U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: DRIVER'S ENHANCED VISION SYSTEM (DEVS)

Date: June 12, 2009

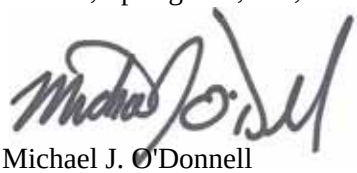
AC No: 150/5210-19A

Initiated by: AAS-100

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. In general, use of this AC is not mandatory. However, use of the AC is mandatory for all projects funded with federal grant monies through the Airport Improvement Program (AIP) and with revenue from the Passenger Facility Charges (PFC) Program. See Grant Assurance No. 34, "Policies, Standards, and Specifications," and PRC Assurance No. 9, "Standards and Specifications."

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 or online at www.ntis.gov.



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CHAPTER 1. INTRODUCTION

1. BACKGROUND. For airport operating certificate purposes, Aircraft Rescue and Fire Fighting (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 four difficult aspects of poor visibility response: 1. locating the accident, 2. navigating to the accident site, 3. avoiding obstacles, 4. 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. System. DEVS is an integrated system consisting of three subsystems: Low-Visibility Vision Enhancement, Navigation, and Tracking. Depending upon their configurations and operational requirements, individual airports may be able to show safety benefits at a lower cost by utilizing a subset of the complete DEVS.

b. DEVS Components.

(1) Vision Enhancement. The Low-Visibility Enhanced Vision subsystem must use a Forward Looking InfraRed (FLIR) device or other comparable state-of-the-art low-visibility enhanced vision technology. The low-visibility enhanced 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 must make the ARFF driver aware of the vehicle's location and serve as an aid in locating the accident site. A minimum 12 channel Wide Area Augmentation System (WAAS) enabled or a Beacon Differential Global Positioning System (DGPS) will meet the specifications of this AC.

(3) Tracking. The tracking subsystem may be integrated with the navigation subsystem through a data link. A tracking capability will reduce driver communications work load and improve the situational awareness of the driver and command and or dispatch personnel. This system also allows the operator to see and interact with other DEVS equipped vehicles.

3. THROUGH 4. RESERVED.

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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 must meet for use at airports. Although the navigation and tracking subsystems are presented as individual subsystems, it is recommended that manufacturers 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 must not increase driver work load or mandate an additional driver during an emergency response. The equipment installation must not obstruct the driver's view or hamper the operation of any other ARFF vehicle system.

a. Vehicle Modifications. The DEVS system must be capable of being installed without requiring extensive modifications to the ARFF vehicle body, cab, or electrical system

b. Power Requirements. DEVS power requirements must allow operation from the vehicle battery power bus for a minimum of 1 hour without adversely affecting other systems. Equipment that is installed on the ARFF vehicle battery power bus must be designed to withstand up to ± 20 percent voltage variations from the nominal power bus voltage, alternator load dumps, voltage spikes/transients/noise and be protected from reverse polarity. DEVS equipment installed at the Emergency Command Center (ECC) or other designated site must be designed to operate from a nominal 115 volts alternating current (VAC) power source and accommodate voltage variations up to ± 20 percent of the nominal source voltage.

c. Equipment Environmental Protection. Exposed DEVS equipment must be able to operate within the same environmental conditions (weather, chemical, and otherwise) as that of the ARFF vehicle.

d. Equipment Repair. The manufacturer must maintain an inventory of spare components to ensure that any failure can be repaired within a maximum of 10 calendar days.

e. Video Recording. The manufacturer may offer an optional (specified by the airport) video recording device to aid with accident investigation as well as training and evaluation of the system if specified by the airport.

7. QUALITY ASSURANCE. The quality and workmanship of an installation must follow best industry standards and practices. These practices generally include the following: all electrical connections must be by locking pin type plugs, all wiring must be loomed, all penetrations in the vehicle body must be equipped with grommets or other guard to protect against wire chafing, all penetrations must be sealed from the weather, all firewall penetrations must be sealed, all splices must be soldered and then sealed with heat-shrinkable tubing (crimp connections are permitted if the proper crimping tool and connection terminals are used), wiring must be color coded and identified from end to end, all controls must be labeled and illuminated, and complete "as built" wiring diagrams must be included with each installation.

8. THROUGH 9. RESERVED.

Section 1. Low-Visibility Enhanced Vision Subsystem

10. OVERALL REQUIREMENTS. The low-visibility enhanced vision subsystem must be operational within 30 seconds (or an alternate time that may be specified by the user based on operational considerations) and useful in 0-ceiling/0-mile visibility.

The subsystem must be able to detect people, debris, wreckage, and equipment for the distances and conditions per 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 must 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 must extend to at least -40° F (-40° C).

11. FLIR. The FLIR sensor must be able to detect long wave (8-12 µm) infrared (IR) energy. The sensor array resolution must be a minimum of 320 horizontal by 240 vertical pixels. The camera must provide an industry standard composite (with automatic gain and level control) or digital video output. It also must have a minimum Horizontal (HFOV) and Vertical Field of View (VFOV) of 27° (± 4°) and 18° (± 4°), respectively.

a. Mounting. The FLIR device must be mounted with remote controlled pan and tilt capabilities and must be designed so that the picture is clear and stable while the ARFF vehicle is in motion. The sensor line of sight must be aligned with that of the driver. The sensor mounting location must not compromise operation of the ARFF vehicle roof turret in any manner.

b. Exposure Considerations. The FLIR device and its housing must be capable of withstanding the same outdoor environment as the ARFF vehicle (exposure to fire extingusihing agents, water, and dense smoke included). The FLIR device and housing must be designed with a means of clearing accumulated water and/or dust/debris from exposed optical surfaces without degrading the transmission quality.

12. DISPLAY. If the display is not integrated with a DEVS computer, it must have a 10-12-inch (25-30 cm) diagonal viewable image screen with a minimum resolution of 640 horizontal x 480 vertical pixels and be capable of displaying industry standard composite video. A thin film transistor (TFT) liquid

crystal display (LCD) is recommended because of its low power requirements and immunity to shock and vibration. The display must have adjustable brightness and contrast controls accessible on the front panel.

13. THROUGH 15. RESERVED.

Section 2. Navigation Subsystem

16. OVERALL REQUIREMENTS. The navigation subsystem must be able to compute a vehicle position solution within 30 seconds (or an alternate time that may be separately specified by the user based on operational considerations). The ECC equipment must be able to generate Global Positioning System (GPS) correction messages continuously (24 hours/day, 7 days/week). It must be accurate to at least 16 ft (5 m) 2D-RMS (Two-Dimensional Root Mean Square) - 95 percent of the time. Vehicle position updates via GPS must be at least once per second. Equipment must be automatically initialized upon start-up and able to withstand vehicle shock and vibration. The system must provide an integrity requirement to ensure that it is either working properly or down altogether, allowing no possibility of wrong/misleading information.

17. VEHICLE NAVIGATION DEVICE.

a. GPS Receiver. The vehicle GPS receiver must accept differential correction messages (internal WAAS capability or a Differential Service Provider). The receiver must be a minimum 12 channel parallel type with all in view tracking capability. The vehicle position accuracy must be within 16 feet (5 m) horizontal 2D-RMS-95 percent of the time.

b. Antenna. The antenna must be weatherproof and mounted high in the center of the vehicle with a clear view of the sky.

18. VEHICLE COMPUTER. The in-vehicle computer selected must be sufficiently robust to provide reliable operation in an automotive type of environment. This means that the computer must withstand exposure to shock, vibration, dust ingress, moisture, and periods of heat and cold that would adversely affect the operation of commercially available laptop portable personal computers. The computer must also provide sufficient processing power to execute DEVS navigation software, interface GPS data from the GPS receiver, interface to the data link for transmit/receive to/from the ECC, keyboard, mouse, and graphics interface for driving a display. The computer must be as small and lightweight as possible. If the computer is not panel or floor mounted, it must be mounted on a full motion bracket that allows it to be stowed. The monitor must allow for touch screen interaction.

a. Computer Ambient Environment Specification. The following specification applies to the computer, keyboard, and display:

Operating temperature range:	-4º Fahrenheit (F) to 140º F (-20º Celsius (C) to 60º C)
Storage Temperature Range	-40º F to 167º F (-40º C to 75° C)
Dust resistance:	Protected against the ingress of dust that could adversely affect keyboard, data communications ports, and mechanical functions.
Humidity:	Operating: 95% relative humidity at 140º F (60º C).

Water resistance:	Resistant to dripping water arising from condensation and spills.
Vibration resistance:	Resistant to damage caused by ARFF vehicle vibration while in operation over rough terrain and firefighting activities (4.5g rms 5-500 Hz Sine).

b. Portable Computer. The DEVS manufacturer may elect to use a portable (laptop) computer with an integrated display that mounts on a full motion bracket. The portable computer must meet all the requirements applicable to a panel or floor mounted computer. Any cables required for interfacing the computer to external equipment must be routed so that they will not interfere with the safe operation of the vehicle or limit the driver's vision through the vehicle windshield.

19. VEHICLE NAVIGATION/MAPPING SOFTWARE. The information displayed on the map must include primary and secondary roadways, all surfaces of the airport movement area, fences, significant buildings, landmarks, and bodies of water. In addition, the software must allow the ARFF vehicle crew to store & access user defined critical documents (for example: aircraft crash charts or hazardous material references). Other user defined information may be made available and displayed by providing the ability to turn on/off the information as required. The map must not be so complicated or crowded that its readability is compromised. The system software must 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 must remain fixed and the map must be capable of translating and rotating to maintain this position with a heading-up orientation.

(2) Level 2. This level corresponds to the Airport Operational Area (AOA). The map must 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 must translate and rotate to maintain a heading-up orientation. As an option specified by the airport, the airport's grid map may be integrated at this level.

b. Visual Cues. Visual cues for proper map/vehicle orientation must be displayed on the vehicle display. The following options are recommended and may be specified by the airport:

(1) Incident Location. The ability for the operator to locate the incident via menu or radio button on the touch screen monitor.

(2) Routing. The ability for the operator to determine a route from his/her location to the incident location by one of the following:

(a) Pre-loaded route. The capability of allowing the operator to create and store pre-defined routes (for example, fire hall to terminal #1).

(b) Automatically created route. The capability to determine the quickest hard surface route from the vehicle location to the incident location.

(c) Manually created route. The capability to allow the operator to touch the points between his/her location and the incident location to determine the route he/she will use.

(3) Navigation support. The system must provide both visual and audible indications to help the operator stay on course towards the incident.

(a) The ability for the system to provide an expected time of arrival (ETA), based on GPS , for both the next point/turn in the route and the final destination.

(b) Provision of audible voice commands to indicate the relative progress and instructions against the defined route. The voice may be male/female and may be turned off/on as required. Volume may also be altered as required.

(4) Staging areas/scenario planning. The ability to allow the operator to preset and save scenarios such as staging areas for various scenarios/configurations. This will allow the operator to quickly set up the incident operation if the feature is selected.

(5) Drawing tools. The ability for the operator to create zones on the map and be able to attribute logic to these zones as required.

(a) Incursion areas. The ability for the operator to set up a zone as an alert for entry to airport movement areas (active runways, taxiways, and ramps) where an incursion could create a safety hazard.

(b) Other Hazards. The ability for the operator to easily create areas via menus and the touch screen that are identified with obstacles and or obstructions (for example: Hazards identified in Notices to Airmen (NOTAMs), foreign object damage (FOD), construction areas, snow and ice, standing water).

(6) The ability to configure any of the zones, routes, and areas to warn the operator if a route will cross them. With this option, the operator will be able to choose whether or not to accept/reject a warning via a radio button or menu on the touch screen display.

(7) CAD Layers. The ability to import, store, and display airport computer aided design (CAD) layers from the airport Geographic Information System (GIS). The GIS information must be the basis to improve the operator's ability to display information critical to the accident location (for example: fire hydrants and underground power distribution).

20. VEHICLE RADIO FREQUENCY (RF) DATA LINK. If specified, the vehicle data link control function must be integrated within the vehicle computer (RF MODEM excluded). The RF data link equipment must also be capable of:

- receiving accident location and text messages data from the ECC.
- transmitting vehicle track data to the ECC.
- Transmitting asset request messages to the ECC.
- Receiving/transmitting informational text messages from/to the ECC that should display automatically on screen and be cleared and acknowledged (to the ECC) with the touch of a button.

The radio data link must use frequencies that are approved for use on the airport by the Regional FAA Spectrum Management Office. In addition, the equipment must meet all applicable Federal Communications Commission (FCC) requirements per Title 47, Telecommunications, Part 15, Radio Frequency Devices, and any additional requirements imposed by the FAA Spectrum Management Office. Antennas mounted on the vehicle must not interfere with or be shadowed by any external equipment.

21. VEHICLE DISPLAY/SYSTEM CONTROL. The display must provide at least 256 colors with adjustable brightness and contrast controls on the front panel. The display must have a 10-15 inch (25-37 cm) diagonal viewable image screen with a minimum of 640 horizontal x 480 vertical pixels. The display must be easily readable in bright daylight since its location is likely to be near the vehicle windshield. The display must also provide sufficient brightness range so that it does not potentially blind the driver at night. The manufacturer may shield the display from ambient light to ensure maximum readability. A cathode ray tube (CRT) type of display is not permitted for the ARFF vehicle. The display must be resistant to the effects of vehicle operation (shock, vibration, humidity, dripping water, and dust/smoke) per the computer requirements in Section 18. 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) may be used. It also must be seen easily by the driver while not obstructing the view from the vehicle windshield and require minimal operator intervention to control (a touch screen display is highly recommended). The display must use an industry standard digital format and interface with the vehicle computer.

22. OPTIONAL DGPS BASE STATION GPS RECEIVER. The DGPS base station GPS receiver must use an all in view tracking receiver with a minimum of twelve parallel channels. The differential corrections receiver (if not integrated with the GPS receiver) must output differential correction messages via an industry standard serial data link to the ECC computer. The DGPS position accuracy must be within 16 feet (5 m) 2D-RMS-95 percent of the time. It also must compute a position solution at least once per second. The GPS and DGPS antenna must be mounted with a clear view of the sky on a survey monument or a surveyed position with an accuracy of ± 3 feet (0.9 meters).

NOTE: *WAAS based GPS receivers do not require a separate antenna.*

23. ECC COMPUTER. The ECC computer and application software/hardware provides interaction with all DEVS equipped vehicles during an incident. The ECC computer may be designed for either fixed or mobile operation (specified by the airport).

a. Mobile ECC. If the ECC is mobile, the computer requirements in Section 18 are applicable.

b. Fixed ECC. If the ECC is at a fixed location within a heated and air conditioned building, a commercially available personal computer (PC) will be adequate. The PC must have sufficient hard disk drive space to accommodate the tracking software requirements and any log, temporary, or scratch files required during program execution. There must be sufficient random access memory (RAM) available to enable program execution and general computer housekeeping functions. The PC must have sufficient serial connector jacks (Example: universal serial bus (USB or EIA-232)) available to enable connection of the GPS receiver, differential receiver (if not integrated with the GPS), and any external data required for wireless data vehicle tracking data or other communications. It is recommended that a separate graphics processor circuit card be used if vehicle tracking functions are used - this will avoid the possibility of loading the processor while generating/updating track data. A portable computer may be used for this application if the display and data port configurations are adequate.

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. This control software is not required at the ECC if the DGPS function is integrated into the vehicle GPS receiver/computer.

25. ECC RADIO DATA LINK. The radio data link must be capable of transmitting DGPS (not applicable to WAAS enabled GPS receivers or equipment with integrated differential receivers) correction messages and any other command center data messages with built-in error checking or correcting codes. The radio must transmit with sufficient RF output power to broadcast correction messages and other data to the extremes of the normal expected response area which may vary with the airport topography. Regional FAA Spectrum Management & FCC rules must be consulted about available frequencies and maximum transmit power levels prior to operation of any radio data link on the airport. In addition, the equipment must meet all applicable Federal Communications Commission (FCC) requirements per Title 47, Telecommunications, Part 15, Radio Frequency Devices, and any additional requirements imposed by the FAA Spectrum Management Office. Antennas mounted on the vehicle must not interfere with or be shadowed by any external equipment.

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.

a. Mobile ECC. If not integrated with the ECC computer, the display must be a minimum of 14 diagonal inches. A CRT display is not permitted for mobile use. The display must be resistant to the effects of vehicle operation (vibration and shock) per the environmental requirements in Section 21.

b. Fixed ECC. If not integrated with the ECC Computer, the display may be any commercially available type to currently available industry standard display resolution.

27. THROUGH 30. RESERVED.

Section 3. Tracking Subsystem

31. GENERAL. The tracking subsystem must derive the vehicle position data from the navigation subsystem. The tracking subsystem must be able to report the vehicle position to, and exchange messages with, the ECC within 30 seconds (or an alternate time that may be specified by the user based on operational considerations) after system initialization. It must be able to track a minimum of 50 vehicles simultaneously with 3 second maximum position updates to the ECC/base station. The tracking subsystem must be automatically initialized upon start-up and require minimal operator actions or intervention.

32. VEHICLE TRACKING SOFTWARE. The vehicle tracking software must compute and format its vehicle track data position reports to the vehicle computer a minimum of once every 3 seconds and be capable of transmitting 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 and track must be indicated by an icon on the vehicle map display. A capability to display vehicle track history with icons must also be included and be selectable by the vehicle driver or DEVS operator.

a. Accident Site Location. The vehicle tracking software (or a related software module) must generate an icon (either manual or automatic). It must also be able to provide for automatic generation in conjunction with other data sources such as ground based radar and aircraft emergency locators (if available) that indicates accident site, or direction and distance to the accident site (if site is off map) should be displayed.

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

33. ECC TRACKING SOFTWARE. The ECC tracking software must display the locations of DEVS equipped ARFF vehicles and other equipped vehicles on a universal transverse mercator (UTM) based air photo map of the airport surrounding area. Information on the map must include primary and secondary roadways, all surfaces of the airport movement area, fences, and significant buildings, landmarks, and bodies of water. Other information may be displayed, but consideration should be given so that the map is not too complicated. The mapping software must 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 grid map may be integrated at this level and specified by the airport.

b. Map Icons. Icons must indicate vehicle positions and have an identification tag. They also must update with changing vehicle track data to indicate locations or show a track history and the last position and direction of the vehicle (if outside the map boundary).

c. Visual Cues. Visual cues for proper map/vehicle orientation must be displayed on screen.

d. Incident Location. The operator must be able to view the incident location via a radio button or menu on the touch screen monitor.

e. Routing. The operator must be able to determine a route from his/her location to the incident location via one of 3 means:

(1) Pre-loaded route- the system must have he capability of allowing the operator to create and store pre-defined routes (i.e. fire hall to terminal #1).

(2) Automatically created route: the system must have the capability to determine the quickest hard surface route from the vehicle location to the incident location.

(3) Manually created route: the system must have the capability to allow the operator to touch the points between his/her location and the incident location to determine the route to be taken.

f. Staging Areas/Scenario Planning. The system must allow the operator to preset and save scenarios such as staging areas for various scenarios/configurations. This will allow the operator to quickly set up the incident operation should he/she choose to use this feature.

g. Drawing Tools. The system must allow an operator to create zones on the map and be able to attribute logic to these zones as required.

(1) Incursion areas. The operator must have the ability to set up a zone to remind him/her of a dangerous area such as the approach from the non-active side of a stop bar, when his/her vehicle enters the pre-defined zone.

(2) Hazards. Areas identified with obstacles and or obstructions such as but not limited to FOD, NOTAMs, snow and ice, standing water etc. must be easily created using the system and the touch screen.

(3) The system must have the ability to setup any of the above zones and areas to warn the operator if a route, per the descriptions above, will cross through one of these zones/areas. The operator must have the choice on what to do with this warning (i.e. accept and be re-routed around or continue through).

h. CAD Layers. The system must be capable of storing and displaying airport CAD layers for the purpose of improving the operators ability to see critical information such as but not limited to fire hydrants, underground utilities, topography etc.

34. ECC DATA LINK. The ECC tracking data link must 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 must use FAA Regional Spectrum Management and FCC approved 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 must employ a message transmission handshake.

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