AFRL-VA-WP-TP-2006-328

URBAN SIMULATION ENVIRONMENT (PREPRINT)

Bradley J. Stoor, Stanley H. Pruett, Matthew M. Duquette, Robert C. Subr, and Tim MtCastle

JUNE 2006

Approved for public release; distribution is unlimited.

STINFO COPY

AIR VEHICLES DIRECTORATE
AIR FORCE MATERIEL COMMAND
AIR FORCE RESEARCH LABORATORY
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433-7542

NOTICE AND SIGNATURE PAGE

AFRL-VA-WP-TP-2006-328 HAS BEEN REVIEWED AND IS APPROVED FOR PUBLICATION IN ACCORDANCE WITH ASSIGNED DISTRIBUTION STATEMENT.

*//Signature//

STANLEY H. PRUETT
Electronic Engineer
Aerospace Vehicles Technology
Assessment & Simulation Branch

//Signature//

Howard T. Emsley, Acting Chief
Aerospace Vehicles Technology
Assessment & Simulation Branch

//Signature//

JEFFREY C. TROMP
Senior Technical Advisor
Control Sciences Division
Air Vehicles Directorate

*Disseminated copies will show "//Signature//" stamped or typed above the signature blocks.

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
June 2006	Conference Paper Preprint	03/01/2005– 05/30/2006

4. TITLE AND SUBTITLE
URBAN SIMULATION ENVIRONMENT (PREPRINT)

5a. CONTRACT NUMBER In-house

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER 0602201

6. AUTHOR(S)
Bradley J. Stoor, Stanley H. Pruett, and Matthew M. Duquette (AFRL/VACD)
Robert C. Subr, and Tim MtCastle (General Dynamics, AIS)

5d. PROJECT NUMBER A096

5e. TASK NUMBER

5f. WORK UNIT NUMBER 0A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Aerospace Vehicles Technology Assessment & Simulation Branch (AFRL/VACD)
Control Sciences Division
Air Vehicles Directorate
Air Force Materiel Command, Air Force Research Laboratory
Wright-Patterson Air Force Base, OH 45433-7542

General Dynamics, AIS
5200 Springfield Pike,
Suite 200
Dayton, OH 45434

8. PERFORMING ORGANIZATION REPORT NUMBER
AFRL-VA-WP-TP-2006-328

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Air Vehicles Directorate
Air Force Research Laboratory
Air Force Materiel Command
Wright-Patterson Air Force Base, OH 45433-7542

10. SPONSORING/MONITORING AGENCY ACRONYM(S)
AFRL-VA-WP

11. SPONSORING/MONITORING AGENCY REPORT NUMBER(S)
AFRL-VA-WP-TP-2006-328

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
This work has been submitted to the 2006 AIAA Modeling and Simulation Technologies Conference proceedings. One or more of the authors is a U.S. Government employee working within the scope of their Government job; therefore, the U.S. Government is joint owner of the work. If published, the publisher may assert copyright. The Government has the right to copy, distribute, and use the work. All other rights are reserved by the copyright owner.

Report contains color. PAO Case Number: AFRL/WS 06-1767 (cleared July 14, 2006).

14. ABSTRACT

Air Force Research Laboratory (AFRL) researchers at the Aerospace Vehicles Technology Assessment and Simulation (AVTAS) Laboratory are developing a realistic urban simulation environment. The near term objective is to provide an appropriate environment to study the performance of cooperative control algorithms for Unmanned Air Vehicles (UAV) in and around the urban landscape. Additionally, operator-in-the-loop interfaces that interact with the cooperative control algorithms will be implemented providing the capability to explore the various facets of UAV control. The simulation environment will include multiple urban databases for visualization, UAV aerodynamics and control models, camera models, articulated human models, and ground vehicle models to serve as clutter and potential targets. Wind and turbulence models will be also be integrated to elicit realistic UAV behavior. The levels of fidelity can be varied depending on available resources and design of the experimental study.

15. SUBJECT TERMS
urban simulation environment, unmanned air vehicles, urban database visualization, operator-in-the-loop interfaces, articulated human models, urban wind models , urban turbulence models, cooperative control algorithms

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT:	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON (Monitor)
Unclassified	Unclassified	Unclassified	SAR	14	Stanley H. Pruett
					19b. TELEPHONE NUMBER *(Include Area Code)* N/A

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18

Urban Simulation Environment

Bradley J. Stoor[*], Stanley H. Pruett[†], and Matthew M. Duquette[‡]
Air Force Research Laboratory, Wright-Patterson AFB, OH, 45433

and

Robert C. Subr[§] and Tim MtCastle[**]
General Dynamics, AIS, 5200 Springfield Pike, Suite 200, Dayton, Ohio 45434

Air Force Research Laboratory (AFRL) researchers at the Aerospace Vehicles Technology Assessment and Simulation (AVTAS) Laboratory are developing a realistic urban simulation environment. The near term objective is to provide an appropriate environment to study the performance of cooperative control algorithms for Unmanned Air Vehicles (UAVs) in and around the urban landscape. Additionally, operator-in-the-loop interfaces that interact with the cooperative control algorithms will be implemented providing the capability to explore the various facets of UAV control. The simulation environment will include multiple urban databases for visualization, UAV aerodynamics and control models, camera models, articulated human models, and ground vehicle models to serve as clutter and potential targets. Wind and turbulence models will be also be integrated to elicit realistic UAV behavior. The levels of fidelity can be varied depending on available resources and design of the experimental study.

Nomenclature

ATR	=	Automatic Target Recognition
AVTAS	=	Aerospace Vehicles Technology Assessment and Simulation
DTED	=	Digital Terrain Elevation Data
GCS	=	Ground Control Station
GPS	=	Global Positioning System
INS	=	Inertial Navigation System
OVI	=	Operator Vehicle Interface
UAV	=	Unmanned Air Vehicle
USE	=	Urban Simulation Environment

I. Introduction

The objective of the Urban Simulation Environment (USE) is to provide a flexible tool for researchers to execute simulations involving air vehicles in a representative urban setting. A representative urban setting would be an environment that has objects typically found in urban situations. This would include such items as buildings, structures such as telephone or light posts, people, and vehicles. Other environments may contain these items, but an urban environment is unique in that the density of these objects is much greater than a rural or suburban environment. The environment could incorporate other models, such as turbulence and urban wind fields, and Global Positioning System (GPS) communications.

The simulation environment would not restrict the type of air vehicle that could potentially be used. Currently, unmanned air vehicles (UAVs) are being modeled but it would be possible to have piloted vehicles incorporated into the simulation if this was desired. An important attribute of the USE is that it has been constructed so that it will be

[*] Simulation Engineer, Aerospace Vehicles Technology Assessment and Simulation Laboratory.
[†] USE Program Manager, Aerospace Vehicles Technology Assessment and Simulation Laboratory.
[‡] Aerospace Engineer, Aerospace Vehicles Technology Assessment and Simulation Laboratory, AIAA Member.
[§] Lead Engineer, Information Technology, Weapon Systems Analysis & Support.
[**] Senior Software Engineer, Information Technology, Weapon Systems Analysis & Support.

relatively easy to make modifications. The interfaces between different components are well defined and based on open standards, so any new models can be incorporated by making them compliant with the interface.

There are several types of simulations with differing fidelities and simulation products. Figure 1 illustrates some of the different types of simulations. Fundamental science level simulations are high fidelity and produce Measures of Performance (MOP). An example of this type of simulation would be to simulate a radar system and its capability to detect aircraft. The simulation would need to take into account the different wavelengths that the radar is emitting and the reflections off of objects. A possible MOP would be the range at which a particular type of aircraft would be detected.

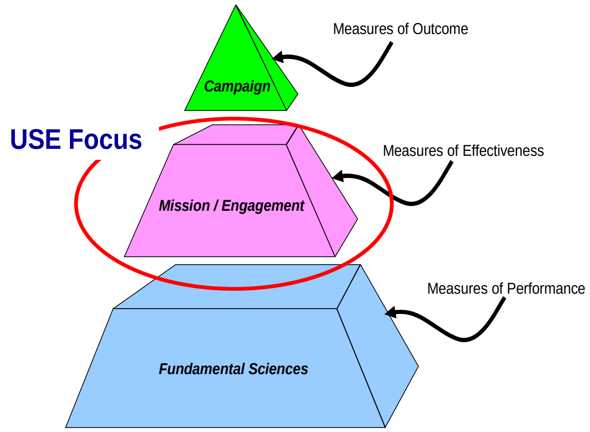

Figure 1. Different simulation levels.
A simulation's fidelity determines the product of tests.

The second level of the simulation hierarchy focuses on mission-level simulations. At this level, measures of Effectiveness (MOE) are used to evaluate how well a mission is accomplished. An example of a mission simulation would be the collection of visual data from some area in search of a set of targets. In this case a MOE of this mission might be the number of targets identified. The highest level of simulation is the campaign level. At this level of simulation, the product is to determine the outcome of a battle or possibly an entire conflict. The USE simulation environment is not designed to address this level of simulation.

The USE is an environment designed for studies that examine the effectiveness of UAVs performing missions in an urban environment. As such, the USE fits the middle section of the simulation hierarchy. Simulation components feature an effects-level fidelity, allowing fast execution while providing enough detail to effectively represent the environment. It is envisioned that the products of the USE will be measures of effectiveness of various concepts of employment for teams of UAVs.

II. Motivation for Development of USE

Urban environments present a set of unique characteristics. Primarily, urban environments are typically cluttered with various types of structures that tend to obscure aerial views. They are often also populated with people and ground vehicles. This presents a higher probability of collateral damage. Furthermore, there is typically critical infrastructure in the environment, such as bridges, power stations, or communication nodes that may play an important part in a simulation.

One of the characteristics of an urban environment is that the aerial views of the urban terrain are obscured from many different angles with respect to the air vehicle's position. Streets are typically lined with many tall buildings, which create a canyon effect. An air vehicle's position with respect to the canyon will dramatically affect what can be viewed. For example, if a person or vehicle model is a subject of interest and is located on a street in the canyon, then a UAV may or may not be able to have a line of sight. If the air vehicle has a view down the street or is high enough, then it may be possible to view the subject of interest. However, if the air vehicle is trying to view across the canyon, the canyon could be too deep to provide a view of the subject. The intent of the USE environment is to provide researchers a simulation environment where most of the effects of the urban environment will be modeled. This includes the obscuration of visual sensor views due to urban structures blocking particular aerial viewpoints.

An example research topic could look at how to overcome the canyons in an urban environment by using a cooperative control strategy of controlling multiple UAVs. If one UAV is unable to view the subject of interest, then the strategy could try to assign the task to another UAV. Research will also need to be done to evaluate the optimum amount of information that can be presented to one or more operators viewing UAV sensor video streams. If you try to present too much information to an operator, then they may be unable to effectively monitor all of the incoming data. The current limitations are unknown, but can be discovered through exercises in the USE.

Another characteristic of the urban environment is that there are many people, ground vehicles and critical infrastructure within a very condensed area. The people can be of various classes. They can be friendly forces, enemy forces, or civilian. It is possible to classify the people into other types of categories depending on the intent of the simulation. The categories can be further refined as necessary but the USE environment primarily has people models in order to provide realism. At this development point in the USE simulation there is a very limited application of people models. The people models in the urban database serve as clutter objects that can potentially distract an operator monitoring streaming video originating from a simulated UAV sensor camera model.

At some future point, the role of people models may become more significant. There are many potential examples of simulation people models taking on a more elaborate and complex roles. The simulated people models may detect a UAV flying within detection range and take some action based on this detection.   Another more complex role for simulated people models would be performing activities that would allow an observer to determine the people models intent and allow the UAV sensor operator the capability to categorize the people models as civilian, enemy, or friendly forces. An example would be a group of people models firing weapons at a known friendly force. There are also more subtle behaviors that an operator may detect on a video stream that may help determine the intent of the people models.

Because the smaller UAVs might potentially fly lower to the ground, the wind field due to the urban structure becomes a factor. The modified flow around the buildings could affect the flight paths and controllability of any UAVs that fly in the proximity. In an urban environment smaller UAVs could experience a sudden change in the winds that affects the UAV's ability to follow its flight path. This deficit of control has two distinct effects. First, there is the possibility of collision with the nearby urban structure. Second, high levels of turbulence makes it difficult to keep onboard cameras focused on a particular object. How much of an impact this will be and what steps must be taken to work around the unique issues of urban winds have yet to be determined. The USE is being designed to help determine the impact of these effects.

To adequately portray all of the characteristics of an urban environment, the simulation environment features a visual database for the urban environment containing ground features, urban structure, people models, and ground vehicle models. Virtual air vehicles can fly through the simulation database and obtain visualizations representative of what would be seen in real life. In order to assure that the video stream from the UAV is a realistic representation, it is necessary to modify the simulation video with representative camera effects to achieve this realism. The specific camera effects that are applied will be discussed in a later section.

III. USE Architecture

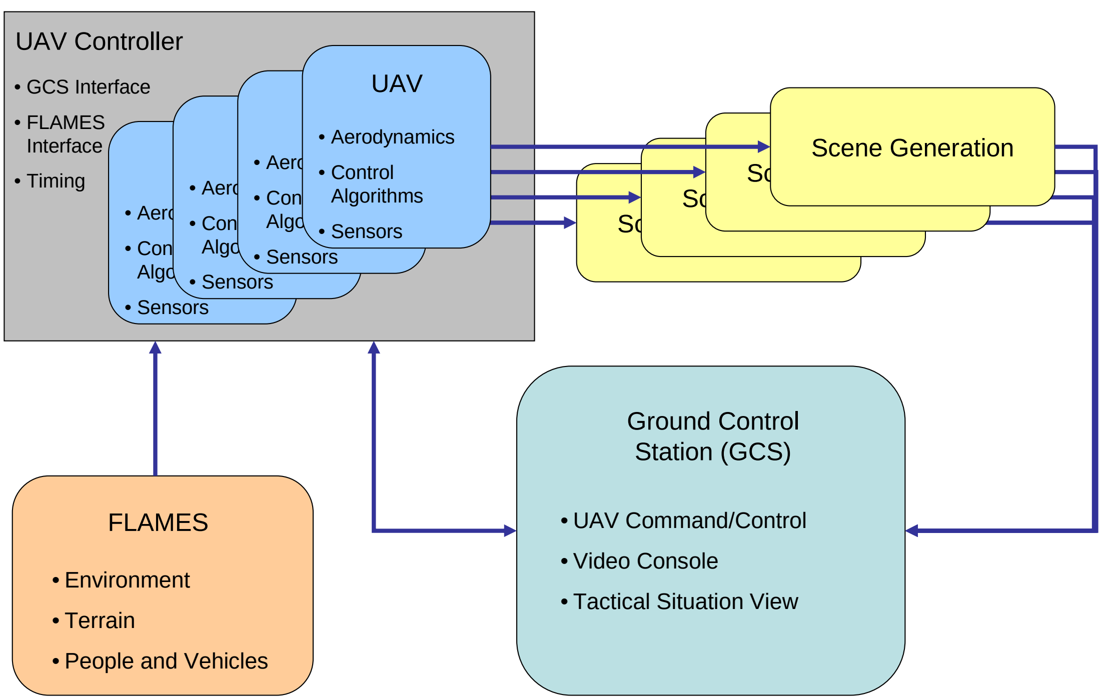

Figure 2. Block diagram of USE.

The architecture of the USE can be divided into 4 separate areas; the ground units and terrain, the flight dynamics models for the UAVs, scene generation, and the operator station. Each of these will be discussed in this section along with a discussion of the future capabilities in development.

A. Overview

The USE currently consists of seven, dual-processor computers with both a gigabit Ethernet and reflective memory network. Figure 2 shows a block diagram of the current configuration. One computer is dedicated to the Ground Control Station. During the simulation execution this is where the UAV operator would have access to control the UAVs. Another computer controls the movement of ground vehicles and people models. A third computer is dedicated to running the flight models of the UAVs and is also the communication hub for the simulation. The UAV computer receives commands and returns status reports to the ground control station. It also receives the location of all of the entities in the environment, which is passed to the scene generation computers. There are four scene generation computers which simulate the video feeds coming from the UAVs. This video feed is then passed back to the ground control station.

B. Ground Units and Terrain

The USE was developed as a relatively generic simulation environment to host many simulations. The key difference between this environment and other simulations is the incorporation of detailed surface objects. Other simulations conducted at the AVTAS facility are conducted at higher altitudes and do not focus on the terrain as much. The terrain is there to provide realism; the players need it to get a visual cue as to their velocity and orientation. Since most of the USE's current work is conducted at a much lower altitude, the details of the terrain play a much larger role. The databases developed for USE generally consist of small urban, suburban, and rural areas of less than 100 square miles. The detail includes buildings, vehicles, vegetation, roads, bodies of water, detailed terrain, and in some cases models of individual people.

The focus of the environment is to provide an appropriate level of stimulus to operators that are viewing the environment via a simulated air vehicle. Often the operator is tasked with finding a potential enemy in an area of civilian clutter. The challenge is to provide the operator with a level of detail that would allow for an operator to distinguish between bystanders and foes. Some of these details include clothes and facial expressions. Their actions would also need to be taken into account. The intent of individuals can be detected much more readily through dynamic activities rather than a group of static individuals.

To animate the ground vehicles and people, the USE uses the Flexible Analysis Modeling and Exercise System (FLAMES)[1]. FLAMES provides many useful tools as a simulation architecture such as built in communications between models and the ability to load in terrain databases. The terrain database is loaded through shapefiles[4]. These shapefiles contain both the terrain elevation and correlated features. There are named features such as roads, buildings and rivers. This allows the ground vehicles to know the location of the buildings and roads. Each ground vehicle can then be given a route to follow which can consist of coordinates or even street names. The ability for the vehicles to roam randomly through the urban database is in development, but will enhance the realism of the virtual urban environment by enhancing the background clutter.

Figure 3. Screenshots of one person and a truck. *These are a sample of the currently available models for the environment.*

Detailed 3-D ground entities such as human models and an urban vehicle set were needed for scene generation. Figure 3 shows some of these models in the USE. A base model set was purchased for the vehicle models which included ten different model types with six different skin colors. These models included sedans, coupes and pickup trucks. Additionally, several unique models were created and added to the base target set, such as an ambulance with particular markings. Articulation was added to the human models to represent basic human motions such as running, walking, sitting and crawling. Using IEEE 1278.1 enumerations for human position states, the visual model can be put into any of these states in the visual scene. The selection of which particular state an individual is in at any given time is driven by FLAMES and is passed along with the entities location to the scene generation system.

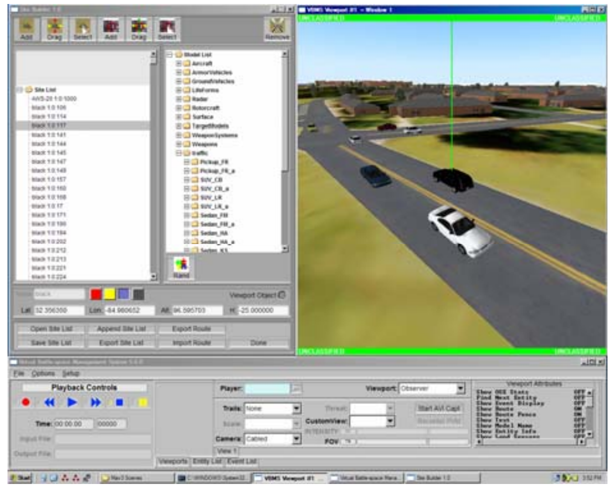

Figure 4. Screenshot of VBMS. *Configuration here is shown with the SiteBuilder plugin, which is used to place vehicles in the environment.*

C. Scene Generation

Scene generation is managed by using two AFRL-developed software packages; the Virtual Battle Space Management System (VBMS) and SubrScene.

The Virtual Battle-Space Management System (Figure 4) is a flexible tool used for visualizing simulation environments. VBMS acts as an observer in the simulation, receiving data in order to record entity interactions in the simulation, but does not interact or interfere with simulation entities. VBMS can be used for validation, monitoring, out-the-window visualization for pilot combat stations, subject debriefing, and analysis. The C++ design is built around an OpenGL based scene manager, which adds a cost effective graphics library for fast prototyping with optimized performance and allows VBMS to operate on the full line of workstation and personal computers. VBMS uses 2D and 3D visualization to view the synthetic environment. In addition to standard capabilities for VBMS, plug-ins can be created to enhance the tool. The SiteBuilder plug-in was created to aid in the scenario development of the simulation. This plug-in allows the user to interactively place entities anywhere in the environment. Ground routes can be added by drawing them out. Through the logging capability, simulation runs can then be used to fine tune entity placement and routes. All data can be exported back into native simulation formats to run scenarios. As a post-run tool, recorded simulation runs are taken for debrief, and AVI capture for final briefings.

Figure 5. Representative Urban Area. *Sample image of 3-D visuals. Terrain is built from aerial imagery with 3-D models placed on top.*

The primary scene generation tool is SubrScene. In Figure 2, SubrScene is the scene generation software that produces the imagery as seen by each UAV. Specific requirements for sensor emulation of various UAVs were required in the USE. Data was collected about each sensor including line rates, transmission formats, integration time of image, and field of view angles. In addition, information on sensor mounting, dynamic positioning and zoom were recorded. Sample video from the sensor was collected and characterized based on signal to noise effects, and environment effects such as sun blooming. For the sensor of interest, effects from the sun, NTSC line

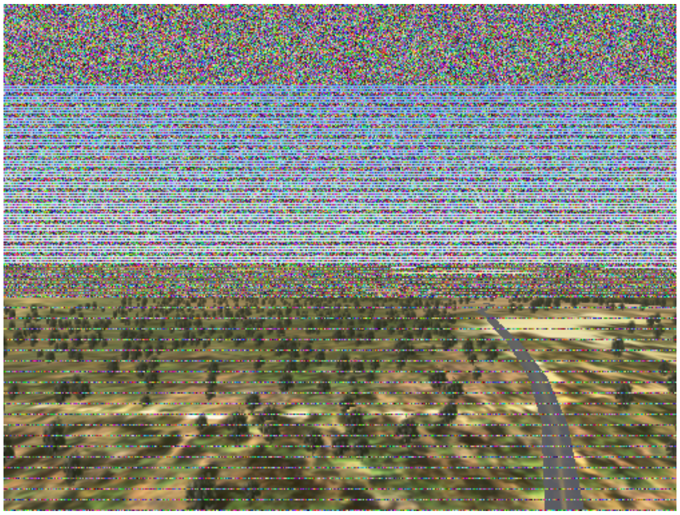

Figure 6. Sample Screenshot from UAV Camera. *Sample image shows the effect of signal noise on the UAV's camera feed.*

reduction, integration time and sensor blooming caused by the sun to sensor interaction were needed. For this simulation an individual copy of SubrScene was used for each sensor. A plug-in was created for the characterized sensor to emulate the effects characterized. Communication from the simulation drove values such as position, field of view, sensor modes and sensor data loss due to line of sight and interference. This video image was then transmitted via reflective memory network cards to the sensor operator station where the various configurations allowed operator interaction with the sensors. A frame of video showing signal loss effects is shown in Figure 6.

The visual database was created by translating elevation data obtained through DTED level 1 data. The elevation data was combined with 0.5 meter aerial imagery to produce the virtual scene. Culture, such as buildings, roads, and bodies of water, were extracted manually from the imagery and then added back in as 3-D models. The database is correlated with FLAMES to ensure that entities controlled by FLAMES would have identical locations with the visual scene. An example of a completed database is shown in Figure 5.

D. Ground Control Station

The ground control station is the human operator's interface to the simulation. The GCS is capable of sending commands and receiving data from the UAVs, such as waypoint following commands, loitering, or sensor requests. The GCS receives data from UAVs regarding location, fuel status, and any available sensor data, such as a video stream or still images.

Although many ground control stations exist, the USE employs an engineering-level station that was written by engineers at the AVTAS facility. This system, dubbed the Engineering Level Vehicle Interface System (ELVIS), is used as a development and testing tool. It is not designed to be used in the field, but it does provide utility in exercising the system. Since it was developed in house, AVTAS engineers are able to add new features quickly. Communication with air vehicles is via an Ethernet packet scheme that is based on NATO STANAG 4586. An example of ELVIS is shown in Figure 7.

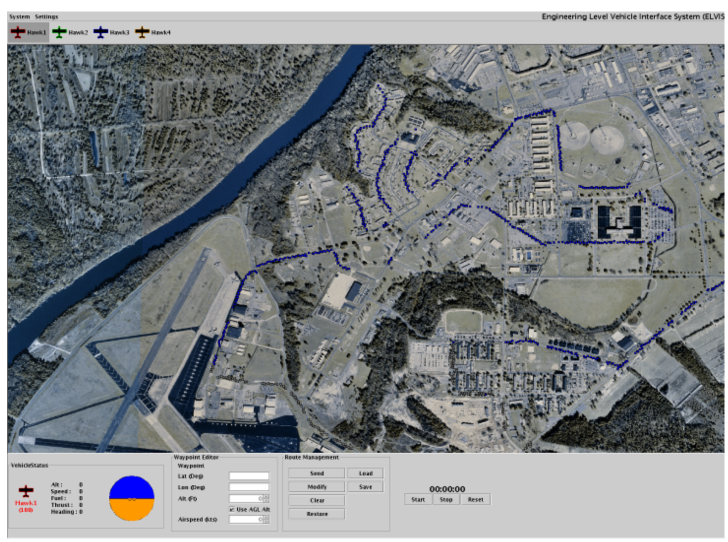

Figure 7. ELVIS Screenshot

Video links between the GCS and the air vehicles are also modeled in the USE. When implementing the video stream, two different approaches were considered. One approach would use a separate computer with video capture boards to capture the data and send it through Ethernet to the operator station. The other approach used reflective memory cards to quickly send the video to the operator station. A reflective memory card has on-board memory and all of the boards on their network have exactly the same data. This means that if a value is written to a memory location on one board that same value will be on every other board. This allows video to be copied out of the frame buffer on the scene generation computers and sent directly to the operator station. AVTAS engineers found the later implementation to be the better approach.

Using the video capture boards has some benefits, but many drawbacks. The biggest benefit would be to lessen the processing burden on the scene generation computer of copying each frame. However, since all of the video capture boards were in the same computer, it was limited by the bandwidth on the PCI bus which connects peripherals to the CPU. All of the video streams that are being captured have to share that bus, which means that the video has to be compressed more to allow them all to fit. This could add unintended artifacts to the video. Also, when sending video over the network, the receiving end has to buffer the video before playback. This caused a one-second delay in the video, making it impossible to correctly simulate the video feed. There may be cases where delays would be desirable, perhaps to model transmission delays, but if the calculated delay is less than a second, then it would be impossible. Because of these limitations, the USE team looked to reflective memory as an alternative method of video transmission.

As mentioned previously, the reflective memory boards provide common memory storage between multiple computers. This enables the ability to copy the scene from the scene generation computer directly to the operator station. This reduces the delay to approximately a microsecond. Additionally, the higher bandwidth of reflective memory allows for the modeling of higher resolution cameras. This additional bandwidth allows for video resolution studies, whereby various resolutions can be presented to operators to help determine an adequate video resolution for the prescribed task.

E. Flight Dynamics Models

Currently, the flight dynamics model for the UAVs is based on non-linear, 6-degrees of freedom equations of motion[2]. It is configurable and cross-platform compatible. There are two tables that are loaded into the model to determine the aerodynamic, physical, and control system parameters for the model. Since the model is not based on any particular system, new air vehicles can be modeled by inserting different data sets. The USE environment was constructed in a manner that allows for new flight models to be rapidly integrated. This allows a single executable to represent different UAVs, which provides the benefit that all of the other processes that allow the UAV to interact with the outside world can stay the same. There are multiple built-in flight control systems available that range from low-level control surface commands to full autopilot control that commands vehicles through waypoints. For all planned USE studies, the UAVs are assigned waypoints, so the current flight model capabilities are sufficient.

The processing of the flight dynamics models is controlled by an in-house developed real-time executive called REX[3]. REX has the capability to run processes as a synchronous or asynchronous task. A synchronous task, such as the flight dynamics model, is run with a set time step. Every one-hundredth of a second, REX tells the flight-dynamics models to run and calculate a new position based on the forces applied to it. Some of the asynchronous tasks include the interfaces for the UAV to communicate with the GCS, the scene generation system and the FLAMES environment. These interfaces need to wait on the other side to send or receive data, so they are not synchronized with the processing of the flight dynamics models.

Weather effects are often ignored when dealing with larger, faster air vehicles that operate at thousands of feet in altitude. However, in urban simulations, these effects have a significant impact on operations. When navigating urban terrain, small air vehicles can be significantly affected by even low wind speeds. This is especially true when an operator is attempting to view a specific point on the ground or an air vehicle is being maneuvered around a structure. The USE includes wind modeling as part of its architecture. Models of steady-state winds and turbulence are inputs to the flight dynamics models. Currently this is done via a wind-field file lookup method. The current wind models do not take into account the interaction between wind fields and structure, such as those shown in Figure 8. The USE team is considering CFD-based models that incorporate the terrain and ground structures. As with the flight control system, the turbulence can be replaced with a higher fidelity model when needed.

F. Future Capabilities

Some of the capabilities that the USE team is currently developing include a global positioning system/inertial navigation system model and a better communication model.

In the current operation of the simulation, the UAV reports back to the operator station its exact location, which does not accurately portray the capabilities of small UAVs. As part of the flight dynamic model, it uses the equations of motion to calculate a change in position based on the applied forces. Real-world air vehicles use GPS or Inertial Navigation System (INS) devices to calculate their

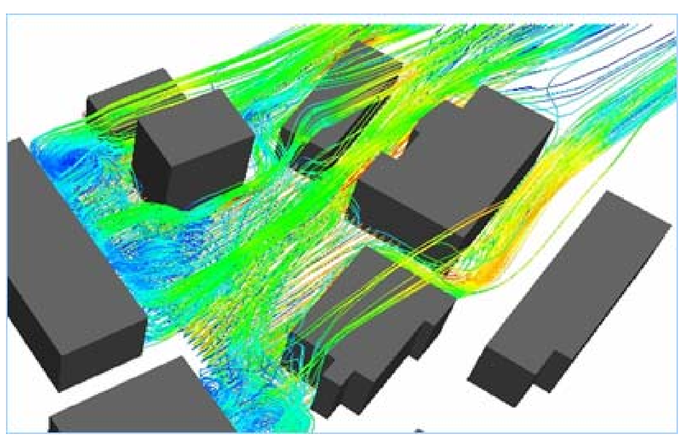

Figure 8. MOUT Site Wind Field. *Computer simulation effect that buildings place on winds. (Source AFRL/VACA).*

position, which experience errors, drop-outs, and jamming.

Communication models are also under development. This would come into play between the operator station and the UAV. Currently, there is an unlimited amount of bandwidth and no loss of signal. But realistically, this would not be the case. By modeling limited bandwidth and signal loss, the amount and quality of data that can be passed between the GCS and the UAVs will more accurately depict real-world scenarios. This would affect the amount of video data passed as well as introducing more realistic confusion and uncertainty.

IV. Multi Video Stream Study

The USE simulation capability is being used by Air Forces Research Laboratory Human Effectiveness Directorate to evaluate the effectiveness of operators viewing multiple simultaneous video streams. Initially, testing will involve the monitoring of multiple video streams with the additional aid of an automatic target recognition (ATR) that places an indicator around objects of interest. The USE is very well suited to this type of task, since a controlled experiment can be constructed using virtual worlds. Experiments can be made to be repeatable and deterministic. Similar real-world trials would have variable lighting and atmospheric conditions that would make such experiments more difficult to manage. Having control over the virtual world also enables engineers to design urban environments of varying levels of complexity.

The study will focus on the ability of the operator to identify targets amid a cluttered environment. Up to four simultaneous streams are presented to the operator. It is envisioned that data collected by this study will aid in the development and implementation of ATR technologies, and will serve as a baseline performance study.

The first spiral will examine the issues with multiple video streams and an ATR to highlight potential targets. The participant will have to monitor each stream in real-time and will only have the time that the target is in the field of view to identify the target. Participants will be given a description of targets, but they will not be given an example picture of the target. In these sessions, the UAV will start at the same location and fly a preset path. Participants will note the location of targets in the video windows via a mouse click. A set of scenarios will vary target placement, number of video streams and the level assistance from an automatic target recognition algorithm. Randomizing the location of the targets will prevent memorization of target location by participants. The targets are also placed so that the operator may or may not have multiple targets in the streams at the same time.

The number of video streams presented to the participant will vary between 1, 2, and 4 simultaneous streams in order to vary the amount of workload by the operator. Without any aid, an increase in the number of streams should result in a decrease in the performance of the operator.

An automatic target recognition algorithm is set up to identify a given percentage of targets in the scenario. Two rates have been selected for this study: 70% and 90%. The ATR will also have a one percent false alarm rate that will identify one percent of all vehicles, not just targets, as a potential target. This will add additional workload, since the operator can not rely on the ATR identifying targets automatically.

Targets will be pickup trucks similar to that shown in Figure 3. The target vehicles will be interspersed among non-target vehicles. It was determined that the trucks present a distinguishable difference from other vehicles while still requiring a significant level of workload for identification.

V. Conclusion

Urban environments are an area where effective real-world tests are difficult to conduct. Concern for public safety and airspace management problems preclude testing in cities. A simulation environment such as the USE eliminates any concerns about safety or of lost aircraft, while providing a cost effective testing solution. Given the special characteristics of urban environments, the USE will likely be used to conduct future simulations involving different types of technologies such as sensors, air vehicles types, cooperative control strategies, and operator interfaces. Being a simulation environment, it is relatively easy to modify parameters of the models and execute parametric studies to determine the effectiveness of different technologies or mixes of technologies.

References

[1] Flexible Analysis Modeling and Exercise System, URL: http://www.ternion.com [cited 22 Jun 2006].

[2] Rasmuessen, S. J. et al, "Introduction to the MultiUAV2 Simulation and Its Application to Cooperative Control Research", American Control Conference, Portland, OR, 2005, pp. 4495- 4496.

[3] Dube, T. and Snyder, A., "Real-Time Executive (REX)", AIAA Modeling and Simulation Technologies Conference, AIAA, Providence, RI, 2004.

[4] Environmental Systems Research Institute, Inc., "ESRI Shapefile Technical Description", URL: http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf [cited 28 Jun 2006].