MISSILE FLIGHT SAFETY AND TELEMETRY AT WHITE SANDS MISSILE RANGE

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ABSTRACT

Missile Flight Test Safety Managers (MFTSM) and other flight safety personnel at White Sands Missile Range (WSMR) constantly monitor the realtime space position of missile and airborne target vehicles and the telemetered missile and target vehicle performance parameters during the test flight to determine if these are about to leave Range boundaries or if erratic vehicle performance might endanger Range personnel, Range support assets or the nearby civilian population. WSMR flight safety personnel rely on the vehicle telemetry system to observe the Flight Termination System (FTS) parameters. A realtime closed loop that involves the ground command-destruct transmitter, the vehicle command-destruct receiver (CDR), other FTS components, the missile S-band telemetry transmitter, and the ground telemetry acquisition/ demultiplex system is active when the vehicle is in flight. The FTS engineer relies upon telemetry to provide read-back status of the flight termination system aboard the vehicle.

WSMR flight safety personnel use the telemetry system to assess realtime airborne vehicle systems performance and advise the MFTSM. The MFTSM uses this information, in conjunction with space position information provided by an Interactive Graphics Display System (IGDS), to make realtime destruct decisions about missiles and targets in flight.

This paper will aid the missile or target developer in understanding the type of vehicle performance data and FTS parameters WSMR flight safety personnel are concerned with, in realtime missile test operations.

Key Words: Flight Safety, Command-destruct System, Auto-destruct or fail safe, Flight Termination System (FTS), Telemetry, and Graphics Display System.

WHITE SANDS MISSILE RANGE

The Test Range opened on July 9, 1945 as White Sands Proving Ground. WSMR is located in south central New Mexico and is approximately 100 miles north to south and 40 miles east to west in size at an altitude of 4000 ft MSL. It is bounded by El Paso, TX to the south, Las Cruces, NM to the west, Alamogordo, NM to the east and smaller communities to the north. Because WSMR is bounded by populated areas on all sides, missile flight safety is extremely important.

WSMR has published a "Range Users Handbook" to present customers of the Range with the organization of WSMR and its measurement and data product capabilities. [1] The document addresses the following:

- Range Points of Contact
- Range Functions and Organizations
- Range Policies and Procedures
- Range Test Capabilities
- Universal Documentation System
- Planning
- Data Products
- Telemetry
- Metrology
- Missile Flight and Laser Beam Safety
- Ground Safety
- Laser Safety
- Security
- Recovery
- Communications
- Photography
- Health and Safety
- Environmental Considerations

BACKGROUND

The goal of range safety at WSMR, or any test range, is the prevention of injury to personnel or damage to property by taking all reasonable precautions consistent with operational requirements. At WSMR, the range safety responsibility is divided into two groups, one dealing with ground safety concerns and the other with flight safety concerns. This paper will only describe the WSMR flight safety operations. The organization responsible for flight safety at WSMR is the Operations Control Division

of the National Range Operations Directorate. This organization, in turn, is divided into two Branches which carry out the flight safety function.

Flight Safely Branch. The Flight Safety Branch, of which the MFTSM is part of, is responsible for the realtime safety operations during missile or target launches. This group is responsible for defining the physical area in which a missile test will be allowed to take place, and for establishing the limits or "destruct lines" whose violations will result in a commanded flight terminate action.

Safety Engineering Branch. The Safety Engineering Branch is responsible for the development and qualification of the FTS, which will be used in a particular missile or target vehicle. Personnel from this Branch check out the FTS and certify to the MFTSM that the FTS is functioning properly prior to missile or target launch. It also monitors the FTS performance during flight and after a missile/target engagement, and advises the MFTSM on the status of the system.

The MFTSM is the final decision maker of the "closed loop" in the range safety process. Each of the major systems that are a part of the loop will be discussed.

FLIGHT TERMINATION SYSTEM'S COMPONENTS

FTS's are very diverse and complex systems with the complexity proportionate to the complexity of the missile or target system. It is impossible to list every type of component which may be used in an FTS, but some of the major components include:

- Command-Destruct Receiver
- CDR Antenna
- CDR Antenna Coupler
- FTS Dedicated Battery (backed up by some other power source, such as the telemetry system battery through isolation diodes)
- FTS Logic Unit
- FTS Safe and Arm Device
- Destruct Ordnance

INTERACTIVE GRAPHICS DISPLAY SYSTEM

At WSMR, MFTSM's primarily rely on an IGDS to display the realtime position of a missile relative to an "electronic" WSMR map. This IGDS uses realtime missile position information, provided by the FPS-16 Range radars. The MFTSM's use high resolution color interactive graphics displays to present the realtime position of a missile overlaid on an "electronic" Range map. This cathode ray tube (CRT)

presentation shows the position of the target, missile, Range boundaries, restricted areas and missile flight parameters.

Targets and missile space position information is provided by the FPS-16 Range radars. This position information is transmitted to the Real-time Operations Control System (ROCS) computers at the Range Control Center (RCC). The ROCS computers provide the position information to the IGDS Digital Equipment Corp. Model 8650 host computer that drives Evans & Sutherland Model 390 interactive graphics displays. The display units have multi-color high resolution 20-inch CRT's, along with joy-sticks, function buttons, control dials, keyboards and data tablets. An electronic map of WSMR is presented on the color CRT with a small symbol of the flying missile or target superimposed on the map. The operator can select appropriate map scales in realtime and move the map so that the missile or target is positioned center screen. Using the IGDS, the MFTSM monitors the position of the missile or target, along with the vehicle data from the telemetry down link to make realtime decisions as to the correct vehicle performance.

The FPS-16 Range radars provide a 20-sample-per-second serial data input of range, azimuth and elevation of their tracked object to the ROCS computers. The ROCS computers transforms these inputs to an earth centered fixed coordinate system. The ROCS computers then filters and smooths the data and provides position, velocity and acceleration data to the graphics system. Generally, at least two radars are assigned to each missile and two radars to each high performance target.

The Range S-band interferometer tracking systems also provide position data of their tracked object to the ROCS computers. The ROCS computers and the IGDS process this interferometer position data in much the same manner as the radar data for display on the IGDS.

FTS MEASUREMENTS INPUTS TO THE TELEMETRY TRANSMITTER

At WSMR certain missile or target vehicle parameters are required by the Safety Engineering Branch for realtime evaluation of the FTS and other missile subsystems. The following are representative parameters that might be required for a "generic" missile and should not be construed to mean that all missile and vehicle programs require these particular parameters.[2] More complex missile systems may require over 50 parameters. A specific list of required parameters would be given to the Range User when the design of the FTS was finalized. However, some of the parameters may include:

a. Analog Missile Functions:

- Fin positions
- Motor chamber pressure
- FTS temperature
- FTS battery voltage
- FTS back-up battery voltage
- FTS storage capacitor voltage
- FTS receiver Automatic Gain Control voltage

b. Discrete Missile Functions:

- FTS Safe and Arm Device status
- Motor Arming and Fusing Device status
- Auto-destruct enable
- FTS receiver arm
- FTS receiver monitor
- FTS receiver optional command
- FTS receiver IRIG tones
- FTS receiver fire outputs

These analog and discrete parameters are inputs to the missile S-band telemetry transmitter.

UHF COMMAND-DESTRUCT SYSTEM

MFTSM's rely upon the missile telemetry system to observe the FTS parameters. The realtime closed loop, shown in Figure 1, involves the:

- Missile Under Test
- Missile CDR
- Missile S-band Telemetry Transmitter
- Ground Telemetry Acquisition/demultiplex System
- Range Radars
- Interactive Graphics Display System
- Flight Safety Team Member
- FTS Engineer
- Missile Flight Test Safety Manager
- Ground Command-destruct Transmitter

A Flight Safety Operations Team Member advises the MFTSM of the missile performance, and the FTS Engineer advises the MFTSM, on the performance of the FTS. Prior to launch, the MFTSM uses the information, in conjunction with realtime information from the IGDS, to make realtime decisions to permit missile or target launches to proceed. After launch, the MFTSM uses the realtime data to make destruct decisions on missiles or targets in flight.

FLIGHT TERMINATION SYSTEMS

At WSMR, as in most other missile test ranges, the primary means for flight termination is an independent UHF command-destruct system. This system is also sometimes required to be auto-initiated upon loss of RF carrier or Inter-Range Instrumentation Group (IRIG) tone or loss of power. A secondary means to effect flight termination may be through the command guidance system for target vehicles.

WSMR requires redundant FTS's for full scale recoverable targets. One of these may be one provided by the command guidance system, such as the Vega Precision Laboratories, Inc. Target Tracking and Control System, or the WSMR Drone Formation Control System. The other system is an independent UHF command-destruct system. These systems may be actuated by the MFTSM when target control is lost, as might occur when a missile has scored a "hit," causing the target to fly in an erratic manner. The redundancy requirement for full scale targets ensures multiple ways of setting off the onboard destruct ordnance. For example, while damage inflicted by a missile "hit" may disable one FTS, it is probable that the other FTS will survive, so that the MFTSM does not lose the ability to conduct a destruct operation. In addition, the FTS's will automatically activate upon sensing loss of uplink or loss of power. Typical full scale target destruction is caused by explosion of the fuel cells or breaking of the air frame.

Sub-scale targets usually have a non-destructive FTS on board. FTS onboard sub-scale drones typically work by shutting off the fuel supply and deploying the parachute.

The UHF command-destruct FTS is the most widely used and is the one principally addressed in this paper.

UHF FLIGHT TERMINATION SYSTEM

When the MFTSM decides to terminate the flight of a missile, a destruct switch is activated at the WSMR RCC. This destruct signal is generally sent via a digital destruct system. A switch closure, initiated by the MFTSM in the RCC, sends a

digital serial stream to the command-destruct transmitters. This digital serial stream is used to select an IRIG transmitter modulation tone or sequence of IRIG transmitter modulation tones at the transmitter site. The selected tone frequency modulates a UHF command-destruct transmitter. There are three fixed and three mobile command-destruct dual redundant transmitters at WSMR. Only one site is active at a time. As a missile flies up Range, one site transmitter may be turned on while another is turned off. The transmitter sites are selected based on the best signal received by the airborne CDR, as indicated by the automated gain control telemetered parameter. Figure 2 shows the transmitters.

An airborne FTS is actuated by (1) a commanded signal which engages a prescribed sequence of destruct tones, (2) automatically, following loss of a designated tone as might occur through a severe loss of RF signal strength, and (3) automatically, following an abrupt or gradual loss of FTS power below a specified voltage level.

UHF COMMAND-DESTRUCT RECEIVERS

WSMR uses CDR's tuned to 409 MHZ. These units are typically less than 50 cubic inches in volume, ruggedized and are designed to receive a destruct tone sequence from a ground based transmitter. These receivers can be tuned from 409 to 525 MHZ. The receivers are responsive to transmitters which are frequency modulated with IRIG tones, ranging from 7.5 to 73.95 KHz. The frequency of the tones is selected in accordance with IRIG Document 307-79, Range Safety Transmitting Systems 406-549 MHZ Band, paragraph 1.0. [3] Upon receipt of the proper tone sequence, the receiver will activate its internal solid state or relay output drivers which in turn causes an explosive package to detonate and destroy the vehicle.

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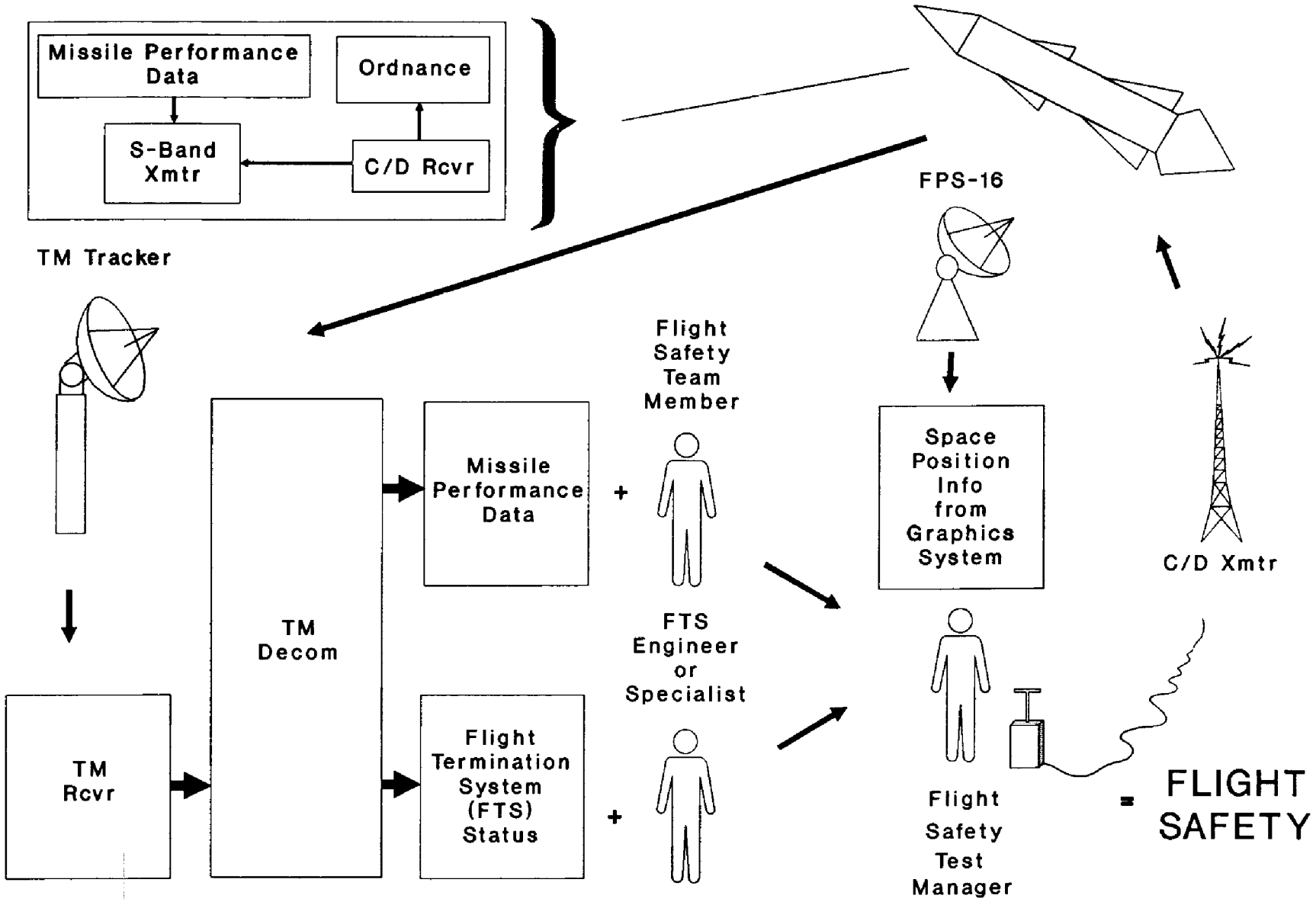

Figure 1. Flight Safety and Telemetry (The Closed Loop).

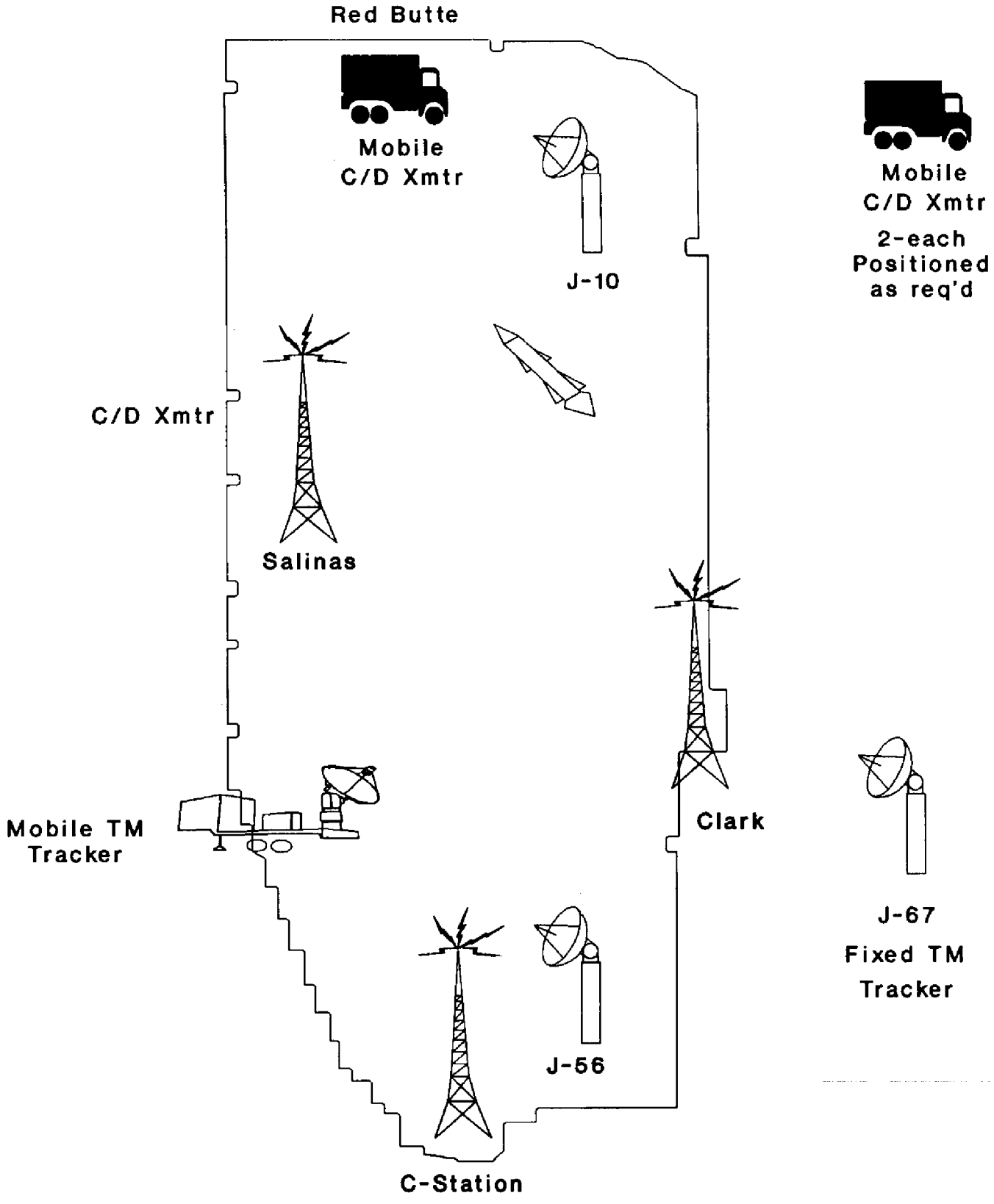

Figure 2. Command-Destruct Transmitters and Telemetry Trackers.