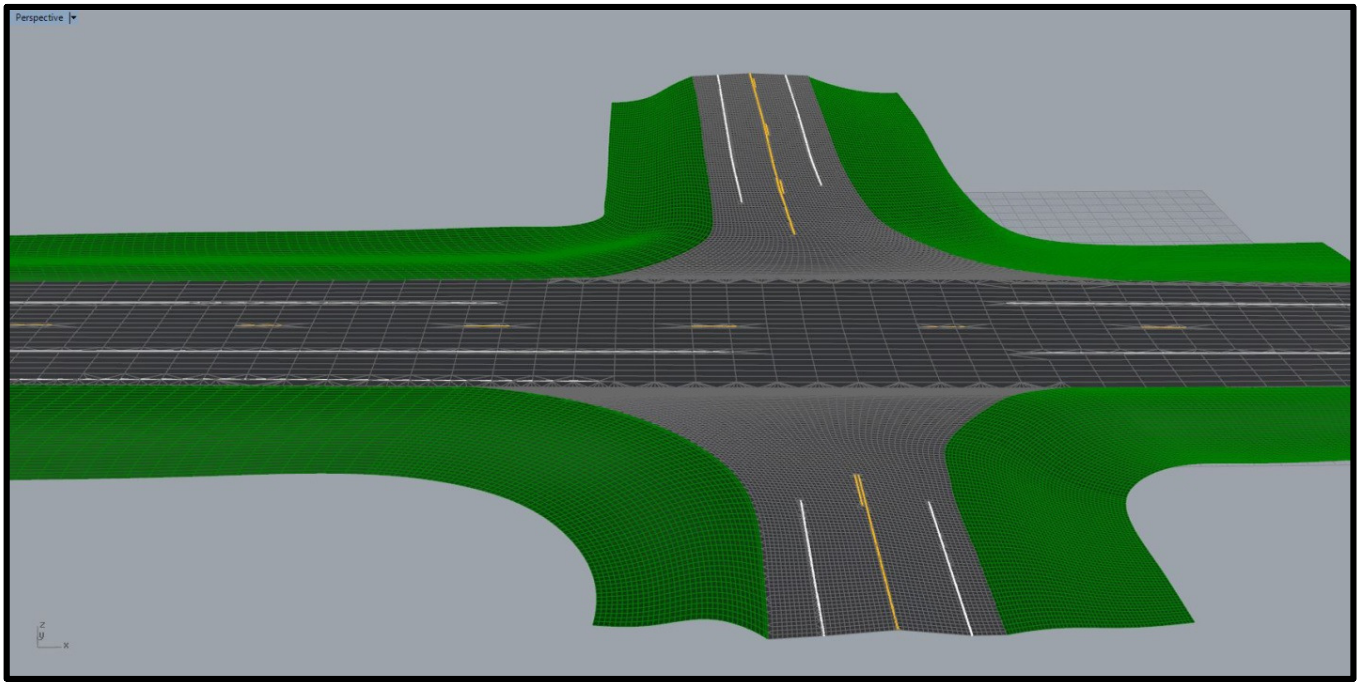

Figure 8 Rhinoceros shaded view of a 3-dimensional mesh suitable to export into HVE

CONCLUSION

This white paper has provided a basic description of the deliverables from current UAV systems and how to incorporate them into HVE simulations. The combination of the UAV technology with HVE simulation software will allow users to produce highly accurate, visually appealing, and powerful computer crash simulations (See Appendix).

REFERENCES

1. Jurkofsky, Drew A., "Accuracy of SUAS Photogrammetry for Use in Accident Scene Diagramming", SAE Technical Paper 2015-01-1426, 2015
2. SenseFly® eMotion2™, eMotion X™, and Post-Flight Terra 3D™ software training programs, 2015
3. IMS Map360™ Software Tutorial, Leica Geosystems®, 2016
4. Sneddon, James P., "Introduction to Creating HVE® Environments With Rhinoceros®, EDC WP # 2002-2

TRADEMARKS

HVE®, Engineering Dynamics Corporation, 8625 SW Cascade Ave., Suite 200 Beaverton, OR 97008

eMotion2™, *eMotion X*™, and *Post-Flight Terra 3D*™ are registered trademarks for the SenseFly® Company, senseFly SA Cheseaux-Lausanne, Switzerland

IMS Map360™ is a registered trademark for Leica Geosystems Inc., 5051 Peachtree Corners Circle #250 Norcross, GA 30092

Rhinoceros 3D® is a registered trademark for Robert McNeel & Associates, 2016

APPENDIX

Figure 9 HVE Simulation over high definition ortho-rectified image

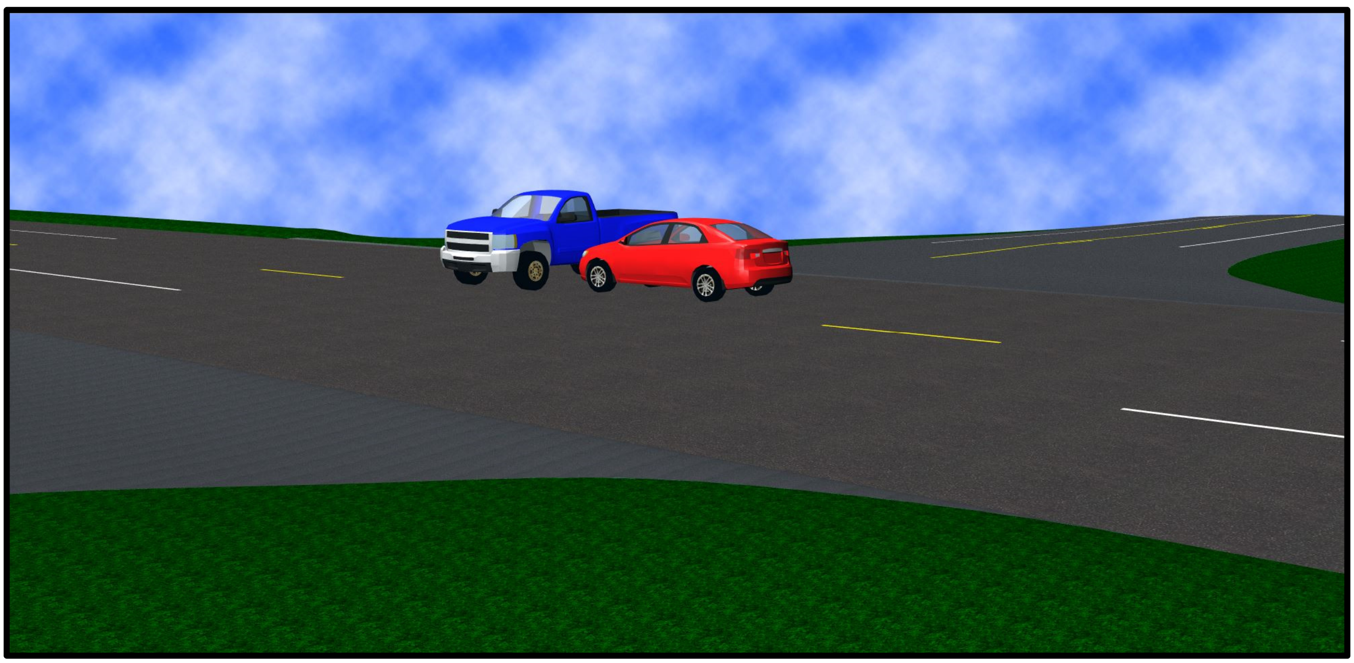

Figure 10 HVE Simulation over 3-dimensional mesh environment