U.S. Department
of Transportation

**Federal Aviation
Administration**

Advisory Circular

Subject: DRIVER'S ENHANCED VISION SYSTEM (DEVS)

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Initiated by: AAS-100

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Change:

1. PURPOSE. This advisory circular (AC) contains performance standards, specifications, and recommendations for DEVS.

2. APPLICATION. The FAA recommends the use of the guidance in this publication for the design and installation of DEVS equipment on Aircraft Rescue and Fire Fighting (ARFF) vehicles. The greatest benefits may be realized at airports with operations at a runway visual range (RVR) of less than or equal to 1200 feet. Under such visibility conditions, airports will often have a Surface Movement Guidance and Control System (SMGCS) Plan. Where Airport Improvement Program or Passenger Facility Charge program funds are used for the acquisition of DEVS, the guidance in this AC is mandatory.

3. RELATED READING MATERIAL. DOT/FAA/CT-94/99, *Driver's Enhanced Vision System (DEVS)*, final report, dated January 1995. This may be ordered from the National Technical Information Service, Springfield, VA, 22161; telephone (800) 553-6847.

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CHAPTER 1. INTRODUCTION

1. BACKGROUND. Between January 1990 and February 1991, three major accidents involving fatalities occurred on active runways at night. ARFF response was impeded to two of these accidents by poor visibility conditions. Due to fog, the accident site was difficult to locate, and ARFF operators were forced to drive slower to avoid becoming lost or colliding with obstacles.

For certification purposes, ARFF vehicles must demonstrate an emergency response time of 3 minutes to a simulated accident on an airport runway, with the goal to get to the accident site in as little time as possible. During periods of poor visibility, ARFF response times tend to increase. The Driver's Enhanced Vision System (DEVS) program, in an effort to reduce response times, is aimed at the three difficult aspects of poor visibility response: locating the accident, navigating to the accident site, and avoiding obstacles and locating people on the way to the accident site. Evaluations conducted at the FAA Technical Center and airports around the country have demonstrated that DEVS technology can improve a driver's ability in these areas. Where DEVS is installed, drivers would be required to receive training on DEVS operation.

2. DEVS SUBSYSTEMS.

a. Subsystem Components.

(1) Night Vision. The night vision subsystem shall use a Forward Looking InfraRed (FLIR) device or other comparable state-of-the-art night vision technology. Night vision capability will improve visual awareness in smoky, foggy, or dark environments by sensing thermal radiation instead of visible light.

(2) Navigation. The navigation subsystem shall make the ARFF vehicle driver aware of the vehicle's location and serve as an aid in locating the accident site. A Differential Global Positioning System (DGPS) will meet the specifications of this AC. Future alternatives must meet or exceed the capabilities of DGPS.

(3) Tracking. The tracking subsystem can be tightly integrated with the navigation subsystem through data link. Tracking capability will reduce driver communications work load and improve the situational awareness of the driver and command or dispatch personnel.

b. Subsystem Integration. DEVS is an integrated system consisting of all three subsystems: Night Vision, Navigation, and Tracking. Depending upon specific circumstances, individual airports may be able to show safety benefits at a lower cost by utilizing a subset of the complete DEVS.

3. THROUGH 4. RESERVED.

CHAPTER 2. DEVS PERFORMANCE REQUIREMENTS

5. GENERAL. The characteristics outlined in the following sections are meant to serve as a set of minimal performance requirements that DEVS equipment should meet for use at airports. Although the navigation and tracking subsystems are presented as individual subsystems, it is recommended that developers who offer both of these functions, offer them as one integrated navigation/tracking subsystem for sponsors purchasing both of these subsystems.

6. OVERALL REQUIREMENTS. Operation of DEVS should not increase driver work load or require an additional driver during emergency response. Installation should not obstruct driver view or hamper any other ARFF vehicle system. The system should be installed without extensive vehicle modification and should include sufficient filtering to protect itself from vehicle voltage spikes and surges. Power draw should be low enough to operate from vehicle power for a minimum of 4 hours without affecting other systems. Otherwise, an independent power supply should be provided. Recommended voltage range for DEVS equipment in ARFF vehicles is 10- to 15-VDC (Volts Direct Current) and 110- to 120-VAC (Volts Alternating Current) for equipment located at the Emergency Command Center (ECC). In addition, exposed equipment should be able to operate within the same conditions (weather, chemical, and otherwise) as that of the ARFF vehicle. Any component which fails to operate should be repaired and be back in service within 10 days. A video recording device may be an option to aid accident investigation as well as training and evaluation of the system.

7. QUALITY ASSURANCE. The quality and workmanship of an installation should follow normal industry standards and practices. These practices generally include the following: all electrical connections should be by locking pin type plugs, all wiring should be loomed, all penetrations in the vehicle body should be equipped with grommets or other guard to protect against wire chafing, all penetrations shall be sealed from the weather, all firewall penetrations shall be sealed, all splices should be soldered and then sealed with heat-shrink, wiring shall be color coded and identified from end to end, all controls shall be labeled and illuminated, and complete "as built" wiring diagrams shall be included with each installation.

8.-9. RESERVED.

Section 1. Night Vision Subsystem

10. OVERALL REQUIREMENTS. The night vision subsystem should be operational within 30 seconds and useful in 0-ceiling/0-mile visibility. As an option, a stand-by mode may be incorporated. The night vision subsystem should be able to detect people, debris, wreckage, and equipment for the distances and conditions specified in Tables 1 and 2.

TABLE 1. HUMAN DETECTION DISTANCES

Distance	Ambient Temperature ∗	Humidity (%)	Camera Dynamics	Weather
500 ft	-20 to 115° F	0 to 100	Moving 55 mph	Clear
500 ft	-20 to 115° F	0 to 100	Moving 50 mph	Light Fog
400 ft	-20 to 115° F	0 to 100	Moving 40 mph	Heavy Fog
400 ft	-20 to 115° F	0 to 100	Moving 40 mph	Smoke
300 ft	-20 to 115° F	0 to 100	Moving 35 mph	Rain/Snow

∗ If winterization is necessary, the temperature performance range shall extend to at least -40° F (-40° C).

TABLE 2. AIRCRAFT DETECTION DISTANCES

Distance	Ambient Temperature ∗	Humidity (%)	Camera Dynamics	Weather
2500 ft	-20 to 115° F	0 to 100	Moving 55 mph	Clear
1000 ft	-20 to 115° F	0 to 100	Moving 50 mph	Light Fog
500 ft	-20 to 115° F	0 to 100	Moving 40 mph	Heavy Fog
500 ft	-20 to 115° F	0 to 100	Moving 40 mph	Smoke
500 ft	-20 to 115° F	0 to 100	Moving 35 mph	Rain/Snow

∗ If winterization is necessary, the temperature performance range shall extend to at least -40° F (-40° C).

11. FLIR. The FLIR can be a cooled or uncooled camera but should be able to detect long wave (8-12 µm) IR energy and have an industry standard output. It also should have automatic gain and level controls and minimum Horizontal (HFOV) and Vertical Field of Views (VFOV) of 27° (± 4°) and 18° (± 4°), respectively.

a. Mounting. The FLIR should be mounted with remote controlled pan and tilt capabilities. It should be sufficiently tight so that the picture is clear and stable. Line of sight should be aligned with that of the driver. The mounting should not compromise operation of the roof turret in any manner.

b. Exposure Considerations. The FLIR should be weatherproof (rain, sleet, snow, dust, etc.) for the environment in which it will be used, able to withstand temperature and humidity changes, and have lens clearing capability. The equipment also should be protected from, or able to withstand exposure to, extinguishing foam, water, dry chemicals, and smoke.

12. DISPLAY. The display should have a 10-12-inch (25-30-cm) diagonal viewable image screen with a minimum density of 640 x 480 pixels. It should use an industry standard video format and have front adjustable brightness and contrast controls.

13. THROUGH 15. RESERVED.

Section 2. Navigation Subsystem

16. OVERALL REQUIREMENTS. The navigation subsystem should be able to compute a vehicle position solution within 30 seconds, and the ECC equipment should be able to generate GPS correction messages continuously (24 hours/day, 7 days/week). It should be accurate to 16 ft (5 m) 2D RMS (Two-Dimensional Root Mean Square). Vehicle position updates should be given once per second. Equipment should be automatically initialized upon start-up and able to withstand vehicle shock and vibration. The system should provide an integrity requirement to insure that it is either working properly or down altogether, allowing no possibility of wrong/misleading information.

17. VEHICLE NAVIGATION DEVICE. The vehicle GPS receiver should accept differential correction messages from an always available and reliable source with accuracy within 16 feet (5 m) and use these messages to compute a differentially corrected GPS position solution once per second. It also should achieve Time To First Fix (TTFF) of 30 seconds and should interface with the vehicle computer. The antenna should be weatherproof and mounted high in the center of the vehicle with a clear view of the sky.

18. VEHICLE COMPUTER. The computer should provide processing power and speed for DEVS navigation and mapping software while maintaining a 50 percent throughput capacity reserve. It also should carry sufficient, upgradable volatile and non-volatile memory (or a hard drive) and be able to interface with the vehicle display/control, data link, and GPS receiver equipment. The computer should be as small and lightweight (lap top size) as possible, as well as shockproof and waterproof. If the computer is not mounted in the panel, it should be mounted on a full-motion bracket that allows it to be stowed.

19. VEHICLE NAVIGATION/MAPPING SOFTWARE. The information displayed on the map should include primary and secondary roadways, all surfaces of the airport movement area, fences, and significant buildings, landmarks, and bodies of water. Other information can be displayed, but consideration should be given so that the map is not too complicated. Software should allow for zooming, panning, and selecting a variable-sized area for full screen display.

a. Map Detail and Orientation.

(1) Level 1. This is the **driving area** (approximately one half mile in front of the vehicle in the heading-up orientation). If the map is zoomed in or beyond this level, the vehicle icon should remain fixed and the map should translate and rotate to maintain this position with a heading-up orientation.

(2) Level 2. This level corresponds to the Airport Operational Area (AOA). The map should translate and rotate to maintain a heading-up orientation.

(3) Level 3. This is the entire airport property, including unimproved access roadways, plus the area surrounding the airport up to the ARFF department's response radius. The map should translate and rotate to maintain a heading-up orientation. As an option, the airport's grid map may be integrated at this level.

b. Visual Cues. Visual cues for orientation should be displayed on screen.

20. VEHICLE DATA LINK. The vehicle navigation data link should be able to receive DGPS correction messages, employ industry standard error checking algorithms, and interface with the computer. The ECC navigation data link should use available communications frequencies whenever possible.

21. VEHICLE DISPLAY/CONTROL. The display should provide at least 16 colors with front adjustable brightness and contrast controls (contrast ratio of 3:1) and have a 10-12-inch (25-30-cm) diagonal viewable image screen with a minimum density of 640 x 480 pixels. A Transparent Window Display System (TWDS), a Head Up Display (HUD), or an industry standard head down display (if mounted near natural line of sight) can be used. It also should be seen easily by the driver while not obstructing the view, require minimal operator intervention to control, use an industry standard digital format, and interface with the vehicle computer and operator.

22. DGPS BASE STATION GPS RECEIVER. The DGPS base station GPS receiver should be able to track the same satellites tracked by ARFF GPS receivers. To ensure this, an **all in view** receiver should be used with a minimum of eight channels (twelve preferable). The receiver should generate differential correction messages with accuracy within 16 feet (5 m) and be always available and reliable. It also should compute a position solution once per second, be capable of continuous operation, and interface with the ECC navigation computer. The antenna should be mounted with a clear view of the sky on a survey monument or a surveyed position accurately determined to within 3 feet (91 cm).

23. ECC COMPUTER. The ECC computer is that which controls the DGPS base station and is usually located at the ECC. This computer can be an integral part of the DGPS base station GPS receiver. If it is not, the following performance requirements apply.

The ECC computer should provide the required power and speed to support DEVS navigation software and still have a 50 percent throughput capacity reserve. It also should have sufficient, upgradable volatile and non-volatile memory, use a hard drive to support the navigation software, and be small and lightweight (desk top PC size). The computer should interface with the DGPS base station receiver, the ECC data link equipment, and the computer display/control equipment. Some means for supplying DGPS corrections may obviate the need for the base station and interfaces to it.

24. ECC DGPS SOFTWARE. The software controls the flow and timing of DGPS correction messages from the base station receiver to the data link equipment. Some means for supplying DGPS corrections may obviate the need for DGPS software in the ECC.

25. ECC DATA LINK. The data link should be capable of transmitting DGPS correction messages with built-in error checking or correcting codes. It also should transmit with sufficient power to broadcast correction messages to the extremes of the normal expected response area which may vary with the airport. In addition, it should use available communications frequencies, when possible, and interface with the ECC computer.

26. ECC DISPLAY/CONTROL. These requirements pertain to the display/control equipment if the ECC computer is not an integral part of the DGPS base station GPS receiver.

The display should have at least 16 colors, be industry standard cathode-ray tube (CRT) or active matrix liquid crystal display (AMLCD), and have, at minimum, a 14-inch (35 cm) diagonal viewable image screen. It should have front adjustable brightness and contrast controls (contrast ratio of at least 3:1), use industry standard control devices, and use an industry standard digital format. The display/control should interface with the ECC computer and computer operator.

27. THROUGH 30. RESERVED.

Section 3. Tracking Subsystem

31. GENERAL. The tracking subsystem should derive vehicle position data from the navigation subsystem. The tracking subsystem should be able to report the vehicle position to, and exchange messages with, the ECC within 30 seconds and have the capability to do so continuously (24 hours/day, 7 days/week). It should be able to track 10 vehicles simultaneously with 1-second updates and be able to track any number of vehicles simultaneously with a maximum update time of 5 seconds. The tracking subsystem should be automatically initialized upon start-up, require minimal operator intervention, and be able to withstand vehicle shock and vibration.

32. VEHICLE COMPUTER. The tracking subsystem should use the same computer hardware as the navigation subsystem. The computer should provide power and speed to support DEVS while maintaining a 50 percent throughput capacity reserve, and it should have sufficient, upgradable volatile and non-volatile memory (or a hard drive). The computer should interface with the vehicle display/control and data link equipment. It also should be as small and lightweight as possible, as well as shockproof and waterproof. If the computer is not mounted in the panel, it should be mounted on a full-motion bracket that allows it to be stowed.

33. VEHICLE TRACKING SOFTWARE. The vehicle tracking software should format and transmit vehicle position reports to the ECC once per cycle and be able to transmit airport definable asset request messages (police, fire, ambulance), position markers, and special messages to the ECC by touching a single button. The current vehicle location should be indicated by an icon on the vehicle map display, and the marked location should be transmitted to the ECC.

a. Accident Site Location. An icon indicating the accident site, or direction and distance of the accident site (if site is off map), should be displayed.

b. Text Message. Informational text messages from the ECC should display automatically on screen and be cleared and acknowledged (to the ECC) with the touch of a button.

34. VEHICLE DATA LINK. The vehicle tracking data link equipment should be capable of receiving accident location and text messages from the ECC; of transmitting vehicle position reports, vehicle mark reports, and asset request messages to the ECC; and of checking messages through industry standard algorithms. A message transmission handshake should be established between the vehicle and the ECC. The data link should use available communications frequencies, have enough power to transmit messages to the extremes of the normal expected response area which may vary with the airport, and be able to interface with the vehicle computer.

35. VEHICLE DISPLAY/CONTROL. The tracking subsystem should use the same display/control hardware as the navigation subsystem. The display should have a 10-12-inch (25-30-cm) diagonal viewable image screen with a minimum density of 640 x 480 pixels, provide at least 16 colors, be of any type capable of providing required brightness and contrast, and have front adjustable brightness and contrast controls (contrast ratio of at least 3:1). The display also should require minimal operator intervention to control, use an industry standard digital format, interface with the vehicle computer and vehicle operator, and be easily seen without obstructing the driver's view.

36. ECC COMPUTER. The tracking subsystem should use the same computer hardware as the navigation subsystem. The ECC computer should provide sufficient power and speed while maintaining a 50 percent throughput capacity reserve and also provide sufficient, upgradable volatile and non-volatile memory. A sufficient hard drive should be used yet the computer should be as small and lightweight (desk top PC size) as possible with the capability to interface with the ECC data link and control/display equipment.

37. ECC TRACKING SOFTWARE. The ECC tracking software should display the locations of DEVS equipped ARFF vehicles on a digital map of the airport surrounding area. Information on the map should include primary and secondary roadways, all surfaces of the airport movement area, fences, and significant buildings, landmarks, and bodies of water. Other information can be displayed, but consideration should be given so that the map is not too complicated. The mapping software should have the capability of zooming, panning, and also selecting an area for full screen display.

a. Map Detail.

(1) Level 1. This is an area approximately one half mile around the vehicle.

(2) Level 2. This level corresponds to the AOA.

(3) Level 3. This is the entire airport property, including unimproved access roadways, plus the area surrounding the airport up to the ARFF department's response radius. As an option, the airport's grid map may be integrated at this level.

b. Map Icons. Icons should indicate vehicle positions and have an identification tag. They also should move to indicate locations or show the last position and direction of the vehicle (if outside the map boundary).

38. ECC DATA LINK. The ECC tracking data link should receive position reports, position marks, and asset request messages from vehicles; transmit accident location and text messages to vehicles; and transmit with sufficient power to reach to the extremes of the normal expected response area which may vary with the airport. It should use available communications frequencies, interface with the ECC computer, and employ industry standard error checking algorithms (check sums, parity checks) to ensure correct message receipt and transmission. It also should employ a message transmission handshake.

39. ECC DISPLAY/CONTROL. The tracking subsystem should use the same display/control hardware as the navigation subsystem. The display should have, at minimum, a 14-inch (35 cm) diagonal viewable image screen, provide at least 256 colors, be of an industry standard CRT or AMLCD type, and have front adjustable brightness and contrast controls (contrast ratio of at least 3:1). It also should use industry standard computer control devices, use an industry standard digital format, and be able to interface with the ECC computer and computer operator.