



DOCUMENT 320-94

CURRENT RANGE SAFETY CAPABILITIES

**WHITE SANDS MISSILE RANGE
KWAJALEIN MISSILE RANGE
YUMA PROVING GROUND
DUGWAY PROVING GROUND
ABERDEEN TEST CENTER
NATIONAL TRAINING CENTER**

**ATLANTIC FLEET WEAPONS TRAINING FACILITY
NAVAL AIR WARFARE CENTER WEAPONS DIVISION
NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION
NAVAL UNDERSEA WARFARE CENTER DIVISION, NEWPORT
PACIFIC MISSILE RANGE FACILITY
NAVAL UNDERSEA WARFARE CENTER DIVISION, KEYPORT**

**30TH SPACE WING
45TH SPACE WING
AIR FORCE FLIGHT TEST CENTER
AIR ARMAMENT CENTER
AIR WARFARE CENTER
ARNOLD ENGINEERING DEVELOPMENT CENTER
GOLDWATER RANGE
UTAH TEST AND TRAINING RANGE**

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CURRENT RANGE SAFETY CAPABILITIES

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**RANGE SAFETY GROUP
RANGE COMMANDERS COUNCIL**

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PREFACE

The main purpose of this Range Safety Capabilities document is to compile and to document the existing safety systems used at the member ranges of the Range Commanders Council. Included is the range description, safety policies, individual system description, and the risk assessment process and criteria for the various ranges.

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AIR FORCE DEVELOPMENT TEST CENTER (AFDTC)

1. INTRODUCTION

a. **Mission.** The Air Force Development Test Center (AFDTC) is located at Eglin Air Force Base, Florida. The AFDTC's overall mission is to plan, conduct, and evaluate testing of U.S. and allied nonnuclear munitions, electronic combat, target acquisition, weapon delivery, base intrusion protection, and supporting systems.

b. **Physical Description.** Eglin's land test areas encompass 463,000 acres, while its water test areas cover 86,500 square miles in the Gulf of Mexico. The Eglin Air Force Base test complex consists of many individual test areas including jungle conditions, rolling hills, heavily forested areas, cleared flat areas, and water areas. The major test support capabilities of the AFDTC Test Complex are briefly described next.

(1) **Electromagnetic Test Environment (EMTE).** Eglin maintains an EMTE to support development and operational agencies in the evaluation of electromagnetic warfare (EMW) devices, components, systems, and techniques. The EMTE is capable of obtaining data on EMW device performance for use in developing EMW tactics and techniques. The EMTE is a complex of tracking and search radars operating in different frequency bands and modes to provide a flexible test facility in the evaluation of EMW. All tracking radar data are transmitted to the Central Control Facility (CCF) which has the capability to receive, record, process, and retransmit EMTE data to the site to conduct closed-loop, real-time EMW test missions.

(2) **General Purpose Sites.** The general purpose test sites and complexes provide general instrumentation support for many AFDTC test mission responsibilities rather than primarily supporting a specific mission function.

- Test sites (TS) A-3, A-13, A-20, C-10, and D-3 contain primary tracking radar systems which are highly sophisticated in the degree of integration with other supporting instrumentation. Test sites D-3 and A-3 contain redundant UHF destruct transmitters (1 kW) used for flight-safety systems required for long range munitions and vehicles.

- The primary telemetry capabilities at AFDTC are located at fixed TSs B-4A and D-3. Additional equipment is available in a van and in a fixed installation (building 130). Real-time data can be relayed by microwave to the Central Control Facility (CCF).

- The Ground Monitor Facility (GMF) at TS B-4B receives radiated signals from active airborne ECM devices. The GMF can display, measure, and record spectral power characteristics.

- The Frequency Control and Analysis (FCA) Facility at TS A-6 monitors and records signals in the radio frequency bands between 1 MHz and 18 GHz. The FCA provides the

RF spectrum surveillance and measurement services required to ensure interference-free operations in the Eglin complex and within the Gulf Area Frequency Coordinator's (GAFC) area of responsibility.

(3) **Land Test Areas.** The AFDTC land range test areas are located within the 463,000 acres comprising the Eglin reservation. Each test area operates through the Range Operations Control Center located in building 104 in the main area. Integration of one or more of the land test areas is accomplished by landline and radio communications. Figure 1 is a map of the Land Range Test Areas.

(4) **Computer Systems.** The 3200 SPTW/SC provides centralized computer processing for real-time and post-mission reduction of test data. The CCF provides the real-time collection, processing, and display of radar, airborne pod, and telemetry data to satisfy range safety and test project requirements. The post-mission data-reduction function provides for timely identification of data-quality problems, if they exist, for film, radar, or telemetry data.

(5) **Weather Instrumentation.** The Meteorological Environmental Services system provides the means for obtaining meteorological and environmental measurements during tests. Data are gathered throughout the land range complex and span the atmosphere from the earth's surface up to 100,000 feet mean sea level (MSL). Portable equipment is available for deployment as required.

(6) **Other Test Facilities.** Other test facilities at Eglin include

- Fuse Test Facility
- Remote Control Disassembly Room
- Dud Fluoroscopic Analysis System
- Primer Sensitivity Tester
- Explosive Component Storage Pits
- Preflight Integration of Munitions and Electronics Systems (PRIMES) Facility
- Static Destruct Arenas and Gun Test Facilities
- Guided Weapons Evaluation Facility (GWEF)
- Sled Tracks
- Gulf Range Drone Control Upgrade System (GRDCUS)
- Radar Target Scatter Facility (RATSCAT)

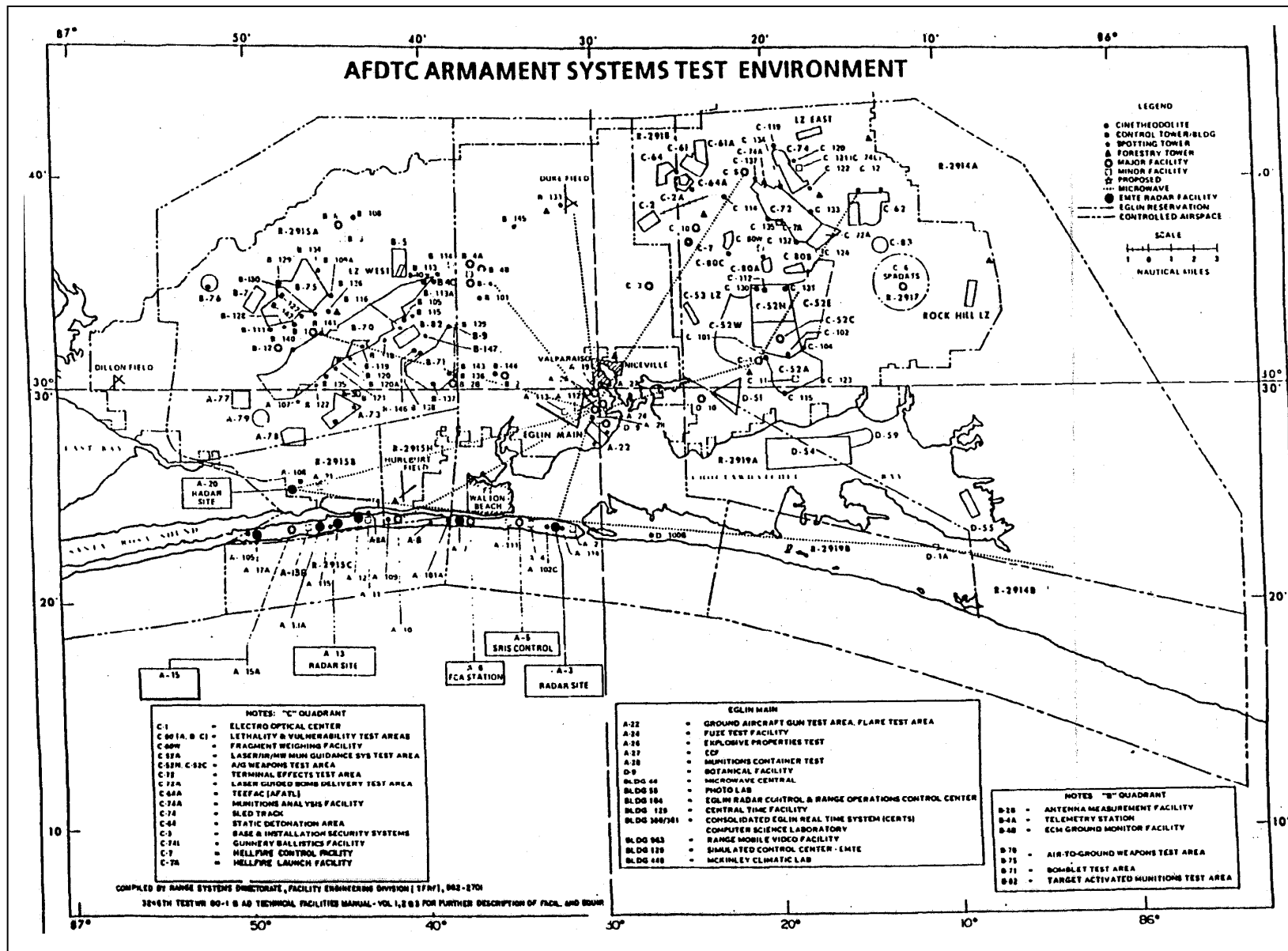


Figure 1. Land range test areas.

c. **Typical Programs Supported.** The following is a cross-section of test programs that are being supported or have been supported in the last year:

AGM-130 Compatibility
Autonomous Guided Weapon
AMRAAM Flight Tests
Improved Data Link for GBU-15
Advanced Airborne Interceptor Simulator (AAIS)
HAVE DASH II
Autonomous Synthetic Aperture Radar
SDI Lethality
Hypervelocity Gun Research
Army Missile (ADKEM, FOG-M, Hellfire) Flight Tests
Army Ranger Live Fire Training
Aircraft Compatibility Tests
JDAM/OCD Test Programs
Israeli F-15 Testing
Saudi Air Force Flight Test
Munitions Warhead Tests
Belgian Air Force Radar Warning Receiver
Royal Norwegian Air Force SAMOVAR ECM
1 SOW Live Fire Training
33 Tactical Fighter Wing Support
William Tell
Automatic Radar Target Identifier (ARTI)
Automatic Self Protection Jammer (ASPJ)
Joint Stars Test
Improved Warhead Cratering Test
Experimental Explosives Performance Test
Aircraft (C-17, V-22) Environmental Testing
CBU-97/B Sensor Fuse Weapon Test
FMU-139B/B Survivability Sled Test
Advanced Tactical Air Reconnaissance System (ATARS)
Silent Attack Warning System
HTOP Penetrator Sled Test
Smart Submunition Technology
Advanced Technology LADAR System
INS/GPS Operational Concept Demonstration
Long Range Conventional Cruise Missile
MMW Seeker Free Flight
AGM-142 Blast Fragment Arena Test
Air-Ground WSEP
Navy Land Survival Training
Joint Services EOD Training
Smoke Week XIV
Vehicle Integrated Defense System (VIDS)

Army MLRS-SADARM Warhead Sled Test
Exoatmospheric Heatshield Test
Army TACMS Dispenser
Shallow Water Mines Countermeasures

2. SAFETY CAPABILITIES

a. **Overview.** Range safety responsibility is delegated to the AFDTC Commander by Department of Defense (DOD) Directive 3200.11, 29 September 1980, which states "The Activity Commander shall ensure safety consistent with operational requirements. In carrying out this responsibility, the AFDTC Commander is charged with (1) determining policies governing safety; (2) establishing allowable limits of flight trajectories and acceptable locations for impact areas; (3) providing instrumentation to maintain necessary information on in-flight position of test associated missiles, rockets, weapons, and aircraft; and (4) taking appropriate action prior to and during test activity to ensure the test object does not violate established limiting conditions or safety criteria."

b. **Individual Systems**

(1) **Radar Systems.** Radars used at Eglin's test range are categorized as either reference (control) radars or threat simulators. Reference radars are used to control test support aircraft within a prescribed flight path. These reference radars provide coverage from west of Hurlburt Field to south of Cape San Blas, Florida. Airborne objects can be tracked throughout the entire range. Each tracking radar generates range, azimuth, and elevation data for the object being tracked and outputs these data to the Universal Data System (UDS). The following is a summary of reference radars located at Eglin.

- **AN/FPS-16 Radars.** The AN/FPS-16 radars were designed specifically to provide accurate space-position data for evaluating the performance of airborne objects. They are capable of acquiring and accurately tracking missiles (with or without beacons), rockets, aircraft, nose cones, boosters, tankage assemblies, instrumentation packages, and debris. They are also capable of providing trajectory data on these objects for real-time use or for future performance evaluation. Eglin has seven AN/FPS-16 radars.

- **AN/FPQ-13 Radar.** The AN/FPQ-13 is a highly modified AN/FPS-16 radar capable of providing real-time and rapid turnaround data at the radar site. It has two operating modes. One mode is composed of what is known as the "on-axis" or "directed track" concept. This concept uses computer-generated drive vectors to position the radar along a predicted trajectory. The other mode uses a conventional tracking technique similar to that of a normal AN/FPS-16 radar.

- **AN/MPS-19 Radars.** Eglin has three AN/MPS-19 radars - used primarily for drone tracking and control.

(2) **Optical Systems.** Optical systems at Eglin provide a wide variety of data products and services for users of the ranges. Primary products of these systems are precision

time-space-position information (TSPI), attitude data, and event time; engineering sequential photography; photogrammetric configuration; base-line data for calibration of other TSPI systems; and operational aids. The following summary lists the instrumentation available:

- Low-, medium-, and high-speed film cameras in 16 mm, 35 mm, and 70 mm formats. These cameras can operate at frame rates from 6 to 40,000 frames per second.
- Bowen ribbon frame cameras (CZR) may be synchronized to provide photographs of an item along a predetermined flight path. These cameras operate at rates of 60, 90, 180, and 360 frames per second.
- Ultra-high-speed cameras capable of rates up to 4,500,000 frames per second in the framing mode or write records of 20 mm per microsecond in the streak mode.
- Video cameras and recorders capable of operating in standard formats as well as shuttered high-speed (200 frames per second) format.
- Cinetheodolites capable of recording event, time, and position data on 35 mm film at 5, 10, 20, or 30 frames per second to determine precise TSPI on test items on five land test ranges and over the Gulf of Mexico water ranges.
- Remote Controlled Videotheodolite Systems capable of recording precise TSPI and event data on videotape. These remote-controlled systems are transportable and capable of providing support in hazard zones on land ranges.
- Mobile Laser Ranging Tracking Cinesextants (LRTC) capable of providing precise TSPI (azimuth, elevation, and range) from a single instrument and at remote locations.
- Support instrumentation such as manual and electrically driven tracking mounts, IRIG time code systems, portable instrumentation platforms, radio remote systems, camera mounts, data poles and boards, programmers, and timers.

c. **Real-Time Processing Systems.** All real-time mission analysis and control is provided at the Central Control Facility (CCF) located in building 380. The CCF is designed to provide state-of-the-art analysis and control resources which are needed to satisfy AFDTC's real-time test support requirements through the 1990s. The general-purpose computers which support the CCF have access to most of the range data sources [radars, telemetry, the Gulf Range Drone Control Upgrade System (GRDCUS), and TPX-42]. Real-time application programs process data collected during missions to provide real-time analysis and control information. The computer resources, displays, and system flexibility are sufficient to support many different types of missions simultaneously. The major CCF resources include the real-time computer network, graphics-display systems, mission-control rooms, radar-data systems, telemetry-data systems, GRDCUS/MTACS data system, and video-display system.

(1) **Facility Description.** The real-time mission analysis and control rooms are most important to the CCF users, because they contain the consoles the user will view and

operate. Building 380 houses the main analysis and control center used during most real-time mission support. The main center is currently divided into eight distinct control rooms. Four of the control rooms each contain one real-time analysis and one real-time control console. These rooms are also equipped with a viewing area separated from the main control room. Partitions dividing these rooms can be opened to support large real-time missions requiring more than one console. Another mission room contains the telemetry data display equipment and still another contains the GRDCUS/MTACS control consoles.

(2) **Hardware.** The real-time analysis consoles are used for presentation of radar, other TSPI, and telemetry data under real-time computer program control. This information can be maps, graphics, air-to-air displays, time histories or other special-purpose displays derived from the various data sources or appropriate simulation models. Keyboards associated with each cathode-ray tube (CRT) display allow the operator to interact with the real-time application software in the set up and control of mission phases, to enter parameters, and to select types of displays. The real-time analysis consoles currently contain the following equipment and hardware:

- Chromatics CX1536 Display system has three high-speed, full-color graphics CRT displays. Operator input devices include keyboards, function keys, and joy sticks. A laser copy unit is connected.

- Tektronix 4128 Display system has two 3D color raster graphics CRTs. Operator input devices include keyboards, function keys, X-Y dial-type cursor, and hard-copy units.

- Gould Telemetry Display system has two chromocolor CRTs that display selected strip-chart parameters.

- TV monitors include four wall-mounted units and one large screen display.

- Communication panels have two panels with five fixed and seven selectable positions plus intercom positions. Headsets and telephone instruments are included.

- The status/control/flight termination panels allow range safety to select the destruct mode, command source, and antenna for each mission and to lock out possible interference from remote locations. Flight termination provides the necessary switches to sequence through a destruct cycle. This capability allows the CCF to be the control site for range-safety functions. The status/control panel allows CCF users to originate and display status signals between central and remote locations.

(3) **Computer Network.** Eglin's real-time computer network consists of the hardware and the real-time system and application software. Characteristics of this system include flexibility, redundancy, and multimission capability as well as the capability to isolate a particular application, to break an application into distinct processes, and to use more than one processor if needed. This system is highly distributed - six VAX processors are used for application processing, and real-time data system input/output, telemetry input, and graphics

display are handled by various PDP-11 processors. The real-time computer network is implemented with the following Digital Equipment Corporation (DEC) hardware: 4 VAX 8600s, 2 VAX 8650s, 1 PDP 11/70, 5 PDP 11/34s, 4 PDP 11/845s, 24 RA81 disk drives, 1 RA60 disk drive, 2 HSC50 shared-disk controllers, 6 Ethernet interfaces, 2 LA120 operator terminals, 2 hard-copy printers, 6 laser printers, and user CRT terminals.

(4) **Software.** The CCF system described is an environment of data systems, computers, and displays for which application software must be developed and executed. The development of a specially tailored application program enables user interaction with the CCF environment. The current real-time software capabilities fall into six categories: range safety, mission control, electronic combat, munitions, aircraft compatibility, and operational readiness.

Range-safety software consists of the Consolidated Safety Program (CSP) which is a real-time, multiprocess software system. The system provides the range-safety officer (RSO) with data to maximize effectiveness in protecting personnel and property in the Eglin area during live-test missions. The CSP software is composed of nine separate processes operating at different priorities under the control of the VAX/VMS operating system in the real-time computer network. Significant characteristics of the CSP software system are briefly outlined next.

- **Instantaneous Impact Prediction (IIP)** computes either vacuum or ballistic drag IIP to include a debris triangle consisting of the largest and smallest fragment IIP and the vehicle position.

- **Fire Control System (FCS)** provides safe fire-control involving live firing of air-to-air rockets against manned aircraft by using rocket trajectory tables and real-time positions of shooter and target aircraft. The FCS

- accepts inputs from up to 20 radars;
- accepts inputs from GRDCUS at Tyndall Air Force Base, Florida;
- accepts inputs from up to eight telemetry streams;
- processes and displays information on up to 16 test vehicles;
- allows definition of 50 computed parameters and displays up to 20 parameters at a given time;
- allows definition and display of up to 75 ships, 25 oil platforms, and 25 generic marks;
- allows definition and display of hazard patterns or other figures of interest by drawing boxes, triangles, arcs, and circles;
- displays a firing fan on any vehicle;

- generates displays on up to six CRTs;
- accepts input commands from alphanumeric keyboards, function buttons, and joy sticks;
- allows mission replay and simulation; and
- displays mission-, vehicle-, and parameter-definition menus; two dynamic-map presentations; three tier-time histories; horizontal and vertical plot displays; one fire control display; ship and oil well location tabulation; hazard-figure tabulation; radar-boreshot and weather menu; and environmental-status display.

d. **Test Site Display Systems.** Television (TV) is used on the Eglin complexes for many different missions including munitions surveillance, long-lens automatic tracking systems on AN/FPS-16 radars, and air-to-ground transmissions and reception. They include

(1) **Lethal Munitions Surveillance.** All lethal munitions test sites are equipped with remote control TV for explosive-ordnance disposal (EOD) and project officer test viewing. The TV system on each of the ranges generally consists of one or more remote TV cameras, pan-and-tilt mounts or pedestals, sufficient viewing monitors, and video recorders.

(2) **Television Tracking Systems.** All six AN/FPS-16 radars are equipped with long-range tracking TV systems which are used for low-level tracking. The TV tracking is 1 to 20 miles on an average day, depending on the light level.

(3) **Air-to-Ground TV Transmission.** The transmission of wide-band sensor (TV camera and IR sensor) information from an aircraft to one or more ground receiving sites provides a standardized, highly reliable method of collecting airborne data by video-tape recorders.

(4) **Central Video Facility.** The Central Video Facility supports video requirements ranging from TV support through sophisticated radar-video support on instrumentation and threat radar systems. Playback of radar and CCTV videotapes to obtain quantitative and documentary data is available.

(5) **Telemetry Systems.** The range telemetry complex operates from several strategically located sites separated by distances of up to 125 miles. Automatic, manual, and fixed wide-beam antenna systems are located at fixed and mobile facilities. All facilities are capable of receiving data transmitted in the 1435 to 1535 and 2200 to 2300 MHz frequency bands.

e. **Communication Systems.** A flexible network of wire, radio, and microwave equipment makes it possible to use any part of the Eglin land and water range complex as a separate facility or to integrate the entire complex as one vast test and development environment. A typical range and site communications configuration will have a control center with voice

control and instrumentation status circuits connected to remote instrumentation sites. Portable microwave extends control and data circuits to instrumentation sites in the absence of wire circuits or to satisfy wide-band data or video requirements. Fixed microwave from the Microwave Center interconnects separate range and site control centers to various control, data, and communications centers on Eglin.

(1) **Radio Communications.** Radios used at Eglin test sites include ultra-high frequency (UHF) air to ground, very-high frequency (VHF) point to point and air to ground, and high-frequency (HF) point to point and air-to-ground radios.

(2) **Microwave Systems.** The microwave systems provide the primary path for interconnecting Electromagnetic Test Environment (EMTE) radar sites. The land range sites are also interconnected to Eglin through the Microwave Center. Microwave systems used are Motorola MR-300 and MC-30 and Collins MW-518, MW-508C, MDR8-5N, MVR-8GW, and 502-D.

f. **Command and Control Systems.** The command and control function is provided by a UHF command guidance system. It provides the command link for remotely controlling unmanned- airborne systems such as drones and missiles from ground stations. The primary command-guidance capability at Eglin employs AN/CTS-100 UHF radio transmitters. Radar beacon control can be exercised through the G(C)-band and E(S)-band radar sets. The Gulf Range Drone Control Upgrade System (GRDCUS) has the capability to command, control, and track four drones, four shooters, and four air-to-air missiles. The system will also provide the data link for selective flight termination of drones and missiles.

g. **Signal and Control System.** The Signal and Control (S&C) system provides visual displays of status information and effect remote control, thereby, alleviating the problems resulting from total dependence on voice communications. The system performs as a partial automation of the mission-control operation by supplementing voice communications. It is readily adaptable to the transmission of any two-condition function such as go/no-go control and ready/hold status. Some of the functions handled by the system are site and mode select and confirmation, destruct and confirmation, command guidance, status reporting, hold fire, range control, and command-control lockouts.

h. **Command Guidance and Destruct.** The primary means of remotely controlling unmanned systems such as drones is through the UHF command guidance system. This UHF destruct signal and control system is the nerve system for the range safety command network. It provides site-control commands to configure the UHF transmitters for a mission, transmits control signals for UHF- command initiation, and relays feedback signals from the UHF transmitter to the range safety officer (RSO) in the CCF upon activation of the commanded signal or function. Eglin's UHF destruct signal and command system is a ground-based real-time signal generation and control system consisting of the signal and control system and the command-control system. It is designed to provide flight-termination commands to weapons, missiles, and drones undergoing flight test. The system uses a telephone line communications network to command UHF transmitters located at Sites A-3 and D-3 and to transmit standard IRIG tones in specific sequences to represent specific actions. Actions initiated by the RSO in

the CCF are communicated to the range-transmitter sites over standard voice telephone communications lines. The RSO actions include site select, site configuration, UHF on or off, and select UHF commands such as transmit, monitor, prearm, arm, and destruct command.

The commanded actions are interpreted at the range sites where action is taken to automatically respond. The commanded site complies with the requested action by proper configuration of the site's UHF transmitter, by selection of the site antenna, and by modulation of the transmitter with an IRIG tone sequence representing the commanded action. The UHF signal is then broadcast to the test article to complete the commanded action. Each transmitter site provides feedback on the site status to the RSO console, providing an indication of communications link integrity and site response. The site status is depicted in terms of status lights representing site configuration and indication of IRIG tone command received at the site.

The actuating controls and visual displays of the Signal and Control system consist of push-button switches and status lights contained on the RSO's destruct panel. Two destruct panels are provided in each of the five mission rooms in the CCF. Commandable functions on each panel include site controls and commanded tones or tone sequences. Once the sites have been captured under CCF control (via site controls), one site is selected as prime and the other as backup. The prime site is selected for "UHF on" and may be used to command IRIG tones. The signaling system may command one of four predetermined codes (A, B, C, or D) or one of two automatic tone sequences (auto destruct #1 or #2) from each destruct panel.

i. **Event Coordination System.** The Event Coordination system is employed as an efficient means of providing wide dissemination of the progress of a mission and of synchronizing widely dispersed efforts in accordance with a pre-planned countdown schedule. Either a verbal countdown communication net or the automatic simultaneous visual display may be used. The displays indicate the plus or minus count in hours, minutes, and seconds and a hold fire or lift-off status.

3. RISK MANAGEMENT

a. **Range Policies.** The AFDTC Deputy for Safety is responsible to the AFDTC Commander for establishing and managing the overall safety program. The Directorate of Range Safety establishes and implements the total range safety program and recommends and establishes policies and procedures related to the administration of the program. The policy of the range safety program is to ensure that all range operations are conducted in a safe manner consistent with operational objectives. The Directorate of Range Safety strives to maximize the utilization of the Eglin Complex without compromising the safety of personnel and equipment.

b. **Hazard Analysis Tools.** Some of the computerized hazard and risk analysis tools used by range safety follow.

(1) **Laser Hazard Area Computation Program.** A computer program was developed to analyze hazards because of direct or reflected radiation from laser sources.

(2) **Fragment Hazard Analysis Algorithm.** This study was a review of the software and state-of-the-art methodology for estimating fragment patterns and velocities necessary for the development of safety-probability contours.

(3) **Methodology for Determining Safe Distances from Exploding Small Munitions.** An effective explosive safety methodology used to determine the effects of fragments and blasts caused by cylindrical and spherical shaped explosive munitions. This methodology is for net explosive weights of up to 10 pounds.

(4) **Tactical Aircraft Overpressure Signature Prediction.** This interactive computer program accurately predicts the locations and magnitudes of ground overpressures (sonic booms) caused by tactical weapon deliveries by maneuvering aircraft flying at low altitudes and supersonic speeds.

(5) **Computer Assisted Flight Termination Requirement and Feasibility Study.** Requirements were analyzed for replacing or augmenting current AFDTC manually triggered flight-termination procedures with computer-assisted test procedures on future advanced tactical weapons.

(6) **Pretest Launch and Target Aircraft Range Safety Hit Probability Methodology.** Methodologies used to simulate test scenarios in which launch aircraft, manned target aircraft, chase aircraft, and other aircraft in the Eglin air space are subjected to hazards from weapons or weapon debris.

c. **Assessment Process.** The Directorate of Range Safety supports test projects from the concept phase to the test completion phase. During the concept phase, the system is analyzed and safety requirements for the contract statement of work are provided. With this contractor-provided data, a safety analysis is conducted, hazards identified and evaluated, and safety criteria for test conduct are developed. Data analyzed include weapon description, aerodynamics, physical characteristics, dispersions, footprints, failure modes, and failure probabilities. It may also include flight termination system design information.

During the course of this analysis, the range safety analyst generates and collects Test Hazard Analysis Worksheets (THAWs) (see figure 2); as chairman conducts a Hazard Review Board (HRB) during which the overall risk level of the test is assessed; prepares the Hazard Analysis Summary (HAS) which are the minutes of the HRB; develops the safety annex which contains the test-specific safety criteria and is attached to the final test directive; participates in the Airborne Test Review/Safety Board (ATR/SB); supports the actual test either at the CCF or on site at the test area, climatic laboratory, or sled track; and exercises safety control over the conduct of the test.

TEST HAZARD ANALYSIS WORKSHEET						
JON #	SUBJECTIVE PROBABILITY OF OCCURRENCE					
		HIGH	PROBABLE	UNCERTAIN	REMOTE	IMPROBABLE
TEST TITLE:	For more information on how to use this form, please see the reverse side.	HAZARD CATEGORY	CATASTROPHIC	HIGH	medium	
HRB DATE:			CRITICAL			
Aircraft/System:			MARGINAL			
			NEGLIGIBLE			
Risk Level Assessment						
HAZARD:						
CAUSE:						
EFFECT:						
MINIMIZING PROCEDURES:						
EMERGENCY PROCEDURES:						
COMMENTS:						
Submitted By: Org	Date:	Interim THA Worksheet-AFDTC/SEU 2-4000 Nov 7, 1991				

Figure 2. Test hazard analysis sheet.

IN GENERAL

The "THA" worksheet is designed to reduce HRB meeting times by providing a concise way to become familiar with your test. Moreover, they provide a historical data base that will improve future tests. Finally, it is a "living" document that should be referenced as necessary for the life of your test.

The lower section of the worksheet is designed to be filled out prior to the HRB, usually by the Test Engineer. Risk levels will be addressed during the HRB. Each form should address a single hazard, although it can contain any number of causes, effects, minimizing procedures, and emergency procedures.

PLEASE DO NOT ADDRESS unquestionably "LOW RISK" hazards that require no minimizing procedures or hazards intrinsic to aircraft or basic equipment operation.

"HAZARD" is defined as something TEST SPECIFIC. It's a CONDITION that has the potential to cause a mishap or accident. For example, a hazard might be early detonation of a test munition dropped from an aircraft.

"CAUSE" is defined as the CIRCUMSTANCES or SITUATION that lead to the hazard's occurrence. In this example, one cause might be a radar prox fuze arming from a nearby chase airplane.

"EFFECT" is defined as the MISHAP or ACCIDENT we are trying to avoid. The effect will determine the HAZARD CATEGORY as described below. Here the effect might be the loss of an aircraft and/or lives.

"MINIMIZING PROCEDURES" are the things you plan to do to prevent the hazard from occurring. For instance, "Chase will go no further aft or lower than the lead aircraft."

"EMERGENCY PROCEDURES" Are test specific and fairly self explanatory. Not all hazards will have appropriate emergency procedures.

"COMMENTS" are made by the HRB, safety review process, ATRSB, or anyone else who wishes to record thoughts or considerations.

RISK LEVEL ASSESSMENT

The risk level is assessed by breaking the hazard into two parts: how much damage it might cause, and how probable it may be. The amount of damage is categorized according to the "EFFECT" and is fairly straightforward. The probability of occurrence is highly subjective and will dominate the discussion. The guidelines below may be of some help.

HAZARD CATEGORY

CATASTROPHIC: Death. Loss of over \$1,000,000 or an airplane Class A.

CRITICAL: Severe injury, lengthy hospitalization, or permanent injury. Loss of over \$200,000 or aircraft Class B.

MARGINAL: Minor injury, medical treatment, no permanent injury. Loss of >\$10,000 or Class C.

NEGLIGIBLE: Superficial injury, little or no first aid. Very minor damage or airplane Class D.

SUBJECTIVE PROBABILITY OF OCCURRENCE

HIGH PROBABILITY: We've done this before (or something very similar) and had a mishap or very nearly did. The test will exceed design limits. There is more than one single point of failure that could lead to CATASTROPHIC consequences.

PROBABLE: We've done this before (or something similar) and come close to mishap. The test is at the design limit. There is at least one single point failure with CRITICAL consequences.

UNCERTAIN: We're not sure, but don't think it's too critical. We've never done this before, but have identified some areas for concern. The test is nearing the design envelope.

REMOTE: We've done this before (or something similar) and have not had a problem. Well within design limits. There is no single point of failure leading to CATASTROPHIC or CRITICAL consequences.

IMPROBABLE: There just isn't a problem. Heart of the envelope. Nothing has ever gone wrong. Several failures required to have serious consequences.

AIR FORCE FLIGHT TEST CENTER (AFFTC)

1. INTRODUCTION

a. Mission.

(1) The Edwards Flight Test Range complex is a major Air Force Flight Test Center (AFFTC) resource located at Edwards Air Force Base, California. The range complex supports the overall mission of the center which is to conduct and to support tests of manned and unmanned aerospace vehicles, flight evaluation, and recovery of research vehicles, and to perform developmental testing of aerodynamic decelerator systems. The range complex also supports the activities of the USAF Test Pilot School, test operations of other services, and the activities of NASA, other U.S. and allied foreign government programs, and commercial aerospace firms. The 412th Test Wing operates the ranges and range facilities and is responsible to the 6510th Test Wing and the AFFTC Commander. The AFFTC facilities include

- Supersonic Flight Corridors
- Reconnaissance Test Ranges
- Instrumented Armament Delivery Ranges
- Terrain Following Radar Range
- Spin Areas
- Groundspeed Calibration Courses
- FAI Sanctioned Speed Courses
- Integration Facility for Avionics Systems Test
- Instrumented Thrust Stand
- Weight and Balance Facility
- Aircraft Gun Buttress
- Anechoic Chamber

(2) Range facilities include radar, optical, telemetry, radio, television, and timing instrumentation. These elements are controlled from the Ridley Mission Control Center (RMCC) and can be modified and adjusted to meet test requirements.

b. Physical Description

(1) The AFFTC is located on the western edge of the Mojave Desert, approximately 100 statute miles north of Los Angeles, California. The range includes parts of San Bernardino, Kern, and Los Angeles Counties. The primary landscape associated with the range is the Precision Impact Range Area (PIRA), which occupies about 90-square miles of the eastern one-third of Edwards Air Force Base.

(2) The Military Radar Unit controls the R-2515 restricted airspace, and flight test activities also have access to the larger R-2508 Airspace Complex.

(3) The R-2515 restricted airspace encompasses Edwards Air Force Base and areas to the north and northeast and includes airspace from surface to unlimited altitudes.

(4) The R-2508 restricted airspace complex extends approximately 140 nautical mile (nmi) north, 120 NM east, and 40 nmi west of Edwards Air Force Base, and includes airspace from 20,000 feet to unlimited altitudes. Airspace below 20,000 feet is shared by private aviation and military users. This area is governed by the R-2508 Complex Control Board under a shared-use agreement between AFFTC; Naval Air Warfare Center Weapons Division (NAWCWPNS(CL)), China Lake; George Air Force Base, Air Force Plant Number 42 at Palmdale; and Fort Irwin. Prior approval for shared use of the R-2508 complex is not required (except for specific restricted areas within the complex). This area is primarily used for nonhazardous test activities and test pilot school training.

(5) The extended range encompasses an instrumented airspace corridor stretching from San Nicolas Island in the Pacific Ocean to Hill Air Force Base, Utah.

c. **Typical Programs Supported.** Following is a list of test programs that are being supported or have been supported in the last year:

A F F T C U n i t s	
F-15 CTF	MC-130H Combat Talon
F-16 CTF	AC-130 Gunship
B-1 CTF	Advance Cruise Missile
C-17 CTF	AFTI F-16
Test Pilot School	F-16 FMS Programs
B-2	F-117
YF-22	GPS Range Application

Other DOD and U.S. Government Units	
NASA Space Shuttle	Air National Guard
NASA X-31A	Reno
NASA X-29	Point Mugu
NAVY Tomahawk Cruise Missile	March AFB
US Army Research & Development	El Toro
F-111 A/E AMP (McClellan AFB)	B-1 Operational Units
NAVY T39 IR Signature Test (NWC)	McConnell AFB
NASA/JPL Airstar	Ellsworth AFB
Palmdale Senior Year P3 (U2)	FCF Flights
Astronautics Laboratory	NAVY Lemoore
NASA Ames Research Center	George AFB

Commercial Contractors	
Mojave Flight Systems	PEGASUS
Mojave TRACOR	Rockwell International
Lockheed Senior Year (U2)	BOEING
Douglas Aircraft Co.	

2. SAFETY CAPABILITIES

a. Overview

The command, control, operational direction, and safe and efficient use of the AFFTC ranges, operating areas, and systems are the responsibility of the 412th Test Wing. The 412th Test Wing uses the customer-generated Operations Requirements document, the Range Squadron-generated Operations Directive, and the daily and weekly center and range schedule to exercise operational control of the ranges.

The Range Control Officer, Operations Duty Officer, and range system supervisors oversee range safety and readiness to meet the center and range schedule. They control the status of range systems for test operations in real time, as required, in the mission control rooms.

b. **Individual Systems**

(1) **Instrumentation Radars**

- **FPS-16.** The four AN/FPS-16 instrumentation radars at AFFTC (two owned by the Air Force and two owned by NASA) acquire and track range targets and operate in the G-Band (5400 to 5900 MHz). The radar systems are housed in concrete buildings located on a ridge approximately 4 miles northwest of the main base. Radar data can be recorded at each site and transmitted via landlines to the RMCC. The G-band transponders, installed on target aircraft, provide a point source of data which provides much greater accuracy than is possible with skin tracking only.

- Short-range accuracies (less than 30 miles) are determined by comparing AN/FPS-16 tracking data with cinetheodolite data. Long-range accuracies (greater than 30 miles) are determined by comparing the tracking data of a GEOSAT A satellite with ephemeris data on the Ellipsoid of Error of Position, can be used to predict expected accuracy for specific flight paths.

- **TPQ-39.** The AN/TPQ-39 Digital Instrumentation Radar (DIR) is a G-Band radar system that also uses G-band transponders to improve tracking performance. The system features raster scan, automatic target acquisition, and automatic and manual bandwidth and coast control.

- **Portable Precision Instrumentation Radar (PPIR).** The 412th Test Wing currently operates two PPIR radar systems which operate in the X-band and can perform either skin or beacon tracking. The radars are presently used to provide FliteVision, range-safety position information to plotting boards, and acquisition data to other sensors.

(2) **FliteVision.** The AFFTC FliteVision system is a video data acquisition system used for the real-time monitoring of aircraft flight tests. FliteVision complements the extensive radar, telemetry, and other data processed in the RMCC and can be recorded for postflight analysis and correlation. The system provides qualitative data of flight tests including spin, weapons release, speed runs, special maneuvering, and taxi tests; recordings of emergencies and special tests to provide data for safety decisions and special reports; and acquisition and tracking information for range instrumentation.

The FliteVision system consists of cameras with 10.5 to 105-inch zoom-capability lenses mounted on both AN/FPS-16 radar tracking antenna pedestals and a camera with an 80-inch fixed focal-length lens mounted on the AN/TPQ-39 radar tracking antenna pedestal. The system also includes video-tape recorders, monitors, video time-display equipment, and a video-distribution center. The video signal is transmitted by the Data Acquisition and Transmission System (DATS) and by landlines with appropriate line drivers and receivers. The transmission network is approximately 100 miles long.

(3) **Telemetry.** The Ground Telemetry Acquisition Systems support instrumented aircraft flight testing conducted at Edwards Air Force Base. These systems are comprised of a

main facility at building 5790, a remote facility at Leuhman Ridge, and another remote facility located at site A10 in the Shadow Mountains. A mobile telemetry van and some additional ancillary systems are also available.

- **North DATS.** The North Data Acquisition and Transmission System (NDATS) consists of data-acquisition systems and microwave-relay systems which link the Utah Test and Training Range (UTTR) and the UTTR control center at Hill Air Force Base to Edwards Air Force Base. This is a duplex link with the capacity of three wide-band (1.5 MHz) TM channels and approximately 60 super group channels for communications.

- **West DATS.** The WDATS system allows AFFTC to interface with the 30th Space Wing (30 SPW) at Vandenberg Air Force Base. The 30 SPW system can provide data to and from the Naval Air Warfare Center Weapons Division (NAWCWPNS(PM)) Point Mugu, California, or from the Western Test Range sites at Vandenberg Air Force Base or Pillar Point, California. The WDATS link between Edwards Air Force Base and Vandenberg Air Force Base is a hybrid system containing three wide-band (1.5 MHz) analog TM channels and a digital multiplexing system capable of 5.68 Mbps aggregate pulse code modulation (PCM) data and 48 channels of voice and data.

(4) **Real-Time Processors**

- **IFDAPS.** The Integrated Flight Data Processing System (IFDAPS) is a minicomputer-based real-time telemetry data processing system. It is capable of simultaneously displaying engineering-units data on 5 high-resolution graphics displays and 16 eight-channel strip-chart recorders. These displays and strip-chart recorders are located in mission-control rooms where test engineers can monitor the progress of the test flight and the quality of the data being produced. There are five IFDAPS systems, each dedicated to its own large control room. All IFDAPS systems operate independently to allow support of five separate test missions simultaneously.

- **SCI.** The four SCI real-time telemetry data processors perform functions similar to IFDAPS, but their CRT displays are character-based, and they can each drive only eight strip-chart recorders. These systems are used to augment data display in the large control rooms or can be used as the sole data source in each of two small control rooms.

- **VAX Real-Time Processors.** The two VAX real-time processors are minicomputer-base systems which provide workstation-class display of telemetry data in any one of the five large control rooms.

(5) **Mission Control Rooms.** User mission control rooms are available in RMCC for real-time control of specific test missions. A standard control-room configuration has been established with the design and installation of a major data distribution upgrade throughout RMCC. Digital displays, in addition to the analog, are available in each control room at several engineering positions. Capabilities include strip-chart recorders driven by telemetry decommutators which display test parameters for analysis; video display terminals which can

display X, Y, Z position data from either radar or telemetry sources; communications systems; flutter analysis filters and computers; FliteVision monitors.

(6) **MT-DARC**

- The MT-DARC, a computerized air traffic control radar system developed in coordination with the FAA, is used to control test missions within the R-2508 restricted airspace. The system allows controllers to maintain airspace integrity and to safely deconflict high performance jet aircraft and nonparticipating civil air traffic.

- The radars that provide data to the system include eight 60-nautical-mile (nmi) terminal (gapfiller) radars and three 200-nmi radars providing coverage for R-2508 and a 20-nmi buffer zone.

- The MT-DARC can track both transponder and non-transponder equipped aircraft simultaneously. The system can combine selected radar target data with geographical data for a composite radar mosaic. The MT-DARC has the capability of tracking up to 50 aircraft simultaneously.

(7) **Plotting Board**

- Four vertical plotting-board systems are available to display and to furnish permanent plots of X, Y, and Z data. Data can be time correlated for postflight analysis to the nearest minute, 12 times per minute, or once per second. Each plotting board is equipped with a headset and microphone to provide intercommunication.

- Data sources for the vertical plotting boards are the instrumentation radars and computer-processed telemetry data. Radar-furnished data is made compatible with the plotting board through analog computers and a polar-to-cartesian coordinate converter. The telemetry data is processed through digital-to-analog converters and is specially formatted for plotting boards.

- A television camera can monitor and record one plotting board for postflight analysis distribution through the FliteVision system. Plotting boards include a digital readout which furnishes the range between any two targets for intercept missions.

3. **RISK MANAGEMENT**

a. **Range Policies**

(1) The 412th Test Wing Safety Officer assures that all range operations are conducted in a safe manner consistent with operational objectives.

(2) The Flight Test Center Safety Officer assures that range safety is a priority during all phases of operations. Before a test can be conducted, the Safety Officer must

complete an operational hazard assessment of the test. Minimum safety requirements for tests conducted on the Edwards Air Force Base ranges are

- a complete test plan is required including objectives, profiles, and required data;
- explosive ordnance disposal directives require a description of hazards in the unit such as hazardous or toxic materials, squibs, spotting charges, or pyrotechnics when units are dropped or fired from an aircraft;
- profiles of all delivery methods used to drop ordnance or fire guns, including altitudes, speeds, climb or dive angles, footprint data, and desired heading at release;
- test units which present unusual hazards may be required to have a radar transponder or a flight termination system installed; and
- graphs and plots of ballistics data and footprints of test units, panels, doors, and parachutes for "full function," "partial function," and "all fail" conditions are required.

b. **Hazard Analysis Tools.** The primary hazard analysis tool used at the AFFTC are the Weapon Delivery computer program, version 4.0 (WD40), ballistics tables and charts in weapons manuals, and data supplied by the test program for unique test articles.

ATLANTIC FLEET WEAPONS TRAINING FACILITY (AFWTF)

1. INTRODUCTION

a. **Mission.** The Atlantic Fleet Weapons Training Facility (AFWTF) mission is to operate, maintain, and develop weapons training facilities and services in direct support of the training of fleet forces and other activities and for the development, test, and evaluation of weapons systems.

b. **Physical Description.** The AFWTF is comprised of four major ranges which are located north and south of Puerto Rico, on and around its adjacent islands, and on the U.S. Virgin Islands. These ranges are supported through facilities located at the U.S. Naval Station, Roosevelt Roads, Puerto Rico. Additional range support facilities are located at Pico del Este, on the island of Vieques off Puerto Rico, and on St. Thomas and St. Croix, U.S. Virgin Islands.

(1) **Outer Range.** The Outer Range encompasses two open ocean operating areas (OPAREAs): ALFA/North and BRAVO/South. These areas are used for various types of live-ordnance exercises and other events requiring large air or sea space (surface-to-air, surface-to-surface, air-to-surface, air-to-air gun and missile exercises, and fleet/task group exercises).

(2) **ALFA/North.** This area is approximately 12,000 square nautical miles and is normally comprised of W-368, W-369, and W-429 warning areas. Each area extends from ocean bottom up to an unlimited altitude. This range can be enlarged significantly by activating areas 21, 22, 23, 24, and 25 which would incorporate an additional 120,000 square nautical miles. The southern boundary of the range is 40 nmi from Roosevelt Roads.

(3) **BRAVO/South.** This area is approximately 8,000 square nautical miles, normally comprised of W-370, W-372, W-373, W-374, W-375, and W-376 warning areas. Areas W-370, W-372, and W-373 extend from the ocean bottom up to an unlimited altitude; W-374 and W-375 extend up to 6000 feet and W-376 extends from 17,000 feet to FL210. This range can also be enlarged by activating areas 26, 27, and 28 which would incorporate an additional 74,000 square miles. The northern boundary is 25 nmi from Roosevelt Roads.

(4) **Inner Range.** The Inner Range is approximately 300 square miles and includes the eastern end of Vieques Island. It consists of W-428B, W-428C warning areas and R-7104 restricted area which extend from surface to FL500. Exercises on the range require close coordination between the unit and range control and strict adherence to procedures because of the large amount of inter-island air and surface traffic and political and environmental sensitivity. This range supports amphibious landings and maneuvers, naval gunfire, air-to-ground firings, laser operations, special and mine warfare.

(5) **Underwater Tracking Range.** The Underwater Tracking Range (UTR) encompasses two oceans: North and South. These ranges are used for various exercises requiring precision underwater tracking such as Antisubmarine Warfare (ASW) and Antisurface

Ship Warfare (ASU) scenarios; air, surface, and subsurface torpedo qualifications; tactics development; and sensor testing and evaluation. The ranges can be operated simultaneously.

(6) **UTR North Range.** The North Range is approximately 300 square miles of instrumented tracking contained in OPAREA 6 which is located 5 nmi off the northwest corner of St. Croix. It has an average depth of 15,000 feet. Aircraft can operate up to 1,000 feet (visual flight rules (VFR)). Clearance to 10,000 feet can be arranged for antisubmarine rocket firings.

(7) **UTR South Range.** The South Range is approximately 100 square miles of instrumented tracking contained in OPAREA 11 which is located 1 nmi off the west end of St. Croix. It has an average depth of 3,000. Aircraft can operate up to 1,000 feet VFR. Clearance to 10,000 feet can be arranged for ASROC firings.

(8) **Electronic Warfare (EW) Range.** The EW Range provides a multi-threat and multi-axis EW environment to fleet airborne, surface, and subsurface units. The EW Range can be used alone or in coordination with the other ranges. Current threat simulators are located on Pico del Este (3,500 feet); Mount Pirata, Vieques (1,200 feet); and St. George's Hill, St. Croix (1,000 feet). Coverage to the units in any range is limited to line of sight. Future EW systems are planned for use on Crown Mount, St. Thomas (1,500 feet) and a range surface craft.

c. **Typical Programs Supported.** The AFWTF supports all customers with a primary emphasis on fleet training. Operations vary from single to multi-unit exercises using subsurface, surface, and air assets. Foreign military (Canada, Netherlands, NATO, United Kingdom, and Germany) operations are also supported on all ranges. Developmental programs such as Tomahawk, Aegis, Arleigh Burke, Harpoon, Penguin, Sparrow, Standard Missile, and MK-48 torpedoes use all ranges.

2. SAFETY CAPABILITIES

a. **Overview.** Range safety is conducted from three areas at AFWTF. The Outer and EW ranges are monitored from the Range Operations Center (ROC) at the Naval Station, Roosevelt Roads. The Underwater Tracking Range is monitored from St. Croix and the Inner Range from Vieques Island. In all cases, the O&M contractor provides for most of the manning for day-to-day operations, but designated range safety officers are present for every event at each site. All the ranges are tied together via a digital microwave which contains communications, radar tracking, and display data.

b. **Individual Systems.** The following systems are available at each of the following sites:

(1) **Naval Station, Roosevelt Roads.**

- Telemetry Receiving Station/Naval Weapons Assessment Center (4 antennas)
- MSQ-51 Tracking Radar (drone and SEPTA tracking)

- Naval Tactical Data System (Link 11, 14, and 4A)
- Integrated Data Extraction and Reduction (IDER) System
- Real Time Display System (RTDS)
- Central Data Processing and Distribution System (CDPDS) (Gould Computers)
- Central Command and Control System (CCCS)
- IRIG-B Timing System
- Remote Data and Drone Control System (RDDCS) (central control of targets)
- Fleet Area Control and Surveillance Facilities (FACSFAC, IOC late 1992)
- Digital Microwave (IOC for entire range mid 1992)
- UHF, VHF and HF Communications (Secure Capable)
- Multipurpose Surface Craft (2/180 FT boats)
- Torpedo Recovery Boats (2 boats)

(2) **Pico del Este**

- FPS-67 Radar (surveillance and FAA support)
- SPS-48C Air Search Radar (IOC late 1992)
- Nike/Hercules Tracking Radar (IOC late 1992)
- Telemetry Receiving Station/Naval Weapons Assessment Center (4 antennas)
- Integrated Target Control System (4 ITCS trackers)
- Threat Radar Simulator (TRS)

(3) **Vieques (Cerro Matias)**

- Nike/Hercules Tracking Radar
- Sperry Marine Radar
- Weapons Impact Scoring System

- Laser Evaluation System (IOC mid 1992)

(4) **Vieques (Mount Pirata).** Threat Platform Simulator (TPS)

(5) **St. Thomas (Crown Mt).**

- SPS-48C Air Search Radar
- Nike/Hercules Tracking Radar (2 antennas)
- FPS-105/Capri Tracking Radar
- Integrated Target Control System (2 ITCS trackers)
- Telemetry Receiving Station/Naval Weapons Assessment Center (2 antennas, IOC late 1992)

(6) **St. Croix (St. George Hill)**

- FPS-105/Capri Tracking Radar
- Sperry Marine Radar
- Threat Platform Simulator (TPS)

(7) **St. Croix (UTR).**

- Underwater Hydrophone Array Tracking System
- Post-Operational Analysis Critique and Exercise Review (PACER)
- Fleet Operational Readiness Accuracy Checks (FORACS)
- Submarine Warning and Communications System (SUBWARN)
- Data Gathering and Processing System (SUN Workstations)
- Surface Ship Radiated Noise Measurement (SSRNM)
- MK-30 ASW Mobile Target System

(8) **Flight Termination System (FTS).** Those exercises that require FTS services usually provide the associated hardware. In most cases, the FTS is set up on the firing unit and under the control of the Officer Conducting Exercise (OCE). Location and control of the FTS is well coordinated prior to actual exercises.

3. RISK MANAGEMENT

a. **Range Policies.** Every unit using any AFWTF range receives a safety brief from range officers. These briefs are held on the unit before the exercise or at home bases at pre-exercise meetings and cover specific operational safety items and FAA airspace requirements. In complex scenarios, multiple target and unit presentations, AFWTF assists in providing information on range limitations and safety requirements. The unit's commanding officer has final approval on these scenarios. Aircraft safety is coordinated with FAA San Juan; AFWTF only provides advisory control. Installation of the FACSFAC will greatly increase air-space flexibility.

b. **Hazard Analysis Tools.** None.

c. **Assessment Process and Criteria.** Safety planning incorporates inputs from AFWTF military, civilian engineers, FAA Liaison, and O&M Contractor. The AFWTF uses Naval Air Warfare Center Weapons Division (Point Mugu) developed hazard patterns, as appropriate to AFWTF's situation, as guidance for range safety. The Submarine Force U.S. Atlantic Fleet developed hazard patterns are used for MK-48 torpedo firings. All other weapon releases and firings use standard published tactical doctrine as described in AFWTF Range Manual, AFWTFINST 3120.1J.

**DETACHMENT 2, SPACE AND MISSILE SYSTEMS CENTER
(DET 2, SMC)**

1. INTRODUCTION

a. **Mission**

Detachment 2, Space and Missile Systems Center's (Det 2, SMC) mission provides DOD with a capability to accomplish research, development, test, and evaluation (RDT&E) for space systems. The SMC accomplishes its mission through work with the various DOD, federal, and civilian space test program offices. Using over 30 years of satellite command and control experience, the Center brings practical experience and lessons learned to new complex space programs and assists through all phases of planning, designing, testing, and evaluating of some of the most advanced satellite systems.

The Det 2, SMC's Mission Safety Officer assists in space and space-related systems testing. The officer assures these tests are accomplished safely with regard to all other space operations, current and future, and that they pose no undue threat or hazard to life, property, or the environment.

b. **Physical Description**

Located in the heart of "Silicon Valley," in Sunnyvale, California, the Center is a control node to the worldwide Air Force's Satellite Control Network (AFSCN). Through the AFSCN and dedicated assets, the SMC has access to and can control testing on a global scale. These tests do not have to be all space based. Through various communications links, valuable assistance to over-the-horizon terrestrial testing for any DOD organization can be provided. The Test Support Complexes (TSCs) within Det 2, SMC, can safely monitor and control multiple test articles on a 24-hour, 7-day-a-week basis.

c. **Typical Programs Supported**. The scope of tests covered by Det 2, SMC include space and space-related tests. Potential users include Army, Navy, Air Force, Strategic Defense Initiative Organization (SDIO), and other federal agencies and civilian program offices. The Mission Safety Office supportable tests are not limited to on-orbit systems. Included are ground-based or ballistic tests which may impact or pose a risk to space-based systems. The types of tests supported include prototyping, proof-of-concept, one-time experiment, development test and evaluation, and operational test and evaluation of space systems that take place before the system is turned over to the using command.

2. SAFETY CAPABILITIES

a. **Overview**

Safety analysis and assessment of the test program, independent from the test program office or their contractor, is conducted by the Mission Safety Officer for those hazards

which have been determined to be high risk or where the test program office and contractor do not have the ability to perform the needed analysis. The technical analysis is performed by experienced space-safety engineers using safety software models to analyze potential hazards resulting from the tests. These analyses are performed, but not limited to, on tests which involve impacts or explosions, directed energy, debris, and chemical releases. The analyses include setting hazard-limit lines and determining optimum location in space for conducting tests.

Detailed procedures are developed for interface between the various support agencies and ranges such as the Space Defense Operations Center (SPADOC) and launch ranges which are used during the test execution. These procedures include specific interface schedules and data requirements needed for safety support of a test. During the critical space-test experiments, a Space Safety Officer monitors test parameters and provides space-safety control in the form of space-safety approvals.

b. **Individual Systems**

The Mission Safety Officer uses a variety of methods to assist in hazard analysis, risk assessment, space test monitoring, and control. Currently, several individual space-safety software models are used based on the different space safety-risk involved. The results of these models are analyzed, and an overall test assessment is provided. The development of an integrated analysis and real-time assessment system is currently underway. The Space Safety System is an SMC-sponsored software development which will initially consist of Close Approach Prediction and Probability Analysis capabilities. This system will be available in September 1992. Additional capabilities will be added in future increments addressing radio frequency interference and hazards from lasers, debris clouds, and decaying objects.

Real-time space-test monitoring and control are provided by Test Support Complexes (TSCs) which contain the computer systems for planning missions, processing telemetry, analyzing data, and sending spacecraft commands. An extensive, dedicated communications system provides connectivity between the TSCs through the AFSCN or dedicated command and control assets to the space-test article. The Mission Safety Officer interfaces with designated individuals within the TSCs to ensure planned test procedures are being executed properly and required safety test data are properly acquired and processed.

3. **RISK MANAGEMENT**

a. **Range Policies.** The following Det 2, SMC policies are fundamental to ensuring on-orbit or reentry safety.

(1) Tests conducted using Det 2, SMC assets must be within acceptable risk limits consistent with mission requirements and national needs as determined by the Det 2, SMC commander.

(2) When multiple ranges and agencies are involved in a test for which Det 2, SMC is acting as the lead range, Det 2, SMC coordinates safety turnover points and integrates the applicable supporting range and agency's safety programs into the test support.

(3) When the Det 2, SMC Mission Safety Office is designated as a participating test agency, it will support mutually agreed upon requirements between Det 2, SMC and the lead range.

(4) Recognizing that space-test programs present unforeseen hazards and issues, each program is independently evaluated by the Det 2, SMC Mission Safety Office. Safety issues are resolved on a case-by-case basis.

(5) The Det 2, SMC Mission Safety program includes a formal safety review process in accordance with Space System Division Regulation 127-8, volume II, and Det 2, SMC supplement.

(6) Programs using Det 2, SMC resources must have a formal system safety program as described in DOD Instruction 5000.2, Applicable Service Directions, and MIL-STD-882.

(7) All interfaces and shared operations with other test agencies must be defined, so responsibilities for implementing hazard controls are clear.

(8) The user is responsible for including the space test safety requirements of the Det 2, SMC Regulation 127-1 into its system safety program. Known hazards associated with systems in the space-test environment must be evaluated and eliminated or controlled. The Det 2, SMC user must provide evidence that systems meet the governing requirements. The Det 2, SMC requires proof that

- user test activities do not cause an unacceptable damage risk to orbital, airborne, or ground assets; personnel; or in-space or earth environment;
- an acceptable low risk of damage by the space environment to user assets is presented;
- an acceptable low risk of harm to the general public is presented; and
- controls are established to minimize risk and track defined hazards.

(9) The burden of proof for safe operations is placed solely on the Det 2, SMC user.

b. **Hazard Analysis Tools.** The Det 2 Mission Safety Officer will identify all on-orbit safety hazards and assess them for the level of analysis effort required. If the hazard is determined to be of high risk or to need more analysis than can be conducted by the program officer, a space-safety engineer will be tasked to conduct the analysis. The space-safety engineer will determine which hazard-analysis tools to use depending on the complexity of the hazard. Some hazards may need only manual-engineering analysis, while other hazards may involve using a series of space-hazard analysis tools to determine the overall risk.

c. **Assessment Process and Criteria**

(1) The Det 2 Mission Safety Office provides four basic support elements to test programs: planning, analysis and assessment, execution, and evaluation. These elements were designed to parallel test spacecraft mission development and Det 2, SMC functions. During the planning operations, safety scenarios are developed and activities such as mission concept development, contract related documentation tailoring, and activity schedule planning are implemented for test programs. Independent space-safety analysis and assessment for Det 2, SMC supported test missions are accomplished by the Det 2, SMC Mission Safety Officer to evaluate the risks of proposed test experiments. These assessments represent a synergy of the traditional applications of "system safety" and "range safety" to form a comprehensive approach to the unique safety concerns of space and space-related testing. Hazards associated with the design and operations of the vehicle in space are identified and evaluated, and procedures are developed to ensure risks are mitigated or controlled. Residual risks which cannot be fully controlled or mitigated are assessed and presented to the program officer and Det 2, SMC Commander for acceptance. A tailored system safety program, such as described in MIL-STD-882B, is required for each program supported by Det 2. During actual test operations the Det 2, SMC Mission Safety Officer will perform near real-time analysis and assessment of the test mission including targets of opportunity as they occur during the mission. Hazard-analysis tools will be used to provide an integrated answer or individual risk analysis to assess the test in reference to near-term safety hazards. The evaluation element of operations is conducted after each experiment or test mission. The goal of this element is to take the lessons learned from a just completed test and apply them to future tests. The functions performed include evaluation of the test results, personnel and procedures, and creation of the lessons-learned report.

(2) The Det 2, SMC safety assessment and approval process requires completion of phased safety-review milestones. Safety milestones are complete upon approval of incremental Accident Risk Assessment Report (ARAR) submittals which are in four phases: 0, 1, 2, and 3. The first three phases, 0, 1, and 2, may be waived at the discretion of the Det 2, SMC Mission Safety Officer, but phase 3 requires the Det 2, SMC Commander's waiver approval. Phase 0 milestone will be targeted for completion during the System Design Review (SDR) timeframe, but no later than the midway point between the SDR and the Preliminary Design Review (PDR). Phase 1 milestone will be targeted for completion during the PDR timeframe, but no later than the midway point between PDR and the Critical Design Review (CDR). Phase 2 milestone will be targeted for completion during the CDR timeframe. Phase 3 milestone will be targeted for completion no later than 6 months prior to launch. Program PDRs or CDRs will remain open until the associated incremental safety approval milestones are satisfied, and launch will not occur until all known space-safety issues have been resolved.

KWAJALEIN MISSILE RANGE (KMR)

1. INTRODUCTION

a. **Mission.** The U.S. Army operates and maintains Kwajalein Missile Range (KMR) as a chartered National Range to provide major instrumentation support for the Department of Defense (DOD) and other government agencies. In the area of technical support, KMR

(1) plans, coordinates, and develops range assets to meet the requirements of current and future range users; and

(2) provides range services in the form of radar tracking and telemetry-data collection for orbital objects, reentry-vehicle data collection and validation, impact scoring, reentry vehicle recovery, command and control of launch vehicles, communications, and meteorological support.

In addition, the Commander, U.S. Army Kwajalein Atoll (USAKA), is the U.S. Commander-in-Chief, Pacific (USCINCPAC) representative to the Republic of the Marshall Islands (RMI) and is responsible for military, security, and defense relations with the RMI government, U.S. government agencies, and civilian organizations.

b. **Physical Description.** Kwajalein Atoll, located in the RMI, is a coral-reef formation, shaped in a crescent, enclosing the world's largest lagoon. Of the 97 islands in the atoll, the USAKA leases 11 from the RMI. Of these 11, 10 are heavily instrumented with radars, telemetry, optical cameras, and tracking devices. These islands are also configured with appropriate communications equipment and extensive logistic services. The depth of the lagoon is between 100 and 200 feet, while the ocean floor outside the atoll quickly drops off to depths in excess of a mile. The lagoon's uniform depth, shape, and surrounding deep ocean area make USAKA an ideal testing location in the middle of the Pacific. The USAKA is capable of recovery and retrieval of incoming reentry vehicles (RVs) that land in the lagoon, while RVs targeted outside the lagoon are implicitly secured by nature from recovery or possible compromise. The USAKA is located in a largely uninhabited region of the world, 2,100 miles southwest of Hawaii and 4,200 miles from the California coast. Physically situated 600 miles north of the equator, the climate is sunny and humid with year-round 85° F and frequent rainshowers.

c. **Typical Programs Supported.** With its unique location, KMR's facilities and instrumentation can support a diverse range of programs. Although KMR is managed by the Army as a national test range, it supports all DOD agencies as well as the Department of Energy and National Aeronautics and Space Administration (NASA). Some specific programs are identified as follows:

(1) **Strategic Defense Initiative (SDI) Programs**

- Exoatmospheric Reentry vehicle Interceptor Subsystem (ERIS)
- Brilliant Pebbles (BP)
- Strategic Target System (STARS)
- Endo/Exo Atmospheric Interceptor (E2I)
- Theater Missile Defense Countermeasures Mitigation Program (TCMP)

(2) **Intercontinental Ballistic Missile Programs**

- Minuteman
- Peacekeeper
- Trident

(3) **NASA and Other Test Vehicle Support**

- Delta
- Titan
- Space Shuttle
- HAVE JEEP

2. **SAFETY CAPABILITIES**

a. **Overview.** The KMR employs an integrated Range Safety Center (RSC), managed by the KMR Safety Office. The office houses all Range Safety System (RSS) computational hardware and software, tracking instrumentation interface hardware and software, command destruct system (DTS) hardware and software, and graphics display system (GDS) hardware and software. Additional resources include range safety analysis computers and Tracking Display System (TDS). The RSC interfaces directly with all range instrumentation required for the missile flight safety solution including radars, telemetry, and GPS.

b. **Individual Systems**

(1) **Radar Systems**

• **ARPA-Lincoln C-band Observable Radar (ALCOR).** The ALCOR is a high power C-band monopulse tracking radar with an ancillary beacon tracking capability. It is

characterized by high resolution in range (approximately 0.5 meter), moderate sensitivity, a high degree of waveform flexibility, and total computer control of real-time radar operations. The ALCOR radiates 2.25 megawatts (MW) peak-power pulses from a 12.2 meter diameter parabolic reflector. Transmitted energy is right-hand circular (RHC) polarized, while both right and left-hand circular (LHC) polarized target echoes are received and recorded.

- **Target Resolution and Discrimination Experiment (TRADEX).** The TRADEX sensor is a coherent, dual L-band and S-band radar system with high sensitivity and high-range resolution using a 25.6-meter antenna. Both L-band and S-band systems normally transmit RHC polarization signals, and receive RHC and LHC polarization return signals. The S-band system can be reconfigured to transmit and receive linear polarization by changing returns only. The system uses both uniform train and burst subpulse spacing to achieve high range and velocity resolution. A digital computer operating in real time provides displays and controls the recording subsystem. A wide-band digital data recording system records the sampled digital amplitude and phase data for each pulse repetition interval.

- **ARPA-Long Range Tracking and Instrument Radar (ALTAIR).** The ALTAIR system is primarily used as a SPACETRACK (deep-space tracking) sensor. It is currently available for SPACETRACK tasking from U.S. Space Command (USSPACECOM) for approximately 128 hours per week (during nonprime shift) and performs satellite catalog maintenance, executes deep-space tracking, and searches for new foreign launches. The ALTAIR gathers coherent data on reentry vehicles and satellites at very-high frequency (VHF) (162 MHz) and ultra-high frequency (UHF) (422 MHz), transmitting at peak-power levels of 5 and 7 MW respectively. The ALTAIR is a high-sensitivity, wide-beam width instrumentation radar which enhances the capability of the USAKA reentry measurements radars with its wide-dynamic range, good range resolution, multiple-target range tracking, and high pulse repetition frequency (PRF). An extended system dynamic range is achieved by delivering several different transmitted waveforms at each operating frequency with pulse compression capabilities to obtain approximately the same receiver output waveform. A general-purpose computer within the radar provides real-time waveform control, PRF, range and angle tracking, multiple-track files maintenance, and target measurement recordings. The 45.7-meter diameter antenna employs a focal point VHF feed and Cassegrain UHF feed in conjunction with a frequency-selective subreflector-giving monopulse tracking capability at either frequency.

- **Multistatic Measurement System (MMS).** The MMS consists of the TRADEX radar on Roi-Namur and remote receiver sites on Gellinam and Illeginni. During operation, TRADEX L-band transmissions illuminate the targets and the remote sites receive the resultant echoes. Microwave communication terminals interconnect the remote sites with TRADEX, KCC, and KDC. The objectives of MMS are to provide bistatic signature recording and precision metric data collection. The MMS collects L-band bistatic signature data in two polarization over a broad range of bistatic angles at low altitude for the tristatic L-band returns. By using the two remote receivers in conjunction with TRADEX transmissions, the cross-range measurement accuracies are far greater than the angle measurements of a monostatic radar.

- **Millimeter Wave Radar (MMW).** The MMW is characterized by high range, Doppler resolution, narrow beamwidth, and precise and stable pointing accuracy. In

addition to signature data gathering on reentry objects at millimeter wavelengths, MMW also serves as a secondary metric standard for the KREMS complex. The MMW radar is exceptionally well suited for the task of two-dimensional imaging of satellites and reentry vehicles, and provides a test bed for technical assessment of the potential role of millimeter waves in ballistic missile defense. The MMW system is not designed for target search and acquisition and normally relies on accurate pointing data from other sensors. However, the current acquisition range for a reentry vehicle is over 1,200 km. The 35 GHz frequency at which the MMW system operates makes the sensor very susceptible to performance degradation caused by weather effects. These system characteristics must be considered during mission planning. The MMW antenna system consists of a 13.7-meter diameter precision parabolic reflector using Cassegrain optics. The antenna is housed within a radome in an environmentally controlled atmosphere to minimize thermally induced distortion and to ensure good beam quality and precise pointing ability.

- **AN/FPQ-19 Radar.** The AN/FPQ-19 radar system is a high-accuracy long-range C-band amplitude comparison monopulse radar capable of manual or automatic track. The system, developed and upgraded to a solid-state configuration, provides radar range, azimuth, and elevation; video azimuth and elevation data in X-Y coordinate digital form; and digital in-phase and quadrature (I&Q) recording for phase derived range data. The radar is derived from the AN/FPQ-6 fixed radar and prior to the latest upgrade was transportable and designated the AN/TPQ-18. The radar system consists of an 8.8-meter antenna, video sensor, pedestal, electronics-equipment building, boresight tower, maintenance shelter, and an office shelter. The AN/FPQ-19 can provide accurate spherical coordinate information on target position with a signal-to-noise ratio greater than 0 dB. The AN/FPQ-19 can track targets in either skin or beacon mode and can provide angular track of targets using video detection and error determination. The optical adjunct to the AN/FPQ-19 is referred to as the Radar Video Metric System (RVMS). The system adds video detection, angular-tracking error, and stellar calibration capabilities to the radar. The RVMS is similar to the KMR Super RADOT sensors in data gathering and reduction capabilities.

- **AN/MPS-36 Radars.** Within KMR, there are two AN/MPS-36 C-band general-purpose instrumentation tracking radars, both located on Kwajalein. Each radar system consists of a 3.7-meter diameter antenna and microwave system, an electronics van, a maintenance van, and a boresight tower. The system is designed to rapidly acquire and automatically track either skin or beacon targets. The system is fully digitized and includes its own digital computer for calibration, acquisition aid, tracking aid, and data output. The system is interfaced with the KMR Instrumentation Control Center (ICC) via high-speed digital modems to provide target acquisition and active tracking data to the KMR data acquisition system. The AN/MPS-36 system provides metric data on incoming missions and local launches in either skin or beacon track modes, real-time acquisition and tracking data to other range instrumentation sensors on local launches or reentry missions via the ICC and sensor integration, and tracking data on weather balloons and meteorological rocket payloads.

- **TPX-42A Surveillance Radar.** This radar system is a surveillance radar used by the FAA in support of Bucholtz Tower Army airfield aircraft operations. It has nearly 180-

nautical-mile beacon tracking capability and is used by range safety during real-time missile test operations to ensure required hazardous airspace is free of unauthorized aircraft.

- **Splash Detection Radars (SDR).** The Splash Detection Radars are X-band scanning radar systems specifically designed to detect the splash of an RV as it impacts the water surface. The radars have a clear weather capability of detecting a splash of 9 meters minimum height and 3 seconds minimum duration from a minimum range of 8 km to a maximum range of 30 km with a detection probability of at least 95 percent. The SDR has a B-scan presentation, a PPI display for 360° azimuth coverage with range sweep radii, plus a flicker-free synthetic B-scope display mode. Correction for range and azimuth zero-sets are determined from the mid-lagoon calibration target. These corrections are applied to the raw synthetic score for quick-look results. The Honolulu Data Reduction Facility reduces the synthetic score (target and calibration sweeps) and provides a final impact report. There are two SDRs located on the range: one on the island of Legan and the other on Gellinam. In addition to their primary scoring function, these radars provide ocean surface surveillance of mission-hazard areas within their scanning range. Sightings are reported to the Range Safety Officer who takes the necessary action to alleviate the violation or hold the mission until an accurate assessment of risk can be made.

- **Optical Instrumentation.** The KMR uses three types of optical instrumentation sensors to obtain RV measurement data: tracking cameras, ballistic-plate cameras, and fixed camera-towers.

- **Tracking Cameras.** The tracking cameras obtain very accurate space-position data of the RVs from the time they become endoatmospheric until splashdown. The KMR's two types of tracking camera systems are Recording Automated Digital Optical Tracker (RADOT) and super RADOT. The RADOTs are computer-controlled camera platforms that are pointed at the incoming RVs by range instrumentation radars, thus allowing long-range automatic-RV target tracking. Azimuth, elevation, frame count, range time, and a camera mid-shutter pulse are recorded on the film of the 70 mm cameras and on magnetic tape for post-mission data reduction. The KMR has three RADOTs. They are located at Kwajalein, Roi-Namur, and Eniwetak Islands. The super RADOT is a modified RADOT that has a 200-inch Cassegrain lens and Intensified Silicon Intensifier Target (ISIT) video camera as its primary data sensor. The super RADOT is capable of exoatmospheric target tracking with optimum lighting conditions. Azimuth, elevation, frame count, and range time are recorded on video tape and on magnetic tape for post-mission data reduction. The KMR has six super RADOTs. They are located at Kwajalein, Legan (this island has two sensors), Roi-Namur, Gegan, and Eniwetak Islands.

- **Ballistic Plate Cameras.** The two types of ballistic cameras used at KMR are BC-4 ballistic plate cameras and spectral ballistic plate cameras. The BC-4s are used to record position versus time data for reentry vehicles using stellar calibrations. The six BC-4 cameras are colocated at the super RADOT sites.

- The spectral cameras use polished glass plates that are ruled with a system of parallel lines or bars (diffraction gratings) to produce spectral separation measurements of the

recorded trace. The gratings available are 300-lines, 150-lines, and 90-lines per millimeter. The KMR has four spectral cameras that can be colocated at the BC-4 sites.

- **Fixed Camera Towers.** The KMR has fixed-camera towers located on Illeginni, Roi-Namur, and Meck Islands. These camera towers support various combinations of 70 mm and 35 mm film, and video-tape cameras to satisfy mission requirements.

- **Telemetry Instrumentation.** The KMR has telemetry stations on the islands of Ennylabegan, Roi-Namur, and Gagan. Ennylabegan is the primary telemetry station and can receive, record, process, and display telemetry data from reentry and locally launched missiles. The Roi-Namur and Gagan stations only receive and record telemetry data. All of the stations have auto tracking Interrange Instrumentation Group (IRIG) S-band antenna systems. Ennylabegan has six antenna systems, one 7-meter, and one 9-meter, while Roi-Namur has one 3-meter and one 5.5-meter. Gagan has a 3-meter and a 1.2-meter antenna; the 1.2-meter antenna is fixed. The KMR telemetry stations have IRIG S-band antenna systems capable of autotracking, receiving, and recording in the frequency band between 2.2 and 2.3 GHz.

- **Global Positioning System (GPS).** Range safety has used GPS data in their real-time solution in an engineering and test mode for two SDIO missions to date. Although GPS antenna configuration problems were encountered with the first test resulting in GPS data dropouts, GPS performed flawlessly for the second flight test. Because GPS data is a high quality, high resolution, independent source of tracking data for the flight-safety solution, it is expected that GPS will become a prime flight safety KMR tracking source in the near future.

- **Skyscreens.** The skyscreen capability at KMR consists of two plexiglass screens overlaid with nominal trajectories for the particular flight test vehicle of interest. They are strategically placed on islands directly aft and adjacent to Meck Island to achieve immediate lateral and "over-the-shoulder" recognition at missile lift-off. Communications for relaying an initial fly-out assessment by the skyscreen operator to the Range Safety Officer are established as required.

(2) **Display Systems.** The Graphics Display Systems (GDS) are dedicated elements of the Range Safety System (RSS) located in the Range Safety Center (RSC). The GDS displays missile performance and range-sensor tracking data to the FSO. These displays supply the information that the FSO uses to make a mission-abort decision. An abort action is warranted when the projection of the missile destruct debris footprint impinges on a inhabited area protection circle. The GDS is a redundant system consisting of a MASSCOMP 5700 computer and work stations for the FSO and his support contractor, Data Acquisition and Reduction (REDAR) engineer. Each FSO work station consists of three graphics terminals, a communications panel, and a status control panel (SCP). The GDS also has one graphics terminal, a communications panel, and an SCP at the contractor's work station.

- **Primary Display Function.** The primary display graphically portrays data necessary for mission termination decisions. This display will accept input data from the ACS and, along with stored background geographic data, processes it for display. The display consists of three instantaneous impact point predictions (based on radar, telemetry, and GPS as available), a debris footprint, a vehicle-present position, and protection circles. These are

portrayed against a background of the islands and atolls in the geographical area. Pertinent mission-specific messages may also be displayed. The scale selection and range sensor selection may be chosen via selection buttons on the FSO safety command panel.

- **Secondary Display Function.** The secondary display presents flight and range safety data in an analytical format which aids the FSO in making a mission-termination decision. Graphs are maintained at a selected scale which show x-range versus y-range, time versus velocity, and total range versus altitude. Scales can be changed automatically by the software or manually by the FSO from the FSO safety command panel.

- **Telemetry Display Function.** The telemetry display obtains telemetry data from the ACS and displays it in graphical form. Telemetry data consists of inertial-measurement unit, navigation computer, missile-booster system, and flight-termination-system data. The display format is a combination of test data, line graphs, and bar charts.

- **Tracking Display System (TDS).** The TDS provides the FSO with the capability to monitor aircraft in the vicinity of the mission-hazard areas via automated real-time input from the TPX-42 Aircraft Beacon Interrogator. Output consists of graphic plots of atolls and islands in the area with markers for ships and radar objects. Some alphanumeric data is also available for radar-tracked objects.

(3) **Real-Time Processing Systems.** The Analysis and Control System (ACS) provides the real-time processing function for the range safety system. The ACS hardware is primarily comprised of two VAX 8650 computers providing a variety of RSS analysis and control functions related to flight safety control of airborne vehicles.

- **Analysis Function.** The ACS computers process the input radar data and select the best data source from all radars assigned a designated safety object. Input radar data is received in the KMR Radar Distribution System (RDS) format at a 10 Hz rate. This data is then used by the Flight Safety Routines (FSR) to analyze and compute critical flight parameters required by the FSO. The ACS also provides GPS or telemetry-positional data in these calculations. There are two different types of safety solutions for mission support situations: passive and active. In the passive safety role, the vehicle position and impact point are monitored. The active safety response, applicable to local launches, have the potential of diverting away from a safe-nominal trajectory. In these situations, the missile is equipped with a destruct package which may be activated by specific IRIG-tone-sequence patterns transmitted from the DTS. This tone transmission is initiated manually through the SCP hardware. In addition to the FSR processing logic, the ACS computers provide appropriate display data to the GDS and respond to operator directives input through the SCP.

- **Control Function.** The ACS computers send pointing data to the Destruct Transmitter System (DTS) and Remote Destruct Transmitter System (RDTS) antennas based on the inputs received from the range sensors. In addition, the ACS can control transitions of the RF switches between antenna and dummy load and monitor the status of vital DTS and RDTS capabilities. When a destruct attempt is made, the ACS validates the received and decoded tone patterns against the tone groups that were intended to be sent.

- **Safety Command Panel (SCP).** One SCP is located at each FSO station.

The command panel functions provided by the FSO SCP include a manual destruct switch, data-source selection switches, and an option to enable protection area infringement warning logic. A similar SCP is located at each REDAR station with different functions assigned to each switch. The REDAR SCP controls and monitors the ACS, DTS and RDTS configuration.

- **Launcher Setting Determination System (LSDS).** The LSDS is resident on the mission room computer of the RSC and accesses data files residing on the ACS computer. It determines appropriate launcher settings for KMR meteorological rockets and for other locally launched rockets. The LSDS input consists of descriptions of the most recent surface and low and high altitude wind conditions. These wind speeds and directions are obtained from weather radars located at Kwajalein and Roi-Namur. This information is applied against known rocket behavioral characteristics to determine the azimuth and quadrant elevation settings which would achieve the desired impact point.

(4) **Destruct Transmitter Systems (DTS) and Remote Destruct Transmitter Systems (RDTS).**

- **DTS.** The DTS is located entirely at the RSC facility. The DTS equipment provides the means to transmit commands to the airborne-test vehicle with an effective radiated power of up to +93 dB. The DTS antennas may be manually pointed or may be controlled with azimuth and elevation data received from the ACS computer from the Digital Input/Output Converter Unit (DIOCU). Sequences of command tones may be output from the DTS to the airborne-test vehicle. These command tones may be either a destruct-tone pattern initiated by the DTS destruct-sequencer hardware or a tone pattern provided by the ACS from the DIOCU interface. The activation of the destruct sequencer is initiated directly by the Flight Safety Officer (FSO) from the FSO Safety Command Panel (SCP) of the ACS. An off-air receiver and tone decoder are also part of the DTS hardware configuration. This hardware provides tone composition and duration information to the ACS for real-time analysis.

- **RDTS.** The RDTS is located at the Launch Ordnance Control Building (LOCB) on Roi-Namur Island. The RDTS equipment provides a backup means to transmit commands to the airborne test vehicle with an effective radiated power of up to +73 dB. The RDTS helical antennas operate at a fixed 15° elevation and may be manually pointed or may be controlled with azimuth data received from the ACS computer via modems. The RDTS omnidirectional antennas do not require pointing and subsequently have a much lower antenna gain figure. Sequences of destruct command tones may be output from the RDTS to the airborne-test vehicle. The activation of the destruct sequencer may be caused manually by the RDTS operator or may be initiated remotely by the FSO from the FSO safety command panel of the GDS. An off-air receiver and tone decoder are also part of the RDTS. This hardware provides tone composition and duration information to the RTDS computer for verification analysis.

(5) **Flight Termination Systems (FTS).** The FTS components are typically furnished by the range user under the direct evaluation and approval authority of KMR. Specific

requirements for these systems are delineated in the KMR Range Safety Manual (RSM); however, with the publication of the RCC document 319-92, *Flight Termination Systems Commonality Standard*, the KMR RSM will be modified to reflect required compliance with the RCC document as well.

3. RISK MANAGEMENT

a. **Range Policies.** It is the policy of the KMR Commander that all reasonable precautions, consistent with operational requirements, be taken during the preparation and conduct of test operations to protect the mission objectives, to prevent personnel injury, to minimize property damage, and to preclude incidents having the potential for international repercussions. As a result of the signing of the Compact of Free Association between the United States and the Republic of the Marshall Islands, this new relationship dictates a greater sensitivity to US-RMI relations and mandates compliance with the Compact in all testing within the RMI. This relationship becomes a primary consideration in evaluating risks associated with missile-system testing at KMR. The following precautions are:

(1) The KMR Safety Officer is responsible to the KMR Commander for evaluating mission risks and providing appropriate recommendations for acceptance. Early-on evaluation by the KMR Safety Officer assures mission objectives are consistent with KMR capabilities. Test scenarios that violate KMR risk criteria must be modified or eliminated as required.

(2) Risk acceptance for nonmission essential personnel is never allowed to exceed 1×10^{-6} . Risk to mission-support personnel may exceed this amount; however, the extent that may be accepted will be determined by such concerns as the number of tests to be conducted, national priority, and numbers of personnel exposed. Because of the range configuration and the types of programs currently being supported, mission support personnel casualty exposure has never exceeded 1×10^{-6} .

(3) Mission-support aircraft risk is evaluated on a case-by-case basis. Post-test vehicle-destruct debris is evaluated to determine the reaction time necessary for the Range Safety Officer to protect the mobile sensor in the event of a missile malfunction. Generally 1×10^{-6} is used as the risk-acceptance criteria in the positioning of mobile sensors supporting missile-flight tests; however, risk evaluation parameters as delineated in the above paragraph will also be used in the consideration of risk acceptance.

(4) Any test program with a flight-test vehicle requiring a flight-termination system for vehicle real-time control must ensure an extensive and comprehensive qualification and validation effort. The reliability of the FTS must be such that the possibility of an FTS failure is insufficient to affect the overall safety-acceptance risk. Specific FTS requirements for KMR are identified in the KMR Range Safety Manual and the RCC document 319-92, *Flight Termination Systems Commonality Standard*.

b. **Hazard Analysis Tools.** Various analytical software is used by the KMR Safety Officer for evaluating range-safety considerations. The software is generally VAX or NeXT PC

(UNIX) based. While most of the software is generic, others are in constant development or modification to support specific test vehicles. The software includes:

(1) **AEROHEAT**. This program uses simplified aerodynamic heating prediction methods to determine heating rates for a vehicle during ascent and reentry. Body shapes, which may be considered, include flat plate, wedge or cone, swept cylinder, and leading-edge stagnation point. Thermodynamic properties for flow-field analyses may be based on either ideal gas or equilibrium air assumption. "Thin skin," "thick skin," or "thin-thick skin" wall temperature response options are included.

(2) **COLIMP**. This program predicts ground-impact footprints resulting from a collision of a missile with its target. The code contains the latest collision-debris modeling techniques used to determine fragment collision induced velocities. This code considers effects of regional and seasonal winds and regional-atmospheric properties on ground-impact footprint. It also performs an orbit and escape velocity analysis on the collision debris fragments and determines impact density. Optionally, the effects of reentry heating and ablation on debris-fragment survivability can be considered.

(3) **DESIMP**. This program computes impact ellipses for a missile destruct at selected times along the vehicle flight. The code provides impact ellipses for each fragment in the destruct debris catalog and is used to determine and to define footprint fragments.

(4) **Debris Impact Statistical Analysis Tools (DISTANT)**. The DISTANT provide accurate estimates of time varying and summary mission risk statistics such as impact probability, expected individual casualty, and ensemble failure modes. Summary statistics include casualty expectation for the entire mission, expected cost of property damage, risk to participating and nonparticipating aircraft, probability of impact within protected areas, and on inhabited and uninhabited land masses. Several utility programs are used in conjunction with the DISTANT model. These programs check the impact data for discrepancies, calculate impact centroid, develop PI contours, plot PI values on a grid map, plot actual impact points for user selected conditions, and filter data.

(5) **Flight Safety Routine (FSR) Simulator**. This program is used to drive the KMR real-time flight safety routine off line. The simulator allows efficient testing of the FSR code off site and premission analysis to determine the FSR footprint trace for a particular mission. It will simulate radar, TM and GPS sensor tracks based on an input trajectory. It is also used to generate premission FSR footprint traces. The FSR performs radar, TM, and GPS processing and filtering, automatic and manual sensor selection, target-data processing, IIP calculation for multiple data sources, and area calculation of endangerment footprints, and protection circle violation detection.

(6) **Launch Risk Analysis (LARA)**. The LARA software assesses risks in the launch area. The LARA uses closed form covariance formulations to predict impact-point perturbations because of destruct, malfunction turns, and winds. The KMR LARA has been upgraded to analyze vehicles which are aerodynamically stable and thus trim out during a malfunction turn. Several utility programs are used in conjunction with LARA. These codes

plot LARA impact ellipses, compute PI and EC contours, output PI values on a map grid, and build LARA input decks.

(7) **PC-GDS.** This code is used to simulate the KMR Range Safety System Graphics Displays. It is a functional representation of the KMR GDS on an IBM-compatible personal computer. The PC-GDS can display output data from the KMR flight safety routine. The code allows off-site FSO training, test scenario development, and safety display development. It is also useful for checkout of FSR code changes and review of FSR footprint traces.

(8) **RFLINK.** This code is used to qualify link margins for the command destruct system throughout a mission; that is, to determine signal-to-noise ratio, aspect angle, and angular tracking rates. The code can also be used to evaluate other links such as telemetry, C-band beacon, and GPS. The code considers vehicle attitude, provides direct processing of digital antenna pattern data, processes multiple links simultaneously, and models links from satellites and aircraft. The code can be used to determine sensor tracking capabilities and to evaluate mission-dependent tracking requirements.

(9) **TELEMETRY SIMULATOR.** The telemetry simulator (TSIM) is used to build telemetry parameter time histories. This data can then be recorded on analog telemetry tape and played through the range safety telemetry system.

(10) **TEST AND SIMULATION SYSTEM (TSS).** The TSS is used for mission-flight simulation and is the major mechanism for FSO training, system test, verification, and certification at the KMR RSC. The TSS is composed of the trajectory generator, scenario driver, and scenario generator.

- **TRAJECTORY GENERATOR.** The trajectory generator is a five degree-of-freedom missile simulation which allows accurate assessment of performance, malfunction behavior, and destruct-debris dispersion. The trajectory generator is built around a generic-coding framework with different modules to define the particulars of each system. Range safety currently maintains models for ERIS FTV1, STARS M1, HAVE JEEP, BP-1M, and LEAP-X.

- **SCENARIO DRIVER.** The scenario driver is the real-time driver program for the TSS. Prior to a mission simulation, the RSC simulation computer is physically connected to Range Safety System computers, using data paths identical to those used by range instrumentation. This code reads the binary-scenario file generated by the scenario generator and outputs the simulated tract data over the proper communication links to drive the RSS computer hardware and software.

- **SCENARIO GENERATOR (SG).** This program generates binary-scenario files for the TSS. It takes trajectory generator outputs or other trajectory data and accurately simulates radar, telemetry, and GPS track of a missile. Using KMR sensor characteristics, realistic sensor outputs are obtained. The SG allows for data corruption to simulate sensor or communication problems.

(11) **XFORMER**. This program performs coordinate transformations. Coordinate systems available include Earth Centered Inertial (ECI), Earth Center Fixed (ECF), Geospherical, Launch Centered Earth Fixed (LCEF), and Meck Battery Origin (MBO).

c. **Assessment Process and Criteria**. The risk assessment process is extremely time critical and as such mandates early on coordination between the program office and the KMR safety office. Complex, high-dynamic programs may require test vehicle and test scenario evaluations as early as two years prior to the planned test date. The following paragraphs describe a typical range safety assessment process.

(1) The proposed test scenario is evaluated for feasibility by the Missile Flight Safety section. At this time the evaluations are very gross and simply determine whether a trajectory appears feasible. Those scenarios which cannot be accommodated within the KMR are discussed with the project office and recommendations are offered to facilitate acceptance.

(2) Once a realistic test scenario is determined and preliminarily accepted for evaluation by the KMR Safety Officer, a more fine tuning of the evaluation process begins. Detailed vehicle performance data is provided by the range user, so the KMR Safety Officer can realistically model the flight-test vehicle.

(3) The hazard-analysis tools previously identified are used to determine destruct debris footprints throughout powered flight, launch-area risk hazards, collision-debris footprints resulting from both endo and exoatmospheric intercepts, and specific RF-link margins for the entire flight profile of the test vehicle to ensure that both UHF destruct links and RF tracking links suffice to satisfy the flight-safety solution.

(4) The real-time flight-safety solution is ultimately fine-tuned or tailored as a result of the previously discussed analyses. The final solution is a real-time dynamic footprint representative of the instantaneous post-destruct debris of the vehicle throughout powered flight. This solution is displayed to the Range Safety Officer for real-time decision making.

(5) The nominal and ± 3 sigma trajectories are incorporated into the Test and Simulation system at the RSC. Subsequent non-nominal perturbations to the overall real-time flight-safety solution are incorporated for range safety officer training. These anomalous real-time conditions include but are not limited to anomalous trajectories, noise-induced tracking data resulting in non-nominal appearing trajectories, tracking-sensor dropouts, tracking-sensor tracking discrepancies, and other system failures which would require critical decision making on the part of the Range Safety Officer.

(6) Detailed post-mission analyses are conducted to evaluate flight-test-vehicle performance, range-safety-system performance, and range-sensor performance. The identification of substandard performance is provided to the appropriate support elements to preclude future deficiencies.

**NAVAL AIR WARFARE CENTER AIRCRAFT DIVISION
PATUXENT RIVER, MARYLAND
(NAWCAD)**

1. INTRODUCTION

a. **Mission.** To establish and to implement the total Range Safety Program including generation of support system requirements, advanced planning, premission analysis, real-time test support and post-mission evaluations and investigations. Recommends and establishes policies and procedures related to the Range Safety Program.

b. **Physical Description.** The Naval Air Warfare Center Aircraft Division (NAWCAD) Patuxent River, Maryland, is located approximately 51 miles south-southeast of Washington, DC on the southern bank of the Patuxent River at its effluence into the Chesapeake Bay. The center's land space covers more than 7,450 acres and the combined inland and offshore operating areas available to NAWCAD exceed 50,000 square miles. The inner range operating areas encompass the majority of the Chesapeake Bay and Patuxent River between Smith Island and Solomons Point. Available open-ocean range areas include W-108 and W-386. The NAWCAD operations frequently involve other agencies such as NASA/Wallops and FACSFAC VACAPES for open-ocean test procedures. Additional support facilities can be accessed from these agencies with minimal coordination.

c. **Typical Programs Supported.** The Chesapeake Test Range (CTR) can support a wide variety of programs. Typically, programs supported by the CTR include technical and operational evaluations of airframes, weapon separations such as MK-82 and -84 general-purpose bomb releases, remotely piloted vehicles like the Maritimized Vertical Takeoff and Landing Unmanned Aerial Vehicle (MAVUS), missile programs such as AIM-9 and Maverick shots, surface effect ship weapons, and gunfire from rotary and fixed wing aircraft.

2. SAFETY CAPABILITIES

a. **Overview.** The CTR consists of six sections: Optical, Radar, Computation and Control, Project Operations, Target Support, and Range Safety to support NAWCAD range safety missions. Detailed instrumented-system information for data compilation and analysis is available in real-time at CTR.

(1) **Optical.** The Optical section comprises all photographic and laser support of CTR projects. Its assets include five fixed cinetheodolite stations located along the western shore of the inner range, two high-speed film and video stations, two mobile laser-tracking units, and portable video and photographic systems. The theodolites are used to determine time-space position of mission aircraft and ordnance. Used in conjunction with high-speed video cameras, they can also be used for visual surveillance of ordnance-drop hazard areas. This section also supports the surface-surveillance radars located at two of the downrange cinetheodolite stations.

(2) **Radar.** The Radar section supports most CTR projects with precision tracking and electronic warfare (EW) capabilities. Assets include seven precision tracking radar systems (C-, S-, and I-band) and one multi-target instrumentation radar. Included is a unique EW workstation that allows real-time interaction between the engineers, aircraft, and emitters.

(3) **Computation and Control.** This section incorporates all data collection, processing, and presentation. It also maintains a variety of advanced-display systems and associated processing systems. Assets include CTR control-room display systems, microwave networks, and the Mid-Atlantic Tracking System. The displays are state-of-the-art, multi-track CRTs with simultaneous data display.

(4) **Project Operations.** The project operations section is the principal range contact for all CTR-supported projects. Pre-project briefings are conducted and range assets are coordinated through this section. Mission controllers and technicians are also included in this section and are tasked with direct mission support.

(5) **Target Support.** The Target Support section maintains range surveillance, clearance, and support assets. This section also supports and maintains air and surface targets as well as electronic communications and termination systems.

(6) **Range Safety.** The Range Safety section coordinates directly with Operations Section to ensure all CTR projects are conducted within the confines of specific safety policy. Assets are primarily in manpower and hazard pattern and ballistic computation systems.

b. **Individual Systems**

(1) The Range Computation and Control System (RCCS) is designed to directly support the test and evaluation of aircraft weapon systems and their components at the Chesapeake Test Range. These systems include weapons-delivery accuracy, navigation systems, weapon separation, and high angle of attack.

(2) The RCCS provides simultaneous testing of different test missions. The RCCS receives raw data from the CTR's instrumentation systems and processes the data to provide real-time displays and recordings of mission-test data.

(3) There are two types of real-time data associated with each test mission: project data and mission-control data. Project data evaluates key events to determine the success or failure of a test mission. Mission-control data are essentially continuous data used by range safety for safe conduct and coordination of multiple missions. The RCCS data interface to the CTR is via two independent range data control units (RDCU).

(4) The two independent streams of data permit simultaneous operation of different test missions. The raw instrumentation data from the CTR is processed by the computation subsystems to provide test and target vehicle position, velocity, acceleration, and other needed information. The output from the computation subsystem is to the Mission Control and Display Subsystem (MCDS) and also to the Range Control and Display Subsystem (RCDS).

(5) The necessary support requirements to perform a standard delivery mission are

- real-time video coverage at release of any store;
- pathfinder coverage (at least one station with full coverage of hazard area + 1 mile radius);
- precision track (radar, laser, or phototheodolite);
- positive radio communication between aircraft and CTR;
- inner-range clearance asset - at least one for each releasing aircraft plus one for recovery (if required); and
- offshore range clearance asset - at least one air asset or two surface assets for each releasing aircraft plus one for recovery (if required).

(6) Precision tracking sources.

• **Theodolites.** Five theodolites are spaced along a curved portion of the western shoreline of the Chesapeake Bay. They are permanently mounted on 25-foot towers and are protected by slaved, revolving astrodomes. While a target is being tracked, instantaneous azimuth and elevation angles of each theodolite optical axis are simultaneously photographed and digitized at a rate of 5 or 20 times per second. The digital data where the target's position in space and root-mean-square (RMS) velocity can be obtained in real time and transmitted to the Range Control Center. Accuracies of 10 to 15 feet in position and are obtained 3 feet/second RMS velocity. Accuracies of 2 to 3 feet in position and 1 foot/second RMS velocity may be obtained by postflight photographic boresight-correction process.

• **Laser Trackers.** Automatic laser trackers (ALTS) determine the azimuth, elevation, and range to a retroreflector fitted target. Space-position accuracies equivalent to those of the boresight-corrected theodolite solution can be obtained on the same day of the flight using the ALTS. Features of the ALTS include automatic acquisition, tracking, and three types of data output. During track, target range, azimuth, elevation, and IRIG-B time are recorded. This data is recorded on magnetic tape and transmitted at 20 samples per second to the Range Control Center for real-time processing and display. Two portable systems are available.

• **Tracking Mounts.** Located at three of the theodolite tracking sites, these mounts are equipped with video and high-speed motion-picture cameras attached to long focal-length lenses. Video transmissions are displayed with computer-derived quantitative data. This type of coverage is required for critical decision making during test maneuvers as well as post-flight slow-motion analysis.

• **Radar.** Tracking radars are used for range purposes, which provide real-time tracking data or data to be recorded on magnetic tape for postflight reduction. Each radar has

analog-data outputs that are used to drive the range displays to provide detailed flight data, dive angle, and weapon-drop point to the aircraft. The analog-tracking data is digitally converted and transmitted to the theodolite stations via UHF radio link. This data can also be used to slave the theodolites in target acquisition.

(7) **Surveillance.** Surveillance and clearance are accomplished using surface-search radar, remote-video sites, and Target Support Section (TSS) vessels. Two surface search Pathfinder radars are employed on the western shore of the inner range (R-4005N). One is positioned at Bay Forest Theodolite (BAY) and the other at Pt No Pt theodolite (POI) stations. Using these radars, range safety can monitor surface traffic in R-4005N out to the main channel (approximately 6 nmi) from Cedar Point to Point lookout (approximately 15 nmi). Video sites are located along the western shore as well.

(8) **Flight Termination System.**

- All vehicles (missiles, remotely piloted vehicles (RPV), guided and unguided weapons) whose maximum energy footprint overlies a landmass, impinges on high-density traffic areas, or contains nonmovable occupied structures shall require a Flight Termination System (FTS). Additionally, any vehicle whose hazard footprint can be significantly reduced by incorporating a termination system, may require an FTS, as determined by the RSO. Multi-staged vehicles shall require independent separation switches, and if any individual stage hazard footprint falls into the aforementioned category, that stage shall require a separate termination system. Regardless of termination type, the termination system shall be under sole cognizance of the assigned Range Mission Safety Officer.

- **Control.** The FTS control can be established from the CTR control room, from the UC-880 aircraft, and from any remote site. Each FTS control system shall consist of two transmitter and antenna combinations (backup is required) and one control panel. The vehicle receiver system will normally consist of two receiver and antenna and power source combinations and one termination device; however, higher performance vehicles may require dual independent destruct devices.

- **Command Destruct Panels (CDP).** The CDPs differ in the technique used to control IRIG-tone combinations. Therefore, each vehicle will need specialized CDP requirements. Several IRIG tones will always be reserved for range safety use.

- **Unmanned Aerial Vehicle (UAV)/RPV.** If control is not regained in the allotted timeframe, termination will be initiated. The preferred method is engine-cut hardware independent of primary-control interface. Another method can involve autonomous flight to a designated point prior to ditching.

- **Missile Procedures.** Procedures are not required on all missile tests, because flight termination is preferred, especially if conducted in the inner range. The preferred method will induce missile-body breakup or engine cut.

3. RISK MANAGEMENT

a. **Range Policies.** The safe prosecution of all tests conducted by and at the NAWCAD is of the highest priority. Because of the inherent danger in weapons-testing operations, every reasonable precaution must be taken to minimize the risks to life, health, and property. Consequently, the basic objective of the Range Safety Office is to ensure that no object violates this predetermined hazard space. In all cases involving release or firing of a weapon or object, a hazard space will be established, surveilled, and if necessary, cleared to reduce the risk to personnel and property.

b. **Hazard Analysis Tools.** Ordnance Down Range Travel and Impact Estimation are calculated on a program written in Turbo C. The program is designed and developed to simulate the trajectories of single unguided ordnances. It may be used to simulate bombs (released ordnance), rockets (thrusting ordnance), or bullets (fired ordnance). Standard meteorological data is calculated and used for the atmosphere. Equations of motion provide only for the translational motion in three-dimensional space. A fourth order Runge-Kutta method of numerical integration is used to solve equations of motion.

c. **Assessment Process and Criteria.** In determining a specific hazard space, ordnance characteristics, release conditions, and surface restrictions are considered. Strict range-safety criteria are applied to a 3-sigma and maximum-energy analysis. The resulting pattern becomes fixed to a reference point to provide efficient clearance, and the releasing aircraft is then vectored to meet the specific conditions of the hazard space. The support and minimum data requirements follow.

(1) **Support Requirements.** The requirements for standard delivery missions are

- real-time video coverage at release of any store,
- pathfinder coverage (one station with full coverage of hazard area plus 1 nmi radius),
- precision track (radar, laser, or phototheodolite),
- positive radio communication between aircraft and CTR,
- inner-range clearance asset - at least one for each releasing aircraft plus one for recovery (if required), and
- offshore-range clearance asset - at least one air asset or two surface assets for each releasing aircraft plus one for recovery (if required).

(2) **Minimum Data Requirements.** These requirements apply to all delivery mission profiles. These mission-required data are to be presented to the Mission Range Safety Officer prior to any flight test and includes

- 3-sigma store dispersion analysis if available,
- brief description of store and data to be obtained,
- desired launch azimuth and elevation, release and impact points, and acceptable variations,
- coefficient of drag versus mach table for all stages and store payloads,
- ballistic wind weighting factors versus altitude,
- nominal flight profile for each stage of vehicle,
- skip potential analysis if available,
- launch aircraft characteristics (velocity, altitude, dive angle, ejection velocity, and launch rail), and
- brief fragment analysis of any objects ejected with or from the store during any portion of its flight.

**NAVAL AIR WARFARE CENTER WEAPONS DIVISION
CHINA LAKE, CALIFORNIA
(NAWCWPNS (CL))**

1. INTRODUCTION

a. **Mission.** The principal mission is to be the Navy's RDT&E Center for air-warfare systems (except for antisubmarine-warfare systems) and missile-weapon systems. The role of the range is to perform the test and evaluation phases of various programs and projects. Historically, the range facilities workload has been divided among the three services, other government agencies, independent contractors, and foreign governments.

b. **Physical Description.** The range is located in the upper Mojave Desert of Southern California about 150 miles north of Los Angeles. Physically, the base covers over 1 million acres, mostly range areas, and consists of two major range areas: the North Range complex and the separate Randsburg Wash/Mojave B area principally devoted to electronic-warfare testing.

c. **Typical Programs Supported.** The air- and ground-launched weapon tests supported include Sidewinder, Sparrow, Harm, Alarm, Tacit Rainbow, 120 mm gun testing for the Army, and 3- and 5-inch naval-gun testing. Testing is limited to tactical items, frequently highly maneuverable missiles, guns, and bombs.

2. SAFETY CAPABILITIES

a. **Overview.** For weapons that have sufficient range to impact off range, the center has flight-termination capabilities. These capabilities include two fixed and one mobile transmitter systems, each of which has two 1 kW transmitters capable of transmitting flight-termination signals on any of the range-approved frequencies. Termination decisions are based on present position estimates founded on real-time presentation of tracking data, rather than predicted impact data. (Most systems requiring flight termination are highly maneuverable).

b. **Individual Systems**

(1) **Tracking Sources.** Currently seven North Range radars are available to track missiles or weapons for range safety purposes. In addition, four radars on the Randsburg Wash/Mojave B range are available to augment the North Range radars during launches which require interrange flight.

(2) **Display Systems.** The current chromatic display systems view scalable range plans and altitude profiles overlaid with predetermined weapon fly-out profiles. The displays include windowing capability to provide graphic information concurrently with alphanumeric weapon-performance data. Additionally, real-time weapon telemetry information, (seeker and flight termination status data) is shown or relayed to the flight termination officer.

(3) **Real-Time Processing System**

- The Range Control Center Integration and Processing System (RIPS) is the primary data acquisition and processing system. The system consists of seven Encore SEL 32/77-80 computers working out of a shared-memory configuration. The system collects, archives, processes, and displays data at a 10-Hz rate for range test command and control and weapon performance evaluation.

- The software consists largely of FORTRAN 77 high-level code with 25 percent of the total code being assembly code to improve processing performance and throughput efficiency.

(4) **Total System Interfaces.** Data at RIPS are received from remote-range radars on a wide-band cable system. The data are in a serial format (RS-422) and received at a 10-Hz rate. All data are received and processed during the 100-millisecond scan following the one in which it is received. Data from more remote sites such as the radars at Randsburg Wash are transmitted via the Fiber Optic Trunk system intrerange to the Range Control Center. In this case, the distance of 28 miles. Transmission time compensation is included in the data processing.

3. **RISK MANAGEMENT**

Risk management is based for the most part on qualitative-risk assessment rather than quantitative-numerical analysis. When possible, the first preference is to conduct tests, so no item impacts off range. The second preference is to conduct tests with flight termination that prevents any debris from impacting off range. However, it is sometimes necessary to conduct tests where these requirements are not met. Every attempt is made to conduct such tests so that the risk to the surrounding area is negligible. Statistical hazard analysis is not considered relevant for the kind of items tested here.

POKER FLAT RESEARCH RANGE (PFRR)

1. INTRODUCTION

a. **Mission.** Poker Flat Research Range, primarily a sounding-rocket launch facility, is owned and operated by the Geophysical Institute, University of Alaska. It is the only university owned and operated launch range in the world and is the only high-latitude and auroral-zone rocket-launch facility located on United States soil. The range is presently funded through contracts with NASA. Nine university employees work year-round at the facility maintaining the site, waivers, approvals, and agreements necessary to the operations.

b. **Physical Description.** Poker Flat is located in central Alaska, 48.3 kilometers (30 miles) northeast of Fairbanks near the town of Chatanika. The geodetic location is 65° 07'45" N and -147° 28'54.6" W with a mean sea level of 198 meters (650 feet). The range is 4200 acres of university-owned property and 1000 leased acres. The range flight azimuth extends from 355 to 053° true north. There are 26 million additional acres the range has permission to use. The flight zones and impact areas are shown in figure 3.

c. **Typical Programs Supported.** The range typically supports sounding-rocket launches relating to upper atmospheric and auroral studies. Vehicles normally launched without guidance packages vary from Super Loki to Black Brant XII. Poker Flat is in the process of launching a Talos-M56A1 with a guidance package. The Flight Termination System (FTS)/Instantaneous Impact Predictor (IIP) for this vehicle is a mobile unit operated by NASA/Goddard Space Flight Center and Wallops Flight Facility (Wallops), Safety Quality Assurance Engineering Branch (SQAEB). They will not be on site after March 1992.

2. SAFETY CAPABILITIES

a. Overview

The range safety capabilities of Poker Flat are minimal in both ground and flight safety and risk management. At present, Poker Flat does not have FTS/IIP capabilities; however, Wallops SQAEB operates a mobile FTS/IIP unit. This system uses information from radar and TRADAT telemetry. The telemetry and radar systems on site are mobile systems and are operated and maintained by Wallops' mobile telemetry and radar groups. They also provide tracking data information to the Windweight computer system.

An Implementation Plan and Orbital Launch Facility Feasibility Analysis address all of the previously discussed issues. Most additions and upgrades to the facilities will not occur in the next 12 months.

b. **Individual Systems.** The details of the Wallops mobile systems should be acquired from Wallops Flight Facility through Mr. William A. Brence, telephone: (804) 824-1613. These

systems are continually being updated and modified. For further information on Poker Flat's Range Users Manual, write to the

Operations Controller
Poker Flat Research Range
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99775-0800

The only Poker Flat system used for real-time processing is the Windweight minicomputer (HP 1000 A900). This system has inputs from a 81 meter (265 foot) meteorological (met) tower containing 6 anemometers and NASA minimum delay data format (MDDF) data from both TRADAT telemetry and radar. The system is identical, both in hardware and software, to the Windweight system used at Wallops. The Windweight trajectory information is provided by the SQAEB at Wallops. This system obtains data from the met tower and radar on met balloons for the winds above the met tower. The wind profile is constantly being updated to give real-time launcher settings. A program for this computer has been written by Poker Flat to use the MDDF data from radar or TRADAT telemetry to display the present position of a vehicle in flight.

3. **RISK MANAGEMENT**

a. **Range Policies.** The present policies concerning risk management are those established by the University of Alaska Risk Management Office. The main policy follows federal, state, and local laws. Poker Flat requires Material Data Safety Sheets (MSDS) on all hazardous materials. All users' hazardous operations are reviewed by both SQAEB at Wallops and the Range Safety Officer at Poker Flat.

b. **Hazards Analysis Tools.** Analysis for all hazardous systems are completed by the SQAEB at Wallops. Any necessary hazardous handling and safety equipment are provided by Wallops or the user for a particular program.

c. **Assessment Process and Criteria.** The main objectives of the Range Safety Officer at Poker Flat Research Range are

- to review the data provided by the users and Wallops to verify compliance with established rules,
- to identify any problems that conflict with other operations or to ascertain if the facilities are adequate,
- to assure NASA GHB 1771.1 safety regulations are adhered to by the range users,
- to provide flight safety for real time operations involving the unguided systems, and
- to provide data base and other information requested by Wallops and the University of Alaska.

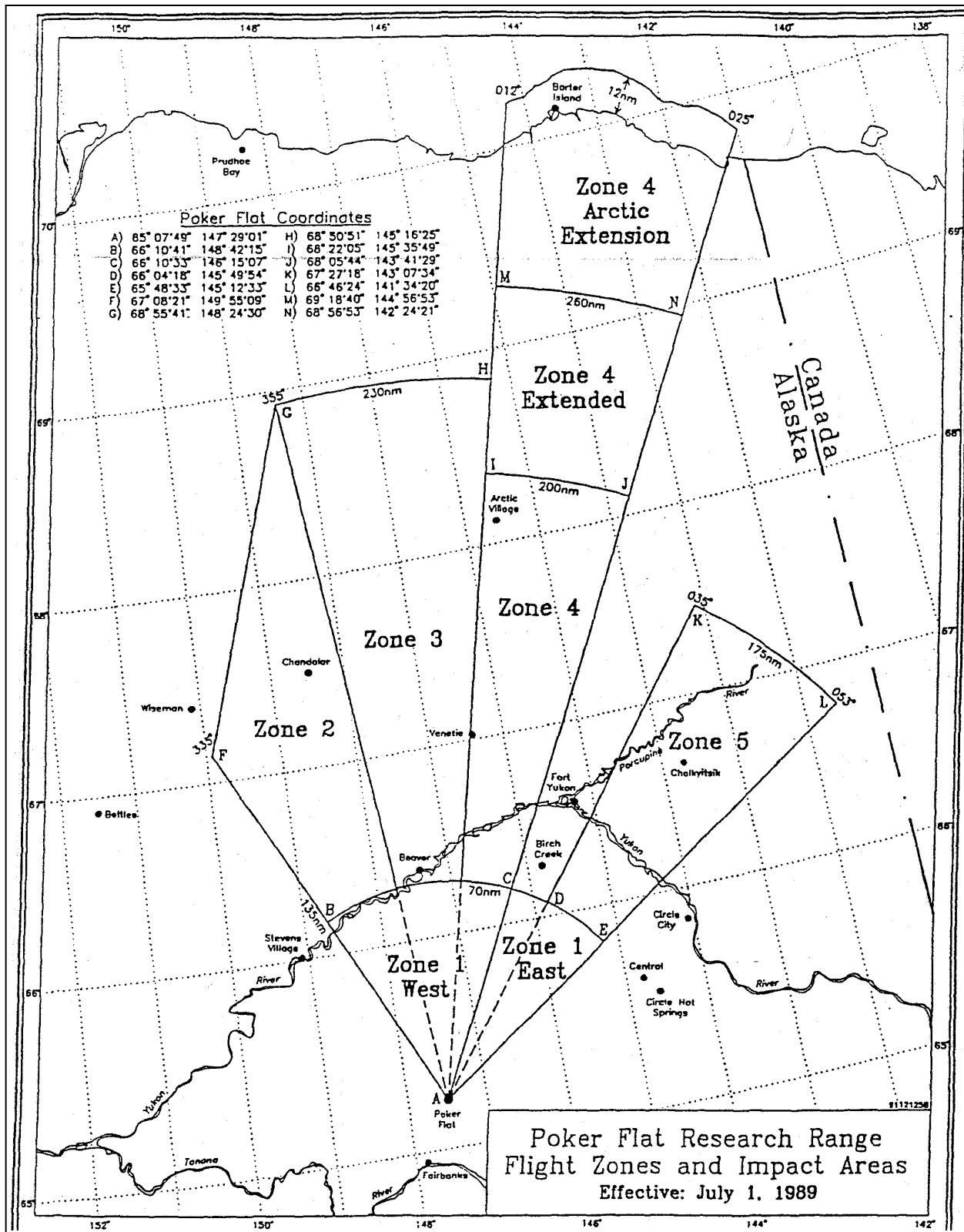


Figure 3. Flight zones and impact areas.

**USAF WEAPONS AND TACTICS CENTER
(WTC)**

1. INTRODUCTION

a. **Mission.** The Nellis Range Complex has been designated a Major Range and Test Facility Base by the Department of Defense (DOD). The range complex is divided into several distinct areas with each area able to accommodate one or more of the primary mission roles. Generally, these areas are the north ranges, the south ranges, the Nevada Test Site, and the Desert Military Operating Areas (MOA). The north ranges provide an area for training and testing against a realistic array of threat simulators and scoreable and nonscoreable targets. The south ranges provide an area for tactics and weapons development, test and evaluation, and instrumented air combat training, while the MOA is an air-to-air range. The Nevada Test Site is an area controlled and used by the Department of Energy (DOE) and its use is highly restricted. Airspace control of much of the range complex and the Desert MOA has been delegated to the Nellis Air Traffic Control Facility by agreement with the appropriate FAA Air Route Traffic Control Centers. Aircraft entering this airspace must be on an instrument flight rules (IFR) flight plan and receive an air traffic control clearance from Nellis Control.

b. **Physical Description.** The Nellis Range Complex is located between Las Vegas and Tonopah in southwestern Nevada and is comprised of the five adjacent areas described in the table.

AREA	TYPE	INCLUDED RANGES	PRIMARY USE
R-4806	Restricted	61,62,63,64, 65, Alamo MOA	Testing, Munitions Training
R-4807	Restricted Pahute Mesa	71,74,75,76,ECS TPECR, ECE	Electronic Combat and Munitions Training
R-4808	Restricted	R-4808E, R-4808W R-4808N, R-4808S	Nevada Test Site
R-4809	Restricted	4809A, ECW	Electronic Combat Range
Desert	MOA	Caliente, Eglin Coyote, Reveille MOAs	Air-to-Air

The total combined airspace equals 12,000 square miles of which approximately half extends over electronic combat and bombing ranges. The complex is bordered on the south by the Nevada Test Site (R-4808) which is operated by the DOE. Overflight of this area is generally limited to transit through R-4808W only. The land is barren consisting mainly of flat dry lake beds, large dry washes, desert vegetation, and rugged mountainous terrain. Large herds of wild mustangs and small herds of antelope can be found throughout the range.

c. **Typical Programs Supported.** A wide collection of targets are available throughout the north and south ranges. Detailed descriptions of each target including authorized munitions can be found in AFR 50-46, NAFB Supplement 1. Ranges may close periodically to conduct a "Coronet Clean" or range decontamination. Since the south ranges overlay part of the Desert National Wildlife Range, their use is governed by a Memorandum of Understanding (MOU) between the U.S. Air Force and the Fish and Wildlife Service. Generally, the MOU places a 2000-foot AGL minimum altitude restriction on all aircraft flying over the wildlife range, except when taking off or landing at Indian Springs Air Field, when using the air-to-ground targets, or when flying low-level missions against specified targets.

Ranges 71, 74, 75, and 76 are all unmanned bombing ranges. Each range consists mainly of tactical-type targets representing airfields, SAM sites, truck convoys, munitions and fuel storage sites, and artillery companies. The Television Ordnance Scoring System (TOSS) is available on ranges 75 and 76 only. Pahute Mesa may be overflown above 500 feet AGL for transit purposes only. Ranges 61, 62, and 64 are also unmanned bombing ranges and are used primarily for tactical air-to-air and air-to-ground combat training with conventional and simulated nuclear weapons training. It is also used by the USAF Aerial Demonstration Team (Thunderbirds), the Nevada Army National Guard, and U.S. Marine Corps Reserve for weapons training. Range 63 is the only range on the complex developed almost exclusively for testing. As such, test projects normally take priority over all other projects. Although test missions using the Red Flag Measurement and Debriefing System do take place on the north ranges, the bulk of testing on the Nellis ranges takes place on range 63. This is the only range on the Nellis Complex which has been developed and instrumented almost exclusively to support test and evaluation missions. The available equipment is designed and positioned to provide the precise data necessary to allow a thorough analysis of both aircraft and delivered weapons performance.

2. SAFETY CAPABILITIES

a. **Overview.** The range-safety concept employed by the USAF Weapons and Tactics Center considers the full protection of all personnel and resources as well as moral and legal obligations regarding adjacent properties. Range Safety Appraisals (RSA) and Hazard Analyses for each proposed test or training activity are the principal vehicles for maintaining minimum range safety requirements. Each test, demonstration, or training mission employing unique ordnance requires an RSA which is specific to that mission. The activities of most training missions and exercises often comply with the safety guidelines set forth in previous RSAs, which negate the requirement to issue a new RSA. The RSAs are assembled by the Weapons and Tactics Center Range Safety Office and approved by the Range Squadron Commander. Coordination between the user, range squadron, and range safety should begin at least 60 days prior to the start of a project. The following information should be made available to WTC/SER

at least 30 days prior to the start of the exercise/test: range entry points, flight profiles, weapons delivery system descriptions, laser or other elements which may prove hazardous to air and ground crews or equipment, and munitions description including footprints, and meteorological restrictions or requirements. Additional studies may also be required if remotely piloted vehicles and drones or guided missiles are to be used or if the mission profile requires flight over or close to private land which may violate destruct or flight termination criteria.

b. **Individual Systems**

(1) **Cinesextants.** These highly mobile-tracking mounts are used to acquire sequential test data and documentation. They can be configured with up to four cameras and a wide variety of lenses. The standard configuration uses a common camera and a 16 mm color camera with a 20-, 24-, or 40-inch lens. Standard film rate for the 16 mm camera is 200 fps and the color-video camera is capable of supporting up to 60 data cinesextants on range 63. There are five systems available for test support.

(2) **Cinetheodolites.** These are precision camera and optical tracking mounts used to acquire azimuth and elevation data for TSPI missions. Range 63 is equipped with five systems. Each system is equipped with a 60-inch lens and video doubler capable of producing either 35 mm film at up to 30 frames per second or black and white video tape from which 60 data samples per second can be derived. The film and video tape contains digital matrix data which includes the camera mount azimuth, elevation, and IRIG time encoded. These data are reduced using a VDAS system and input into a computer which defines object position referenced to either target coordinates or user defined coordinates. Accuracies of up to 2-3 feet are possible.

(3) **Enroute Automated Radar Tracking System (EARTS).** The EARTS is the authority in control of air operations on the Nellis range. It is operated by FAA-certified personnel and controls range airspace. It provides a radar capability which permits the range to operate in a free interactive environment. If the situation dictates, EARTS advises the ROC commander, who may direct ROC to cease range activity.

(4) **Precision Tracking Radar (PTR).** The PTR is a modified I-band Nike-Hercules target-tracking radar equipped with a television camera which is boresighted with a tracking pedestal. It can track either skin paint or beacon signals. The PTR can produce the following data products:

- magnetic tape with time, radar mode, and position vectors;
- boresight camera video tape with range, azimuth, elevation, height, and time; and
- real-time position, velocity, and acceleration of the target relative to a particular surface point.

c. **Display Systems**

(1) **Paper x, y, z plots.** The PTR "quick-look" TSPI data on the aircraft is normally provided within 5 working days although delivery times of 1 hour after the mission may be prearranged.

(2) **Remote Cameras.** These unmanned cameras may be located anywhere on the range to record localized event data such as bomb impact characteristics. Remote cameras differ from cinesextants in that they are unmanned, operate at higher film rates, and do not have synchronized timing with the rest of the range. Event location may be possible if reference points are available within the camera field of view.

(3) **Aerial Video.** The test team may prearrange, through range squadron, to have an Air Force audiovisual team film test-mission events from aboard a helicopter.

(4) **Video Data Analysis System (VDAS).** The VDAS reduces and cinesextant raw shuttered video-data tapes and 16 mm and 35 mm film for post-mission analysis. The VDAS reviews the film and generates a magnetic tape which a Cyber 380 converts to TSPI products. There are three major TSPI products.

(5) **Flight Data Listings.** Position data (x,y,z) which are referenced to a target plane coordinate system provide velocity and acceleration components and slant and ground range from target to tracked object.

(6) **Plots.** An 8 x 11-inch, two-dimensional plot shows the TSPI parameters. Time, x and z are plotted versus velocity, acceleration, trajectory angles, and slant and ground ranges.

d. **Range Operations Center.** The Range Operations Center (ROC), call sign Blackjack, is an integrated control center responsible for directing and monitoring the activities and safety of project participants and nonparticipants, controlling land and airspace use, and under the direction of the Range Squadron Commander, directing search and rescue operations. The ROC is composed of communications, instrumentation, data processing, and display equipment that provide observers with a comprehensive picture of mission events. When required, range-safety officers typically monitor and control operations from the ROC.

The equipment contained in the ROC includes the Range Information System (RIS) which incorporates a large screen display (LCD), four event scoring consoles (ESC), and hard copy recorders. The RIS is the primary data processing and display system for the range squadron. It receives, analyzes, and depicts real-time inputs from threat simulators, ATC radars, and scoring sources, and it can simultaneously record and display both incoming and previously recorded data. Video outputs from the RIS are displayed on a single large screen display and on each of the ESCs. Each of the four ESCs provide the displays necessary to monitor threat activity, perform air-to-ground and ground-to-air engagements, target scoring, and record data. A color and a monochrome CRT, a communications panel, and operator control keyboards are located at every console where RCOs can perform operations requiring such support, along with a hard copy unit which produces a video hard copy of selected displays from that console. The

RIS is capable of interfacing with up to 255 remote range systems via the Nellis network interface, up to 16 FAA reference radar devices, and up to 48 other devices via modem interfaces and serial-data lines. Display formats which can be viewed from the ESC include:

- (1) **Situation Display.** Provides side-view images of selected range areas with aircraft symbology, IFF codes, altitudes and trails, and threat-simulator tracking.
- (2) **Boresight Display.** Provides a view of the target as seen by the selected ground threat and is available only from selected threats.
- (3) **Event-Status Display.** Provides chronological threat simulator event lists arranged in various formats.
- (4) **Television Ordnance Scoring System (TOSS) Display.** Provides selected TOSS maps, ordnance impact points, and target scores.

3. **RISK MANAGEMENT**

a. **Range Policies**

Training, test, exercise, and special project activities on the USAF Weapons and Tactics Center range complex present certain hazards to personnel and equipment supporting each project. In some cases, the potential hazard may extend to other nearby manned ranges, ground teams working on the tactical ranges, range facilities, other government agencies, and public or private properties. The range-safety concept employed by WTC must consider protection of assigned resources as well as moral and legal obligations regarding the public, lateral agencies, and adjacent properties. The hazards are identifiable and the degree of risk exposure can be calculated in most cases. For situations that cannot be quantitatively assessed, qualitative analyses will be made, using the best available data. The development of essential safety parameters and careful evaluation of equipment and procedures can minimize the potential risk. Safety assessments and hazard evaluations for each proposed activity will be principal vehicles for establishing the minimum range-safety requirements and to interface range-safety controls with flight, ground, and weapons mishap prevention requirements.

Compliance with the established assessment procedures is of utmost importance to avoid needless delays and degradation of operational capability. Users cooperation will also provide adequate time for thorough analysis and for making any changes to proposed plans as well as proper implementation of safety measures on the ranges concerned.

b. **Hazard Analysis Tools**

In all projects, the risk to personnel and equipment must be determined. This determination requires that mission, system and operational requirements, and phase characteristics of the operation be assessed for hazards by interfacing and mitigating the identified hazards. To accomplish this endeavor, analyze the test vehicle including its subsystems, personnel qualifications, procedures, environment, support equipment, payload,

armament, and support facilities. Assessment of mishap records, deficiency reports, previous hazard analyses, similar operation, system constraints, mission requirements, and operational records are also conducted. When qualitative or quantitative assessments of the previous factors are combined with the likelihood of exposure and consequences of the hazard effects, the level of risk to personnel and equipment is determined. The WTC/SER typically recommends a project be approved if the risk level (casualty expectation) is no greater than 10^{-6} (one in a million) for non-essential personnel, is no greater than 10^{-5} for mission support personnel, and is no greater than 10^{-4} for mission essential personnel. Support-personnel are those who support the mission but are not essential to the mission, (for example, cinetheodolite operators or electronic combat range threat operators). Mission-essential personnel are those participants without whom there would be no mission such as a special-forces ground team placing a target. For equipment with potential mishap class A, B, and C loss values (as defined in AFR 127-4), the risk level should be no greater than 10^{-4} , 10^{-3} and 10^{-2} . A cost-effectiveness analysis must be conducted on each mitigation factor that is involved in the risk-reduction process. The level of risk is reduced when the effectiveness of the risk-reduction factor and its cost is determined to be justifiable.

- **Weapon Hazard Area (Footprint) Development.** Footprints are used to determine maximum possible deviation of a particular weapon from a normal or planned flight path. Whenever possible, published hazard areas are used to protect personnel and equipment. An example is the series of footprints published in AFR 50-46 which provides 0.9999 weapons containment ellipses used in training operations. However, a study is required when suitable weapon-footprint data are not available from prior development. A study is required if the weapons employment flight path or footprint involves any of the following:

- **Private Land Overflight.** Overflight are those that are so close to private land that a normal vehicle may violate destruct or flight termination criteria (if used).

- A period during flight when private property or critical areas cannot be protected by flight termination or destruct systems. The required studies will be identified by the WTC/SER during the initial hazard analysis and should be submitted by the range user at least 30 days prior to the test start date.

- Whenever risk criteria, outlined in the above risk analysis criteria, cannot be maintained for personnel or equipment.

c. **Assessment Process and Criteria.** To make sure that all safety requirements are identified during the planning stages of a proposed operation on the ranges, the range user

(1) Coordinates with WTC/SER during the program planning stage (a minimum of 60 days) prior to the start of active testing who assigns a safety project officer who will be a member of the test planning team and will assist range users immeasurably in the planning effort by making sure safety requirements are identified as early as possible in the program. For complex tests or projects that entail highly hazardous operations, contact well in advance of the 60-day minimum is recommended.

(2) Submits required data for hazard analysis not later than 30 days prior to beginning mission operations as specified in this chapter or as specifically requested by the WTC/SER in correspondence to the user.

(3) Defines to WTC/SER all known hazardous operations and hardware associated with the proposed project including but not limited to special tactics to be used, hazardous material on board the aircraft, in subsystems, or in the weapons.

(4) Makes sure that all aspects of the proposed mission comply with established directives (Air Force or DOD publications and military standards) governing flying, explosives, and ground safety.

(5) Submits waiver approvals or approved licenses for operations when deviations from flying, explosive, or ground safety directives are required for conducting the project.

(6) Defines the sequence of events for identifying risks, publishing restrictions, and monitoring the compliance with published safety restrictions. The WTC/SER normally receives notification of a proposed project through the 57th Fighter Wing Test Group, the USAF Fighter Weapons School, or the 554th Range Squadron Operations Division. After initial contact, the following actions are taken:

- The WTC/SER reviews the user's objectives and proposed method of achieving these objectives. A written statement of objectives and the method of accomplishment are required from the range user, unless otherwise specified by WTC/SER. The written statement will be in a test or program introductory document.

- The WTC/SER conducts an initial hazard analysis based upon the written objectives and methods.

- When time and circumstances permit, the WTC/SER apprises the range user of any additional safety data requirements by routing an information request through the 57FW/TG or 554RS/DO project officer, depending on how the range users' initial range safety contact was made.

- Nellis AFBR 127-8 is the document used by the range user to comply with range safety requests at the WTC range complex.

UTAH TEST AND TRAINING RANGE (UTTR)

1. INTRODUCTION

a. **Mission.** The mission of the Utah Test and Training Range (UTTR) is to test and evaluate new and diverse weapon systems and provide effective training areas for operational systems. Accomplishment of that mission with minimum loss of resources is the most efficient way to satisfy customers and preserve our assets. The UTTR and Dugway Proving Ground (DPG) form a complex for testing of manned and unmanned air vehicles, munitions, and missiles along with training for flight and ground units from all services in DOD.

The 545th Test Group was established to manage the UTTR and coordinate 501st Range Squadron and 514th Test Squadron missions. Since the roles of the two squadrons are complementary, the 545 TESTG can support a wide range of mission and support functions. The 514 TESTS mission is to support the testing of unmanned air vehicles and to provide airlift support for AFFTC and DOD missions. The Test Squadron maintains and operates a variety of C-130 cargo and test support aircraft along with HH-1H light-lift helicopters. The 501 RANGES provides support for testing weapon systems and training operational aircrews and other combat units. The squadron ensures UTTR air and ground space are used safely, responsibly, and efficiently. It provides users with the timely and cost-effective acquisition, transmission, and data processing generated during testing and training on UTTR. The 299th Range Control Squadron (RCS) or "Clover Control," a Utah Air National Guard unit, is responsible for the air traffic and weapons control service for the UTTR.

b. **Physical Description.** The UTTR is located in Western Utah and Eastern Nevada. The range is divided into the north and south areas, separated by a corridor used by the FAA for commercial flights to and from Salt Lake City International airport. The range encompasses more than 2,800 square miles of land and more than 17,000 square miles of airspace. The North Range consists of 348,787 acres of land, while the South Range, including Dugway Proving Ground, covers 1,341,247 acres; 14,595 acres of the South Range extend into Nevada.

The UTTR is bounded by the Lucin, Gandy, and Sevier Military Operating Areas (MOAs). These areas provide for high-speed (above 250 knots) military operations outside the restricted airspace. The South Range Supersonic Area has been designated for supersonic flight 5,000 feet above ground level (AGL). Aircraft may fly supersonic only above 30,000 feet mean sea level (MSL) in other range areas. The 299 RCS is responsible for the Montello Extension, an Air Traffic Control Assigned Airspace (ATCAA) extending west of the North Range from FL390 to FL500. It is also responsible for the Gandy ATCAA, the airspace from FL180 to FL580 above the Gandy MOA.

Much of the UTTR airspace is over BLM land and some air force equipment is located on this land. Ground operations on BLM land must be approved prior to the program commencement, and no munitions can be expended on this property. The range restricted airspace is divided into "working sectors" to permit efficient scheduling and safe concurrent use of all parts of the range.

c. **Typical Programs Supported.** The following list of programs are being supported or have been supported in the last year.

Air Launched Cruise Missile FOT&E
ALCM Advanced Guidance
Advanced Cruise Missile FOT&E
Combat Hammer (WESP)
Next Generation ACM
Commercial Experiment Transporter (COMET)
BI-B FOTZE
BI-B Conventional Weapons
Baron (UAV)
B-52 Conventional Weapons
Aircraft Decontamination
ALC Service Life Testing
AEGIS (Drone)
F-16 Enqr Flight Test
ALC ARN-101 (PAVE TACK)
Unmanned Air Vehicle-Medium Range
Classified Programs
Tacit Rainbow
Electro-Optical Long Range Oblique Photography System
Training/Exercises
Global Shield
Sea Saw
Quick Force
Gallant Eagle
COMNAV AIRLANT
COMNAV AIRPAC
TAC Operational
SAC Operational
Special Operations (Army)
Air National Guard
USAF Reserve
US Army (Air/Land)

2. **SAFETY CAPABILITIES**

a. **Overview.** The command, control, operational direction, and safe use of UTTR, military operating areas, and test and training programs are the responsibility of the 545th Test Group and the 501st Range Squadron. The 545th Test Group representatives use Statements of Capability, Operations Directions, Hazard Analyses, and weekly schedules to exercise operational control of programs and training on the range. The Range Control Officer, Program Manager, and Range Safety Officer monitor range readiness and safety to assure project accomplishment in a safe manner. They control the status of test systems and range operations, as required, from the Mission Control Center.

b. **Individual Systems.**

Range facilities include radar, telemetry acquisition systems, cinetheodolites, cinesextants, air-to-ground radios, flight television, High Accuracy Multiple Object Tracking System (HAMOTS), HAMOTS Upgrade System (HUS), status alarm and control (Badger) system, coordinate converters, voice communication equipment, Television Ordnance Scoring System (TOSS), Meteorological Sounding System (MSS), and timing equipment. The instrumentation sites are connected by microwave links and fiber optics to the Mission Control Center (MCC) at Hill Air Force Base, Utah. The central computer located in the MCC is the Data Acquisition, Processor, and Controller (DAPAC).

The tracking radars provide time-space-position information (TSPI) to the UTTR Mission Control Center, pass pointing data to each other, and furnish information necessary for individual cinetheodolites to track airborne objects. A description of the radars follows.

(1) **AN/MPS-36 Radar.** The AN/MPS-36 is a C-band general-purpose instrumentation radar located at Wendover Field. It can provide real-time x,y,z data to the MCC and solar data for post-mission data reduction. The system can rapidly acquire and automatically track both skin and beacon targets. The system is fully digitized and includes its own digital computer for calibration, acquisition aid, tracking aid, and data output. Depending on target size, this radar can skin track out to 200,000 yards.

(2) **AN/TPQ-39 Radar.** The AN/TPQ-39 radar is a C-band digital-instrumentation radar which tracks targets using skin returns or beacon transponders. The radar can track targets with a maximum radial velocity of 20,000 yards per second. The radar performance for skin tracking of 1-square-meter target is 34 nautical miles. The beacon system has adequate transmitter power and receiver sensitivity to track beacon targets 500 nautical miles.

(3) **Range Instrumentation Radar (RIR)-777.** The RIR-777 is a C-band automatic-tracking radar which provides range, azimuth, and elevation and x,y,z data in real time to the MCC. It is manually controlled by the operator in either skin or beacon-tracking modes. Skin-tracking range is approximately 200,000 yards.

(4) **Surveillance Radars**

- The 299 RCS uses the local Federal Aviation Administration Air Route Surveillance Radars at Francis Peak, Cedar City, and Battle Mountain. An Airport Surveillance Radar at Wendover Field and Cedar Mountain provides gapfiller coverage. Additional "gapfiller" radars are installed on Trout Creek and Bovine Mountain to provide radar surveillance of the central range and Dugway Proving Ground areas and of the southern, northern, and western approaches to the range.

- The Airport Surveillance Radar at Wendover Field is AN/GPN-12 continuous-scan radar. It provides low-altitude surveillance, primarily from ground level to 10,000 feet MSL. It is a short-range radar using a scan radius of about 60 miles. Data from this radar are available for observation in the MCC. Distance error is less than two percent.

(5) **High Accuracy Multiple Object Tracking System (HAMOTS)**

- The HAMOTS tracks, records, and displays the TSPI data of one or more mission participants. The TSPI data are displayed in real time at the MCC. Real-time data collected by HAMOTS are recorded and used for post-mission data reduction, where it may be merged with cine-T and radar data.

- The UTTR HAMOTS Upgrade System (HUS) Air Combat Maneuvering Instrumentation System is an instrumentation-tracking system for aircraft involved in controlled, simulated-weapons training exercises. The system tracks aircraft equipped with AN/ASQ-T21 transponders (pods). The system provides real-time monitoring of aircraft position, flight dynamics, weapon status, and firing parameters. Significant performance data are relayed via a communications network, processed in real time at the MCC, and displayed in building 3 for the Range Training Officer and other observers. The HUS performs the same functions as the ACMI systems at Nellis Air Force Base, Nevada, and Tyndall Air Force Base, Florida, and the Navy's Tactical Aircrew Combat Training System at Fallon, Nevada.

(6) **Photo-Optical Instruments**

- **Cinetheodolites (cine-Ts).** The cine-Ts at UTTR provide a film or video record of the flight path of an airborne object. This record indicates the azimuth and elevation angle of the object being tracked and indicates the exact time at which the picture was taken. There are 21 Contraves cine-Ts at UTTR. All models are housed in mobile dome-type trailers. They operate from several surveyed sites on UTTR. They are moved from one site to another to support mission requirements. Moving, setting up, and testing one cine-T requires one day.

- **Cinesextants.** Cinesextants at UTTR track airborne objects and provide motion picture and television data. These data are not used to determine the TSPI of the object being tracked. There are six Photo-Sonics Corporation cinesextants at UTTR. These mobile cinesextants can be located almost anywhere on the range where commercial or generated power is available. Products produced by the cinesextants include documentation film, high-speed time-control sequence data, and real-time television data.

- **FlightVision.** FlightVision at UTTR provides real-time television recording of range activities with playback and editing capabilities at the MCC. FlightVision is received from the TPQ-39 radar and the MPS-38 radar.

(7) **Telemetry.** Telemetry systems at the UTTR include three range telemetry acquisition stations and a ground station located in the MCC. Telemetry acquisition sites are at Granite Peak, Grassy Mountain, and Wendover Peak. All can operate on both L- and S-bands and can insert data into the UTTR microwave data relay system at Grassy Mountain, Wendover Peak, Cedar Mountain, or Granite Peak sites. Raw telemetry data is sent by microwave from range sites to the telemetry ground station for processing and display. The UTTR microwave system sends raw-telemetry data to such other locations as Air Force Flight Test Center (AFFTC), Edwards Air Force Base; 30th Space Wing (30 SPW), Vandenberg Air Force Base;

and the Naval Air Warfare Center Weapons Division (NAWCWPNS(PM)), Point Mugu. These sites can, in turn, send telemetry data to the UTTR ground station.

(8) **Data Processing.** Data Acquisition Processor and Controller (DAPAC) is located in the MCC to process HAMOTS, radar, and telemetry data in real time. It also processes post-flight data from these same sources, along with cine-T data reduction. The DAPAC outputs all position data to a display subsystem including various CRTs as well as to a large screen display in the MCC. It presents telemetry data on two displays, each containing up to 28 engineering unit parameters.

• **The Acquisition and Display System (ADS).** The ADS, located in the MCC, routes and stores telemetry data from several sources in real-time or post-flight environments. It can process on frequency modulation and two-pulse code-modulation telemetry data streams. The ADS processes up to 2,000 measurements with limit checking in real time. Data are received from the telemetry acquisition systems at Grassy Mountain West, Granite Peak, and Wendover Peak and are sent by microwave to the ADS. It performs general-purpose signal conditioning, synchronization, decommutation, dynamic-data merging, time tagging, and data compression. All telemetry first and some second-generation processing is performed on ADS during real time. Processed data can be displayed and recorded on strip charts and on 300-megabyte disk drives. Displays are user-defined and programmed by range personnel. Displays present engineering units in various graphic forms on computer-video terminals and are duplicated on 5x7-foot screens if required. The strip charts can be modified during real time to allow maximum use of the resources. The display subsystem, located in MCC, provides a real-time graphic representation of mission participants on UTTR along with telemetry engineering unit displays. The graphics are displayed on a Megatek color workstation. The workstation CRT image is repeated to other viewing CRTs as well as projected on one of the large screens with a repeater projector.

3. RISK MANAGEMENT

a. **Range Policies.** Safety is an integral part of mission. The 545th Test Group Safety Office is responsible to the 545th Test Group/CC for establishing and managing the overall Range Safety Program. The 501 RANGES/CC and the 545 TESTG/SE establish coordinated UTTR safety criteria.

b. **Hazard Analysis Tools.** Tests must be reviewed using procedures contained in AFFTCR 127-3. To support this review, safety planning as outlined in MIL-STD-882 and as required by AFR 800-16 and AFR 127-2 must be accomplished.

c. **Assessment Process and Criteria.** The UTTR hazard analysis process applies to all test and training activities involving UTTR personnel, aircraft, ranges, equipment, and airspace. In addition, the process can apply to any special-flying activities or nontest activities which are unique, present significant hazards, or are not covered by routine procedures or management directives. The assessment process includes:

(1) A technical review board which is conducted by the project manager, using a test plan which describes the project objectives and detailed activities.

(2) An operating hazard analysis and a copy of the approved test plan which will be provided to the 545 TESTG/SE. These documents will be used by the program manager and the safety officer to conduct the program safety review. The hazard analysis and review will be tailored to the intended project activity when UTTR resources are involved. The safety review board must convene between 45 and 60 days prior to the start of testing.

(3) The completed test plan, technical-review board and safety-review board documentation which will be forwarded to AFFTC, Edwards Air Force Base, California, for approval by the Flight Test Center Commander, prior to the beginning of the project.

WHITE SANDS MISSILE RANGE (WSMR)

1. INTRODUCTION

a. **Mission.** White Sands Missile Range (WSMR) was established as a national test range in 1945. The WSMR is maintained primarily for support of research, development, test, and evaluation of weapons and space systems, subsystems, and components. The range, a major range and test facility base, is available to Army, Navy, Air Force, all DOD components, NASA, other government agencies, domestic commercial agencies, commercially sponsored space launches, and foreign governments when sponsored by an appropriate agency of the U.S. Government. In addition, WSMR and its tenant organizations participate in environmental and nuclear-effects testing, astrophysics research, high-energy laser tests, and weapons systems simulations.

b. **Physical Description.** White Sands Missile Range is the largest, all overland test range in the free world. It is located in southcentral New Mexico, primarily in the Tularosa Basin. The basin's average annual rainfall is about 10 inches, so the area is primarily arid grasslands. White Sands Missile Range's approximate altitude is 4,000 feet with mountain altitudes ranging from 5,000 to over 9,000 feet. Mountains are located on both side of the basin. The range extends 37 miles across the basin, east to west and 100 miles north to south and contains nearly 1.9 million acres of controlled land. A 37-by-37-mile (884,000 acres) extension area lies adjacent to the north range boundary, and a 17-by-60-mile (654,000 acres) extension area lies adjacent to the west range boundary. When these extension areas are added to the main range, the range comprises a total controlled land area of nearly 3.5 million acres. If extended flight trajectories are required to support vehicle testing, off-range launch sites can be established. For example, launch sites at Fort Wingate, New Mexico, and Green River, Utah, and associated flight corridors were developed to support programs such as Pershing and Ballistic Missile Target System. Within WSMR proper, there are several areas designated for specific testing. These areas include the Hazardous Test Area (HTA), Denver, Rhodes, Pup, and Stallion warhead impact test (WIT) areas, White Sands Space Harbor, Large Blast Thermal Simulator, a DNA test site, 90-mile smart munitions test site, Aerial Test Range, High-Energy Laser Systems Test Facility, and Small Missile Range (SMR).

c. **Typical Programs Supported.** White Sands Missile Range supports a wide variety of missile and laser programs. Although WSMR is operated by the Army, it is a national range and supports Army, Navy, Air Force, Department of Energy, other Department of Defense programs, and commercial space launches. These programs are as follows:

(1) **Army Programs.** Bats, Patriot, Stinger, Hawk, Army Tactical Missile System (ATACMS), Multiple Launch Rocket System (MLRS), Forward Area Air Defense (FAAD) Forward-Heavy and Non Line Of Sight (NLOS), Copperhead, Chaparral, Infrared Terminally Guided Submunitions (IRTGSM), Pedestal Mounted Stinger (PMS), Kinetic Energy Missile (KEM) and Lance.

(2) **Air Force Programs.** Sparrow, Sidewinder, Advanced Medium Range Air to Air Missile (AMRAAM), Have Nap, Illuminator II, Silent Attack Warning System (SAWS), B1-B, ADP-1020, Have Thrust II, Cem-Hi, CBU-67, and cruise systems such as ALCM, SRAM, GLCM and ACM. White Sands Missile Range also supports the Tactical Air Command wing located at Holloman Air Force Base.

(3) **Navy Programs.** Standard Missile, Sea Sparrow, Rolling Airframe Missile (RAM), Tomahawk, Sea Lance, and Standoff Land Attack Missile (SLAM). The Navy and NASA share high-altitude rocket-launch facilities which support NASA's Black Brant, Orion and Ariès rockets, commercial space tests such as Consort and other DOD high altitude tests. The High Energy Laser Systems Test Facility (HELSTF) houses the Mid-Infrared Advanced Chemical Laser and conducts Army, Navy, and Air Force damage assessment, lethality demonstrations, vulnerability, and associated laser testing. The HELSTF is managed by the Navy but is owned by the Army.

(4) **Strategic Defense Initiative (SDI) Programs.** High Endo-Atmospheric Defense Interceptor (HEDI), Extended Range Intercept Technology (ERINT), Theater High-Altitude Area Defense (THAAD), Lightweight Exo-Atmospheric Projectile (LEAP), Ground Based Interceptor (GBI), Special Project Flight Experiment (SPFE), Endo/Exo-Atmospheric Interceptor (E²I), Bear, Spear, Initial Deployment (ID), Single Stage To Orbit (SSTO), and Exceed III.

(5) **Target Systems.** White Sands Missile Range accommodates a host of target systems; full-scale targets (air breathing): QF-100, QF-106, QUH1-B, QS-55, AQM-37C, QF-86, and QF-4 (in development); subscale (air breathing): MQM-107, MQM-34, QH-50; and various towed targets and missile target systems: Ariès, ERINT Target (Sergeant-3d Stg MM1), ALCOR, Lance, and Patriot.

(6) **Department of Energy Programs.** Nuclear Effects Laboratory tests, Misty Castle high explosive test series, and the Large Blast Thermal Simulator (LBTS) facility.

2. SAFETY CAPABILITIES

a. Overview

White Sands Missile Range is a land-locked test range and consequently is limited to its available controlled land area for debris dispersion impacts. Currently WSMR is investigating the possibility of reopening some of the off-range launch sites that have been used in the past. Additional launch locations that have never been used before are also being pursued. For example, just approved was a new off-range corridor for an air-launched target, AQM-37C, that will be launched just south of Albuquerque, New Mexico, and then flown onto WSMR. For those missile systems that are deemed too risky to fly off range or where land-abort areas for boosters and other nominally occurring debris is not available or too costly, there is an attempt to maximize land resources by employing auto-destruct techniques, which allow for testing of more dynamic weapon systems and at higher altitudes than previously envisioned.

White Sands Missile Range has the capability to test any type of weapon system. There are reservations about testing systems that are toxic to the environment. In addition, new smart submunitions testing which began at WSMR has caused some concern. The range must ensure that under failure conditions all submunitions can be tracked to impact so that total recovery can be accomplished. Without this capability, portions of the real estate would have to be withdrawn to prevent range personnel from innocently walking in or around failure impact areas in later years, thinking it was safe to do so when, in fact, it would not be.

b. **Individual Systems**

(1) **Radar Tracking Systems.** At the present time, the range has eleven FPS-16 radars; two FPS-16 radars are portable. One portable MPS-25 and six portable FPS-36 radars are also available. These radars operate in the C-band at approximately 5,800 MHz and vary in output power from 1 to 3 MW, depending on the radar type. The above radars are designed to operate in transponder or skin-track modes and are capable of transmitting acquisition data to each other through the Radar Display and Acquisition Display System (RDAS). They can also operate in a coordinated mode through the Real Time Data System (RTDS). Two state-of-the-art phased array radars, Multiple Object Tracking Radars (MOTR), are aboard and are presently going through acceptance testing. One MOTR is currently on loan to the Atlantic Fleet Weapons Training Facility (AFWTF) in Puerto Rico. These radars will also be capable of operating through the RDAS and RTDS systems. One additional radar system of note, the miss-distance indicator (MIDI) radar, is a specialized system used to score miss distance of projectiles fired at aerial targets. Post-test Target Motion Resolution (TMR) data provides more precise data, translational motion of data, event data, and radar cross-section data and is available from all coherent radars. Weapon system information from TMR is currently a post-test process; however, studies are underway investigating the possibility of using TMR in a real-time setting.

(2) **Interferometer Tracking Systems.** There are three interferometer systems at WSMR that passively track the S-band airborne telemetry (TM) carrier and provide real-time trajectory information to the user. The Electronic Sky Screen Equipment (ELSSE) provides data from vehicle launch to approximately 10 seconds into flight. There are ELSSE sites at several locations on range, and new sites can be established for minimal cost and time. The angle-measuring equipment (AME) can passively track the TM carrier of two objects. The system is range limited by the signal strength of the carrier and by line of sight. The AME is located in the 50-mile area and provides mid-course trajectory data. The three object angle measuring equipment tracking system (TOAME) operates in the same fashion as AME but is capable of tracking three objects simultaneously. The TOAME is located in the south range. Data from these systems can also be integrated into the RTDS system. In this instance, all three systems can be used to form antenna pairs that give better geometry and a higher tracking reliability.

(3) **Optical Tracking Systems.** White Sands Missile Range has an extensive array of optical instrumentation that provides event, trajectory, and miss-distance information. A massive effort has been underway for several years to develop submunition data collection capability in conjunction with radar instrumentation. Excellent results have been achieved on submunition data collection with more improvements expected in the future. There are over 400 fixed cameras available to provide attitude, event, and state vector information for portions of the flight. The cinetheodolite system is the primary optical-tracking system. Cinetheodolites

operate at relatively slow frame rates and provide position, velocity, and acceleration data. There are many fixed cinetheodolite sites throughout the range. Portable systems are also available to support flight testing. Versatile tracking mounts (VTM) operate at a much higher frame rate than cinetheodolites and incorporate long focal-length lenses to provide precision data at crucial portions of the flight. For collecting data from hazardous locations, several cinetheodolites have remote operating capability. They fall into a category of automated tracking systems referred to as Kinetic Tracking of Objects (KINETO), Multiple Acquisition Tracking System (MATS), and Launch Area Tracking System (LATS).

c. **Display Systems.** Displays at WSMR are provided by an Evans and Sutherland (E&S) system composed of two model PS350 computers connected to a Digital Equipment Corporation (DEC) VAX 11/750 host computer. The VAX computers are, in turn, connected to individual Real Time Computer Operating Systems (ROCS). The model PS350 computers have at least three megabytes of memory which are used to store map backgrounds and real-time display structures for position plots, Instantaneous Impact Prediction (IIP) plots, axis plots, and digital readouts. This system is currently being upgraded, so each general data processor which drives two E&S displays can provide distinct and individual displays on each of these two graphic monitor displays. Current capacity permits some utility in displaying different pictures such as H vs R and velocity plots on each of the two monitors driven by one GP, but basically one monitor is a slave of the other, and separate x, y information and IIPs are not available. Several hundred colors are available and thousands of shades or hues are available to the operators. Roads, mountains, instrumentation sites, and various other objects can be visually imposed onto the E&S system. Very little pretest interaction is required between the Range Safety Officer (RSO) and the E&S system because the E&Ss can be easily preprogrammed prior to mission time. One additional upgrade is currently in progress; two large screen display systems are being installed in the Operations Control Display Facility (OCDF) in preparation for accommodating reentry satellites.

- Strip Chart Recorders are still used to look at telemetry information except for inertial-platform data which are processed in real time and displayed as x, y or IIP position data and, on occasion, velocity data. Near-term plans are to transfer the telemetry data to the E&S graphic system where it will be displayed in the form of charts, dials, graphs, and in digital tabloid form.

- Video is used quite often for launch and intercept scenarios. Video monitors also supplement the E&S system by displaying status information of assigned radars, meteorological data, mission progress, and a variety of other diagnostics including telemetry data quality.

- Other displays include the range's ready/hold system, destruct system status/zone monitors, Drone Formation Control System (DFCS) consoles, and project equipment such as Patriot radar scope displays, Vega Control consoles, and onboard weapon system video. Many of the voice and data communication lines at WSMR are being replaced with fiber optics.

d. **Real-Time Processing Systems.** White Sands Missile Range uses eight Concurrent Computer Corporation 3280 computer systems to process mission information for both project and range data requirements. This system was updated several years ago by supplementing it with a data preprocessor which has increased its computing capacity twofold. Five of these

systems provide the necessary computing utilities required for the displays in the OCDF, one is used to process telemetry data, one is used for development purposes, and the eighth one is located in a mobile van that provides processing for three additional mobile vans. These vehicles are a range-control van, a telemetry receive/record/relay van, and a display van that can be used for flight safety purposes or by the customer when not in use for flight safety. The display van was just recently reconfigured with an E&S graphics system.

- Telemetry data are preprocessed by one of the model 3280 Concurrent Computer Corporation ROCs. Various other ancillary functions during mission operations are managed by a sundry of micro processors.

- Standardized software includes the real-time RTMIN computer program which calculates IIPs, x, y, velocity, and other computer displays including the auto-select function which chooses the highest quality and succeeding lower quality data sources for display.

- WSMR is in the process of finalizing an auto-destruct simulation that will invoke destruct when one or more tracking sources exceed predefined criteria such as ground limit lines and velocity limits for a specific period. Programs are becoming more challenging (dynamic) and to accommodate these "larger" test programs, they must be confined within available land resources. Some of these weapon systems must be initiated to destruct prior to 3 seconds of sustained failure.

3. RISK MANAGEMENT

a. **Range Policies.** An overall axiom that is actively pursued at WSMR is that if a risk, no matter how small, can be reduced within the acceptable limits of cost and national test priority requirements, then the risk should be reduced. Consequently, there is no predefined risk limit. It should be noted that as a threshold upper limit, risk to mission-essential range personnel should not exceed 1×10^{-5} and 1×10^{-6} for nonparticipants. This value, of course, must be tempered by the number of tests to be conducted. For programs with a high test rate, these values may be too high. Consistent with personnel resources, every attempt is made to conduct a complete risk assessment for manned-instrumentation sites that must be placed within the weapon system's evacuation area. This risk assessment is especially true for ground-to-ground and ground-to-air launched systems. Air-launched systems are more difficult to manage from a risk assessment standpoint since launch parameters are difficult to normalize; that is, launch parameters vary from test to test so drastically that there is an insufficient number of samples for a given set of tests. These programs are generally managed by defining exclusion areas or keep-out zones for all personnel.

(1) For those programs requiring complex range-safety instrumentation-support configurations, risk-to-test studies are also implemented to ensure that a nominally flying-weapon system will not be destroyed because of some deficiency in our flight safety support configuration. For example, lack of redundancy, if available, and if not, single-point failures are identified to ensure that they are within acceptable limits. Total system reliability is computed, and an upper-bound confidence interval is determined for the system.

(2) All FTSs must undergo a stringent qualification and acceptance program such that an FTS failure is so remote that the calculation of risk to personnel is not significantly increased.

(3) All auto-destruct systems must be approved by the WSMR Commanding General.

(4) Every attempt is made to restrict population increases in the test areas of the range. Administrative functions are restricted to existing range centers, and when possible, new test areas are located on the range periphery.

(5) Weapon systems that have the capability, under failure conditions, to impact international land areas must be approved by the WSMR Commanding General. Appropriate state and federal elected officials will be briefed on off-range overflights.

(6) Off-range impacts of nominal test debris must be evacuated to at least the 2-sigma level, and when possible, the 3-sigma level.

(7) No test will be designed which relies on the FTS to conduct the test safely. Generally, FTS designs will not rely on weapon-system components that are under test unless the user agrees to qualify system components to the same reliability levels of range-provided FTSs.

b. **Hazard Analysis Tools.** Flight safety does not have the ability to model weapon systems that are under thrust; however, it does have two simulation models that can calculate ballistic impacts of single and multiple pieces which are a 6DOF simulation and an abbreviated 3DOF simulation. These simulations are written in ASCII FORTRAN and can be run on either the WSMR UNIVAC 1191 computer or on the inhouse Macintosh FX computer systems. Production contractors provide thrust-simulation models on magnetic tape which are then installed on the ROCS to determine reaction (flyout) times to range-sensitive areas or range boundaries. Many times the ballistic coefficients of debris are not known until program maturity which is sometime after the thrusting simulation; however, the ballistic coefficients and the number of debris pieces in the real-time simulator can be varied for estimating dispersion area dimensions.

An inhouse generalized risk routine has been developed that can take empirical data and reduce it to risk contours. The routine is implemented through the Univac 1191 system and a local Tektronics graphic system. The parent program run on the Univac has a choice of nine preprogrammed statistical distributions. Unfortunately, most engineers still prefer to individually tailor risk-simulation models on a test-to-test program basis which prevents these models from being applicable on a generic basis. This tailoring is necessary, in part, because many risk assessments must be theoretical since the weapon systems are being flown for the first time.

At the present time, population data are being installed and digitized on the Macintosh systems for the states of New Mexico, Arizona, Utah, and eventually Texas and Idaho. This information is being used to conduct risk assessments for a variety of possible off-range corridors from 300 to 1,400 kilometers.

Often, debris impact points of destructed weapon systems are surveyed to determine ballistic coefficients. An inhouse routine called Beta Search is available that can "back out" ballistic coefficients of debris given that the initial conditions at destruct are known and impact points can be accurately determined.

c. **Assessment Process And Criteria.** Chronologically the risk assessment process proceeds as follows:

(1) Using the simulator, determine the size of the needed evacuation by assuming that after 5 seconds of failed flight, the failure can be recognized and confirmed and a destruct signal sent.

(2) Range instrumentation elements and project requirements will determine the number of personnel needed to be inside the evacuation area. If the weapon is being flown for the first time, the contractor is asked to perform a Failure Mode and Effects Analysis (FMEA) on those systems and subsystems that could cause inflight failures. These reliability data are used as part of the risk analysis. A word of caution though, almost half (if not more) of inflight failures are caused by the human element which is rarely reflected in the FMEA results received. Other unknowns include uncertainty in failure-rate curves, the question of whether failures occur more often at launch than at staging, and the distribution of debris on the ground especially in the cross-range component. Generally, if data are available, failure rates and distribution debris can be accurately determined; however, for systems that are flown for the first time, the best educated guess is often relied on.

(3) After risk assessments have been conducted, optic sites are removed or repositioned within the evacuation area. Also the number of test personnel that can be inside the evacuation area is limited.

(4) For high-fire rate programs, a reevaluation of the risk to personnel is made after 30 or more firings. However, recently the heavy workload has prevented this reevaluation.

(5) After each failure, assumptions are reassessed in the risk-analysis process to see if something has been overlooked. Many times the project officer is required to provide corrective actions taken prior to testing. The review process of the corrective action is not taken lightly and often requires the project officer to supply supplemental information of one or more iterations.

30TH SPACE WING (30 SPW)

1. INTRODUCTION

a. **Mission**. This report provides a summary of the range safety support capabilities of the 30th Space Wing Safety Office (30 SPW/SAFETY). It includes a brief description of the 30 SPW/SAFETY's operation support activities, general information on the Western Range (WR) resources, and an overview of how these resources are used by the Safety Office to support WR operations. More detailed information can be found in the referenced documents listed at the end of this section.

b. **Physical Description**

(1) The 30 SPW/SAFETY is a staff agency of the 30th Space Wing (30 SPW) located at Vandenberg Air Force Base (VAFB), California. As an operational wing under the Air Force Space Command (AFSPACECOM), the responsibility for safety is consistent with DOD Directive 3200.11. Its primary mission is to establish, manage, and direct the overall safety program for ground safety, flight analysis, system safety, and missile and spacelift vehicle ground and flight operations at the WR.

(2) The 30 SPW Safety Office organization structure was devised to fit the Air Force Chief of Staff operational wing structure as well as the primary safety tasks specified in DOD Directive 3200.11, AFR 80-28, and WRR 127-1 which include defining and enforcing system, ground, and flight-safety constraints to ensure WR operations are within acceptable risk limits consistent with mission requirements and national needs. The following specific functions are performed by 30 SPW/SAFETY to accomplish these tasks:

- **System Safety Branch (SES)**. The SES functions include design engineering and testing of all airborne equipment used for flight safety control purposes; formulation and verification of the engineering criteria and acceptance requirements for flight termination and tracking systems; implementation of the 30 SPW System Safety and Radiation Safety Programs; formulation of system safety requirements for all launch vehicles, facilities, ground-support systems, spacecraft, and reentry vehicles; and issuance of the Missile System Ground Safety approval and the Flight Termination System approval.

- **Ground Safety Branch (SEG)**. The SEG functions include the development of ground-safety requirements for launch pads and complexes and their associated support facilities; enforcement of ground and system safety requirements (on-site); review and approval of hazardous operations; execution of mishap prevention programs; and management and implementation of the Base Safety Program. The branch is responsible for explosive safety including site planning, inspecting, and monitoring of all ground hazardous operations along with the operations at the Hypergolic Stockpile Storage Facility (HSSF).

- **Missile Flight Control Branch (SEY)**. The SEY functions involve analyzing and controlling all missile and space booster launch scenarios to minimize risks to life and

property and the research, design, and development of prelaunch range-unique risk-assessment tools to evaluate operational hazards. The functions consist of analyses of vehicle performance characteristics, development of launch restrictions and safe flight corridors, and implementation of hazard studies including debris, toxic, and explosive overpressures. Also included is the responsibility for development of real-time display systems, operational reliability requirements, instrumentation and tracking requirements, and the control and termination of a flight in the event of a failure that violates flight-safety constraints.

c. **Typical Programs Supported**. The unique location, facilities, and instrumentation systems of the WR can support a wide range of programs. Table I is a summary of currently supported and projected programs. They are grouped into three categories. A fourth category involves space surveillance which requires limited safety support. Safety provides support for most of these programs as well as other special programs such as small rockets, directed-energy systems, and high-energy radio-frequency systems on a case-by-case basis.

(1) **Spacelift**. The prime mission of the WR is to support spacelift operations which involve planning, processing and launching a variety of payloads into polar-earth orbits. This category includes government and commercial spacelift programs. The launch azimuths for current orbital programs range from 153 to 215°.

(2) **Test and Evaluation**. A secondary mission of the WR is to support developmental and operational test and evaluation programs. This category includes a variety of vehicles and programs such as orbital and ballistic vehicles, cruise missiles, crossover vehicles, and strategic defense initiative operations. The launch azimuths for current ballistic programs range from 264 to 280°.

(3) **Aeronautical**. A wide variety of programs using aircraft are supported by the WR. Included are fighter operations (F-16, F-15, F-14, F-117, ATF), associated operations (WB-57F, KC-135, C-141, P-3), flight tests (B-IB, B-52), and air-to-air intercepts. The West Coast Offshore Operating Area (WCOOA) which extends along the Pacific Coast from Mexico to central Oregon is used for aeronautical support.

TABLE I. WR PROGRAM SUMMARY		
SPACELIFT	TEST AND EVALUATION	AERONAUTICAL
Titan II/IV and Payloads	AFSLV/Pegasus (DARPA)	Fighter Operations
MLV I/Delta II and Payloads	Strategic Defense Initiative Operations	Associated Operations
MLV II/Atlas E/II and Payloads	National Aerospace Plane DT&E (Projected)	Flight Tests
MLV III (projected)	Minuteman I/II Reentry System Launch Program	Air-To-Air Intercepts
Shuttle On-Orbit Support	Minuteman III DT&E/OT&E 11	
Commercial Space Launches	Peacekeeper OT&E	
Scout Launch Vehicle and Payloads	HLV/National Launch System and Payloads (Projected)	
	Anti-Satellite DT&E (Projected)	
	Taurus Launch	

2. SAFETY CAPABILITIES

a. **Overview.** In this section, emphasis is placed on those data acquisition, processing, display, command systems, and software which directly support the prelaunch and real-time operation activities of 30 SPW/SAFETY. The following paragraphs are not a comprehensive summary of all WR resources, but rather an overview of the basic functional capabilities of the range systems used by 30 SPW/SAFETY.

b. Individual Systems

The WR resources used to support safety activities have been grouped together to form the Missile Flight Control System (MFCS). This system provides Range Safety "... with real-time missile [and space vehicle] flight performance data, the means to terminate the flight of

missiles [and space vehicles] that violate safety constraints, and the communications capability to coordinate with those people necessary to ensure safety criteria are met." The specific resources required for safety support depends on the vehicle characteristics, performance, and launch profile. The data acquisition element of the MFCS encompasses all the sensors used to collect vehicle trajectory and status information. It includes the WR radar, telemetry, and optical instrumentation sites as well as the skyscreen observers. A brief description of the real-time MFCS elements and how they are used for range-safety support are provided in the following subparagraphs.

(1) **Radar Systems.** Historically, the radar component has been the primary source of tracking data for range safety. It is used to collect both prelaunch weather-balloon tracking data and real-time launch-vehicle tracking data. The radar component consists of eight WR metric radars, three of which meet the safety criteria for a Missile Precision Instrumentation Radar (MIPIR) system. The majority of the radars are located at VAFB with additional radars at Pillar Point Air Force Station, Hawaii, and Saipan (surveillance only). The WR can also use tracking data provided by radars located at Point Mugu and San Nicholas Island, California, and Barking Sands, Hawaii, which are a part of the Naval Air Warfare Center Weapons Division, Point Mugu and Pacific Missile Range Facility. In addition, a Multiple Object Tracking Radar (MOTR) is currently being installed at VAFB and is planned for initial operating capability in FY-94. The 30 SPW/SE requires only a small subset of the radars listed for real-time safety support. They are chosen based on their location, data quality, and classification.

All of the WR radar systems, with the exception of the TPQ39, are capable of tracking in either skin or C-band transponder mode. All launch vehicles are required to carry a C-band beacon to ensure dual quality tracking data from lift-off through end of powered flight. Coherent transponders are used on ballistic missiles to improve tracking accuracy.

(2) **Telemetry.** The telemetry component consists of the telemetry acquisition sites located at VAFB (TRS) and Pillar Point AFS, and the telemetry processing system (TAER & TIPS) located in building 7000 at VAFB. A total of eight telemetry antennas are located at the two sites. These antennas can obtain up to 25 channels of data from flight and ground instrumentation and transmit it to the data processing and display systems. The data provided by this component are used for both vehicle tracking and monitoring. Trajectory information is extracted from the telemetered inertial guidance (TMIG) data which are used to provide a display of present position and impact prediction after it has been verified by an independent tracking source. In addition, health parameters are extracted from the telemetry stream and displayed on the telemetry observer and flight safety project officer consoles. These data are used to conduct prelaunch flight-termination system checks and to monitor the flight performance of the vehicle.

(3) **Optical Devices.** The optical instrumentation component consists of three permanent tracking telescope sites located at Tranquillon Peak (LA-24), Santa Ynez Peak (ROTI), and Anderson Peak (DMI). The Santa Ynez and Tranquillon Peak sites are the primary source of real-time video coverage for range safety. All optical data are recorded at each site and provides engineering sequential data for inflight and postflight evaluation of performance.

(4) **Skyscreen (Outside) Observers.** The skyscreen observer component consists of two subsystems. Each subsystem consists of a skyscreen observer, a camera, and the

associated instrumentation and communications needed to send skyscreen information to the missile flight control center. One subsystem is located behind the launch pad approximately 180° to the planned launch azimuth of the vehicle, and the other is located to the side of the launch pad approximately 90° to the planned launch azimuth of the vehicle. This component provides vehicle-performance information to missile flight control personnel during early vehicle flight until quality metric tracking data are received and general flight progression information until the vehicle is out of view.

Other data acquisition systems used to support safety activities are: (1) the weather system which is used to update risk-analysis program results and range safety displays; (2) the surveillance system which is used to monitor and control hazardous land, sea, and air areas in the vicinity of VAFB; and (3) the Data Acquisition System which is used to determine and to provide the "best source" acquisition data to the various tracking sensors.

c. **Data Processing.** The data processing element consists of computers, software, data bases, operational procedures, and external interfaces necessary to accept and to process metric and telemetry data. It is used for both prelaunch and real-time data processing. (The data processing element also includes the nonreal-time Metric Data Processing System (Cyber 840A)). Prior to an operation, the data processing element is used to analyze trajectories, to develop safety displays and destruct criteria, and to assess risks and hazards. During an operation, the data processing element is used to process and to display sensor information. It can process up to 15 sources of radar data and 3 sources of TMIG data and can compute both single and multi-station impact predictions at a 50-millisecond update rate. Two independent real-time systems are used to meet the safety requirement for no single-point failures.

d. **Display.** The display element provides the means by which vehicle-performance and system-status information is displayed and controlled by missile flight control personnel. It consists of three major components: (1) cathode ray tubes (CRTs) with graphical charts of vehicle trajectory (both expected and actual), geographical-background data, flight-safety parameters such as destruct lines, debris circles, and alphanumeric readouts for system and sensor status; (2) console switches and indicators for controlling the CRTs display data; and (3) close circuit television (CCTV) monitors for display of video information provided by optical instrumentation and skyscreen observer sites.

e. **Command Control.** This element provides the capability to terminate the flight of a launch vehicle if it is determined by the Mission Flight Control Officer (MFCO) to be performing abnormally or outside of the predetermined safe flight-path corridor. It consists of two general components: the ground component and the airborne component. The ground component includes the local (3 at VAFB) and remote (1 at Pillar Point AFS) command transmitter (CT) sites. These CT sites are used to transmit selected RF carrier and radio signal noncommand and command functions to missile systems. The Central Control Processing System is used for the control and status of the CT sites. The airborne component includes the thrust termination or destruct system used to terminate the flight of the launch vehicle.

Currently, the flight termination control system can be configured to operate at either 416.5 MHz (primary) or 406.5 MHz (secondary) and can issue either standard or secure tones. Each of the CT sites is composed of two identical redundant systems with automatic failover

capabilities. A 10 kW signal level is maintained to ensure capture of the airborne command receiver and decoder. Both omni and directional antennas are used to ensure control and termination of an errant vehicle.

f. **Communications.** The communications element consists of the microwave, fiber optics, copper cable, radio, and satellite systems used to transmit voice, data, and video information. These systems are used to tie the instrumentation, control, and display elements into a cohesive support capability.

3. **RISK MANAGEMENT**

a. **Range Policies.** The 30 SPW Safety Office is responsible for determining the risks associated with WR operations. The risk-analysis function involves identifying, characterizing, and quantifying the hazards created by conducting a spacelift, test and evaluation, or aeronautical operation. The primary launch-related risks analyzed during the prelaunch phase of an operation are the hazards created by debris, toxic, and blast overpressure. The following subparagraphs provide a brief description of the computer programs used to analyze these hazards.

b. **Hazard Analysis Tools**

(1) **LARA.** The Launch Risk Analysis (LARA) computer program is used to calculate the hazards to population centers from space [and missile] vehicle failures during the early and mid portions of flight. The LARA calculates the risk levels from planned events such as the jettisoning of hardware and from vehicle failures. During the process of calculating the hazard levels, LARA models such phenomena as the vehicle dispersion off the nominal trajectory when or if it breaks up; the dispersion of falling fragments caused by explosion-induced velocity, drag and wind; the area hazarded by an impacting fragment; and the level of protection to populations sheltered by structures.

(2) **BLAST.** The BLAST hazard-prediction model is used to predict casualties from inadvertent high-order detonations of missiles and space vehicles. For a user-specified explosive yield and detonation location, BLAST models the overpressure propagation and predicts the resulting window breakage. Casualty estimates are then made on the basis of the predicted number of broken windows.

(3) **REEDM.** The Rocket Exhaust Effluent Diffusion Model is a hot-spill toxic-analysis computer program that simulates the hazards produced by the exhaust products of all Titan and Delta launch boosters. It models the buoyant rise, transport, and dispersion of a toxic cloud created by nominal or catastrophic launch scenarios. The toxic footprint information output by this program is used to estimate and control possible toxic hazards to populated areas.

(4) **Enhancement.** The Eastern (45 SPW) and Western (30 SPW) Ranges are starting a potential decade-long Range Standardization and Automation (RSA) program. Many changes to the WR resources are expected to result from this effort. The major objectives of RSA are to modernize, standardize, and automate all functions related to the acquisition, tracking, and command destruct for launch operations consistent with "normal" USAF operations and maintenance. Commonality between the ranges to the maximum extent possible is a major

design goal of the RSA program. Currently, the 45 SPW, the 30 SPW, and the Aerospace Corporation are conducting concurrent Launch Range Architecture studies to explore potential solutions such as new architectures to range-operational requirements. The government will use these results to provide one common range architecture for all future range funding and acquisition.

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