



Modern Driver's Enhanced Vision Systems for Supporting and Enhancing ARFF Operations



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1. Introduction:

Modern Driver's Enhanced Visions Systems provide excellent opportunities to enhance ARFF navigation and therefore improve response times in adverse weather conditions. GPS and GIS are the driving technologies behind these systems. From individual vehicle navigation to "Command & Control" of the entire ARFF fleet from a remote location, DEVS provide reliable and robust means of improved navigation and situational awareness.

Modern systems also provide for dramatic improvements in communications via wireless networks, which support better data flow while keeping radio channels "uncluttered". Where radio and verbal communications were the only means of communication in the past, newer systems support text messaging and graphical reminders of certain circumstances and/or requests and commands.

Access to critical documentation and references is also a key component of modern DEVS systems. Whether documents are stored locally and/or accessed across wireless networks, ARFF personnel have the ability to have the information they need instantly. A typical DEVS library may include items such as MSDS sheets, aircraft schematics, emergency plans, list of critical phone numbers and more.

This paper is designed to provide information about the modern DEVS system and how it may be of benefit to ARFF operations.

NOTE:

Items relating to the optional wireless communications functionality are noted with a ✈ throughout the document.

2. Background:

Between January 1990 and February 1991, three major accidents involving fatalities occurred on active runways at night. ARFF efforts were impeded by poor visibility hindering the response to two of these accidents. Due to fog, the ARFF operators had difficulty locating the accident sites and were forced to drive slowly in order to avoid becoming lost or colliding with obstacles.

One of the goals for the ARFF vehicles is to arrive at the incident site as quickly as possible. However, during periods of poor visibility, ARFF response times tend to increase. In an effort to reduce these response times, the Driver's Enhanced Vision System is aimed at the three aspects of response in poor visibility:

- Locating the accident
- Navigating to the accident site
- Avoiding obstacles and people on the way to the accident site

The original DEVS consisted of a simple Forward Looking Infrared Camera (FLIR) which allowed ARFF responders to detect heat signatures within view of the camera (a typical FLIR includes pan, tilt, and zoom capabilities) and basic situational awareness (i.e. the vehicle is currently located at the approach end of runway 33L) via GPS.

The DEVS system has evolved dramatically over the past decade through technological advances and user feedback. Advances in GPS and mapping technologies have also allowed for more precise location information and more frequent and accurate moving-map position updates.

3. System Overview:

The modern DEVS is a moving-map navigation system, coupled with a FLIR camera views that assist rescue crews in finding their way to the site of an incident in low visibility conditions. Additionally, an optional wireless data link⁴ allows vehicle crews and command center to exchange critical information in order to react to changing situations and save lives. The modern DEVS system is designed to meet or exceed the FAA specifications for DEVS, as published in the FAA Advisory Circular 150/5210-19A, 14 CFR Part 139, and NFPA 414, Emergency Response Requirements.

The modern DEVS includes the following components:

- **Computer Display:** This computer display features a resistive touch screen for interacting with the moving-map and various applications. Additionally, a standard computer keyboard may be connected to the computer to allow for more efficient data entry when the vehicle is not in motion. The display is typically located in clear view of the driver (**Figure 1**). As an option, an additional display may also be installed for the officer (**Figure 2**). The officer's display is typically connected to its own computer (see "**Dual DEVS**" section below), but could also be configured to mirror the driver's.



Figure 1 – Driver's DEVS Display



Figure 2 – Officer's DEVS Display

- **DEVS Computer:** The DEVS computer is constantly powered on and ready. It is wired directly to the vehicle battery. The DEVS system is ready to assist with navigation at a moment's notice without wasting valuable time to boot the operating system and to load the DEVS software during an emergency response.
- **FLIR Display:** The Forward Looking Infrared Camera display (**Figure 3**) is a key component of the DEVS. During navigation the FLIR assists the vehicle operator to avoid obstacles such as aircraft, other vehicles, people, and stationary objects that may not be easily seen with a naked eye in low-visibility conditions. The FLIR image may be displayed on a dedicated screen in the vehicle or as a picture-in-picture capability on the DEVS Computer Display.



Figure 3 – FLIR Display

- **Global Positioning System (GPS) Receiver and Antenna:** DEVS uses the latest in GPS technology (**Figure 4**) to accurately determine the position of the equipped vehicle. Modern GPS receivers are capable of updating GPS position multiple times per second and with accuracy of two (2) feet or 60 centimeters. These receivers allow for increased position accuracy for ARFF vehicles to stay centered on paved surfaces even when navigating narrow areas such as service roads. Increased accuracy combined with a rapid update rate allows for a smooth scrolling of the moving-map and a very accurate display of the vehicle location at all times. GPS repeaters are also available so that the GPS signal can always be received even inside structures, such as the vehicle bay of the fire station. This allows for DEVS to maintain constant lock on satellites and to always be ready to navigate.



Figure 4 – Professional-Accuracy GPS Receiver Antenna

- **DEVS Software:** The software is the heart of the system and is designed to assist the driver with navigating in poor visibility by displaying the location of the vehicle and the location of other equipped vehicles on the moving-map display. The software also provides the user with a capability to quickly access an information library located on the computer. The library typically contains reference materials such as MSDS sheets, aircraft schematics, emergency plans, list of critical phone numbers and more.
- **Dual DEVS:** The Dual DEVS configuration includes two individual DEVS computers and monitors that are interconnected. Designed for ARFF vehicles staffed with two people, the Dual DEVS assists both team members in accomplishing their respective tasks. As an example, while the driver is using the moving-map features (**Figure 1**) and viewing the FLIR to navigate to the site of the incident on their computer, the officer is able to assist the driver in creating routes while also previewing pertinent information from the document library on their own DEVS workstation (**Figure 2**).

- **Optional Communication Module[↗]**: Sending data to and from equipped vehicles and or a base station/remote location is accomplished via various technology options including cellular, Wi-Fi, RF and Mesh networks. Please note that items relating to this optional wireless communications functionality are noted with a [↗] throughout the document.

3.1 The Modern DEVS Features and Attributes:

- **GPS/GIS Guided Map**: Using a high resolution aerial image or CAD drawing of the airfield and appropriate surroundings as the background, the modern DEVS depicts the location of the vehicle in use as well as any other equipped vehicles. More importantly the map provides visual guidance assisting the vehicle to navigate from the present position to the destination via visual cues and audible prompts. The map also displays a predicted ETA at the next waypoint and at the final destination based on vehicle's heading and speed (**Figure 5**).



Figure 5 – DEVS Guided Moving-Map

- **On-Board Information Storage**: Provides access to stored documents organized in a systematic manner (**Figure 6**). Allows the operator to quickly access the information library containing reference materials such as MSDS sheets, aircraft schematics, emergency plans, list of critical phone numbers and more. For example, ARFF responders may want to access the relevant documents for the B-737 (**Figure 7**) they are quickly approaching. Doing this electronically via touchscreen versus searching through a binder is much more efficient.

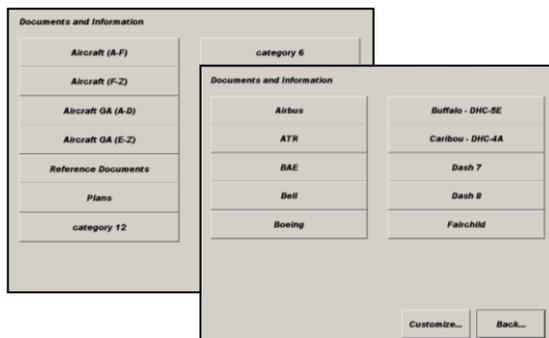


Figure 6 – On-Board Document Library Access Screen

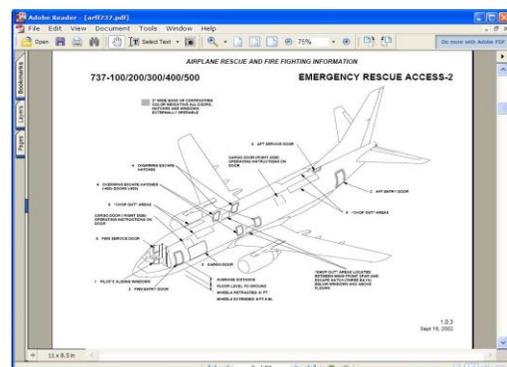


Figure 7 – Aircraft Schematic for B-737

- Identifying and Displaying the Location of an Incident:** By simply touching the map at the appropriate location and or downloading location information from another workstation on the system (possibly dispatch or the ATCT), a GPS based location by type of incident is depicted on the map (**Figure 8**).
- Route Creation, Management and Storage:** Allows for the easy creation, editing and storage of predetermined routes (from the fire station to the terminal as an example).
- Computer Generated Routes:** Allows for easy creation and editing for the most efficient route from A to B (**Figure 9**). The route determination algorithm is based on preset values and attributes (i.e. it is possible to drive faster when less turns are required and a higher rate of travel is possible on the runway and taxiways than around the terminal area or on a service road). The logic behind computer generated routes aims to maximize travel on paved surfaces as much as possible.



Figure 8 – Incident Type Selection



Figure 9 – Computer Generated Routes

- Creating Staging/Standby Areas:** Allows for easy creation, editing and storage of predetermined staging areas for various scenarios. These points can be vehicle specific.
- Incursion Warnings and Safety Management:** The RIWS is a critical part of the modern DEVS aimed at reducing the number of VPDs. This feature allows for easy creation, editing and storage of predetermined on screen visual warnings (**Figure 10**) and voice alert messages or audible tones against specific areas of the airfield, such as RSA boundaries, holding position markings, non-movement area boundary markings or any markings bordering the AOA that may cause an incursion or surface incident as well as easy creation of reminders for NOTAMS, construction areas (**Figure 11**), etc. Meeting or exceeding the performance specification in the FAA Advisory Circular 150/5210-25, the integrated RIWS feature as part of the DEVS, increases the operator’s situational awareness and assists in runway incursion prevention and increased safety while

operating on the airfield. The location and timing of incursion warnings is based on vehicle's speed and direction of travel, allowing for greater distance for the operator to react when traveling at a higher speed.



Figure 10 – Incursion Warning at a Hold Short Line



Figure 11 – Construction Area on DEVS

- **Accessing Critical CAD Layers:** CAD layers such as locations of airport fire hydrants (Figure 12) can be easily accessed and utilized during an incident (i.e. show me the location of the closet hydrant to the incident or to the current position of the vehicle).

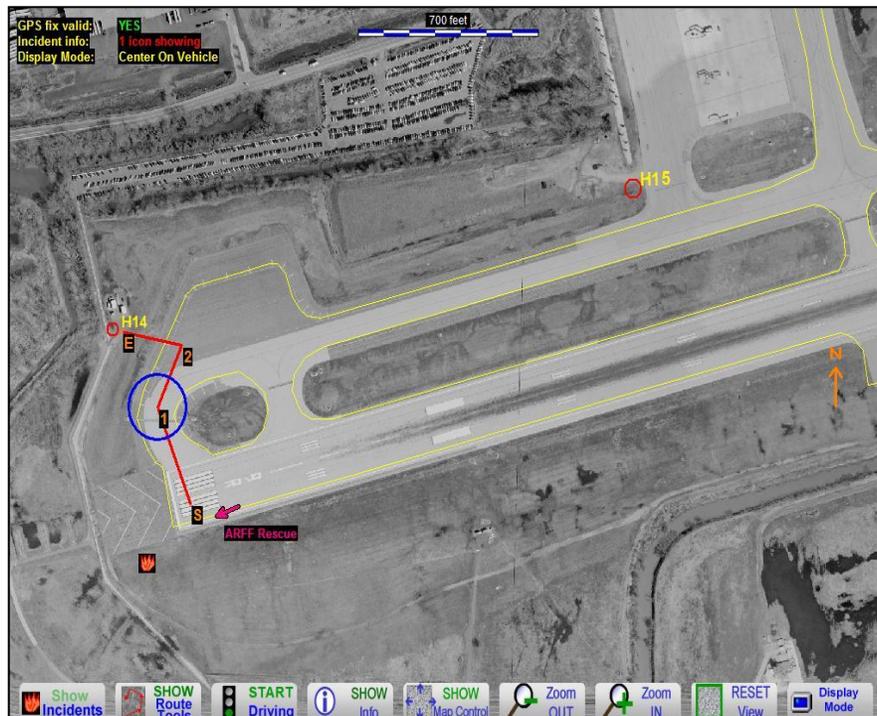


Figure 12 – Airport Hydrant Layer Overlay

- **Text and preset instant messaging**: Allows users to send and receive pre-set and or ad-hoc text messages (**Figure 13**) to other equipped vehicles such as emergency services (EMS, fire, and police).

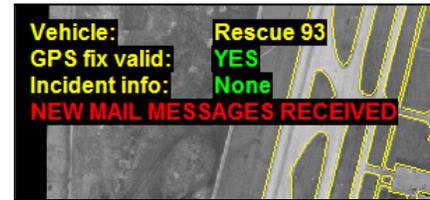


Figure 13 – Text Message Notification

- **Send screen shots**: Allows for the capture and transmission of on-screen information such as current location of vehicles and incident.

- **“Command and Control” (C&C) Software**: While the above attributes are largely devoted to stand-alone applications, Command and Control (**Figure 14**) from a remote location is possible using wireless networks to accomplish a number of important functions, including but not limited to directing vehicle traffic, making decisions regarding resource use etc., as a situation unfolds. The Command and Control workstation may be located in the incident command vehicle, dispatch, and/or the ATCT and provides capability for tracking all equipped vehicles, transmission of text messages, streaming of video and documents, alerts on vehicle actions, and many other tools. The C&C software can also be used to record and replay historical data as part of training and post-incident evaluation and analysis.



Figure 14 – Command and Control Software Display

3.2 Other features:

- **FOD Detection and Retrieval**: Modern DEVS systems are capable of integrating with FOD detection systems that generate a geographic coordinate (latitude and

longitude) for FOD being identified. DEVS can create a computer generated route to navigate right to the FOD location for immediate retrieval and removal.

- **Multiple Video Sources:** It is possible to link multiple cameras (back-up camera, forward looking video camera, etc.) and other video sources such as the FLIR to the DEVS for viewing images using a picture-in-picture capability on the DEVS computer display. This is an attractive feature to maximize the space in the cab. Much less cab real estate is required compared to the option of using stand-alone monitors for each camera output and the DEVS.
- **Heads-up Display:** The modern DEVS is capable of accommodating HUD to allow drivers to keep their focus on the road. The most popular version of this tool comes in the form of glasses, which simply put the display in the line of sight of the operator without having the operator to re-focus to accommodate viewing what is in front of them out the window. Other options that project images onto the windshield are available as well. HUD cannot serve as the sole interface to view the DEVS as the monitor for map interaction, viewing of the information stored in the document library, and display of the FLIR is still required.

4. Future Developments:

- Include aircraft locations on the DEVS display. This can be accomplished using a link to various surface surveillance systems such as ASDE/ASDE-X, ADS-B, and MLAT. This integration would display aircraft and ground vehicle locations on the airfield on the DEVS moving-map display. This would allow ARFF operators to not only see where the location of the potential incident aircraft is, but to also navigate there more efficiently by avoiding routes that may be blocked by aircraft and other vehicles.
- Link to Aircraft ELT (another industry idea) to allow for tracking of the aircraft during approach/incident. This may allow for easier, faster location and subsequent response.
- Live video, image, and document streaming⁴ is widely available and will be more commonplace in the future as wireless communications improve and cellular bandwidth grows. This capability allows for those not located at the site of the incident to see and be more directly involved in what is happening (**Figure 15**).

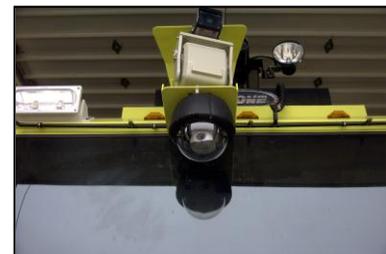


Figure 15 – ARFF Vehicle Equipped with Video Camera and Live Streaming

5. Training:

As DEVS is not typically used as an everyday resource, it is critical that ARFF teams, as with all equipment, train frequently on its use to ensure comfort and preparedness when the situation requires utilization of the system. It is recommended that DEVS be kept in sight or in peripheral view as a reference for situational awareness in all conditions and that ARFF departments include DEVS proficiency in their recurrent training programs.

6. Benefits Summary:

The modern DEVS can meet its original goals of:

- Locating the accident
- Navigating to the accident site
- Avoiding obstacles and people on the way to the accident site

In addition to the above, access to critical information, communications using both text messages and relevant graphical information, and overall situational awareness, from both the individual vehicle operator's perspective as well as Incident Command, can be improved.

The wireless communications capabilities⁴ also allow for improved overall situational awareness and communication as well as incident recreation and evaluation, which is very valuable for training and improvement for ARFF groups.

7. Acronyms

AC	Advisory Circular
ADS-B	Automatic Dependent Surveillance - Broadcast
AOA	Air Operations Area
ARFF	Aircraft Rescue and Fire Fighting
ASDE	Airport Surface Detection Equipment
ASDE-X	Airport Surface Detection Equipment – Model X
ATCT	Airport Traffic Control Tower
CAD	Computer-Aided Design
CFR	Code of Federal Regulations
DEVS	Driver's Enhanced Vision System
ELT	Emergency Locator Transmitter
ETA	Estimated Time of Arrival
FAA	Federal Aviation Administration
FLIR	Forward Looking Infrared Camera
FOD	Foreign Object Debris
GIS	Geographic Information System
GPS	Global Positioning System
HUD	Heads-Up Display
MLAT	Multilateration
MSDS	Material Safety Data Sheets
NFPA	National Fire Protection Association

NOTAMS	Notice to Airmen
OBIS	On-Board Information Storage
RF	Radio Frequency
RIWS	Runway Incursion Warning System
RSA	Runway Safety Area
VPD	Vehicle/Pedestrian Deviation
Wi-Fi	Wireless Fidelity – reference to Wireless Internet access

8. Relevant Documents and References

FAA Advisory Circular 150/5210-19A

FAA Advisory Circular 150/5210-25