

AD-A201 312

ESL-TR-87-32

POSTATTACK MITIGATION ANALYSIS

H. PIKE, J.H. STORM

THE BDM CORPORATION
7915 JONES BRANCH DRIVE
MCLEAN VA 22102

JULY 1988

FINAL REPORT

SEPTEMBER 1986 - OCTOBER 1987

DTIC
ELECTE
OCT 18 1988
&
D

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED



ENGINEERING & SERVICES LABORATORY
AIR FORCE ENGINEERING & SERVICES CENTER
TYNDALL AIR FORCE BASE, FLORIDA 32403

88 10 18 129
~~88 10 17 108~~

NOTICE

PLEASE DO NOT REQUEST COPIES OF THIS REPORT FROM
HQ AFESC/RD (ENGINEERING AND SERVICES LABORATORY).
ADDITIONAL COPIES MAY BE PURCHASED FROM:

NATIONAL TECHNICAL INFORMATION SERVICE
5285 PORT ROYAL ROAD
SPRINGFIELD, VIRGINIA 22161

FEDERAL GOVERNMENT AGENCIES AND THEIR CONTRACTORS
REGISTERED WITH DEFENSE TECHNICAL INFORMATION CENTER
SHOULD DIRECT REQUESTS FOR COPIES OF THIS REPORT TO:

DEFENSE TECHNICAL INFORMATION CENTER
CAMERON STATION
ALEXANDRIA, VIRGINIA 22314

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED			1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY			3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release. Distribution unlimited.		
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE			5. MONITORING ORGANIZATION REPORT NUMBER(S) ESL-TR-87-32		
4. PERFORMING ORGANIZATION REPORT NUMBER(S) BDM/TYN-87-0311-TR			7a. NAME OF MONITORING ORGANIZATION The Air Force Engineering and Services Center		
6a. NAME OF PERFORMING ORGANIZATION The BDM Corporation		6b. OFFICE SYMBOL (if applicable)	7b. ADDRESS (City, State, and ZIP Code) HQ AFESC/RDCF Tyndall Air Force Base, Florida 32403		
6c. ADDRESS (City, State, and ZIP Code) 7915 Jones Branch Drive McLean, Virginia 22102		9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER F08635-84-C-0185			
8a. NAME OF FUNDING/SPONSORING ORGANIZATION		8b. OFFICE SYMBOL (if applicable)	10. SOURCE OF FUNDING NUMBERS		
8c. ADDRESS (City, State, and ZIP Code)		PROGRAM ELEMENT NO. 62206F			
		PROJECT NO.		TASK NO.	
		WORK UNIT		ACCESSION	
11. TITLE (Include Security Classification) Postattack Mitigation Analysis					
12. PERSONAL AUTHOR(S) Pike, H.; Storm, J. H.					
13a. TYPE OF REPORT Final		13b. TIME COVERED FROM 9/12/86 TO 10/11/87		14. DATE OF REPORT (Year, Month, Day) July 1988	
				15. PAGE COUNT 40	
1a. SUPPLEMENTARY NOTATION Availability of this report is specified on reverse of front cover.					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	SUB-GROUP	Postattack Fires; POL Systems (petroleum, oil, and lubrication sys)		
			Secondary Fires; Self-Contained Breathing Apparatus;		
			Splinter Protection; Fire Communications Center; (NT)		
19. ABSTRACT (Continue on reverse if necessary and identify by block number) This document compares the causes of secondary fires during wartime operations. It relates facility damage to ignitions, and compares secondary fires resulting from World War II conventional and nuclear bombings, earthquakes, tornadoes, and conventional explosion accidents. It lists the probabilities of secondary fires resulting from each of these categories and outlines passive and active mitigation actions that can reduce the damage and severity of the environment firefighters must face during postattack and base recovery operations. The report also discusses the probability of secondary fire starts in petroleum, oil, and lubricant areas, facility prioritization, splinter protection, fire vehicle hardening, chemical warfare protection, survivable command, control, and communications, plans, water supply, installed systems, training, and other areas where mitigation could have a major impact on reducing the severity of the firefighters' postattack environment. <i>Keywords: chemical warfare protection;</i>					
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED		
22a. NAME OF RESPONSIBLE INDIVIDUAL Joseph L. Walker			22b. TELEPHONE (Include Area Code) (904) 283-6194		22c. OFFICE SYMBOL RDCF

PREFACE

This report was prepared by the BDM Corporation, 7915 Jones Branch Drive, McLean, Virginia, under Contract F08635-84-C-0185, for the Air Force Engineering and Services Center, Engineering and Services Laboratory (AFESC/RDCF), Tyndall Air Force Base, Florida 32403.

The performance period for this effort was 12 September 1986 to 11 October 1987. The AFESC/RDCF program manager was Joseph L. Walker.

This report has been reviewed by the Public Affairs Office and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.


JOSEPH L. WALKER
Chief, Fire Technology Branch


LAWRENCE D. HOKANSON, Colonel, USAF
Director, Engineering and Services
Laboratory


ROBERT J. MAJKA, Lt Colonel, USAF
Chief, Engineering Research
Division

Accession For	
NTIS CRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By _____	
Distribution/	
Availability Codes	
Dist	Availability Codes
A-1	



TABLE OF CONTENTS

Section	Title	Page
I	INTRODUCTION.....	1
	A. OBJECTIVE.....	1
	B. BACKGROUND.....	1
	C. SCOPE/APPROACH.....	1
II	SECONDARY FIRES.....	3
	A. OBJECTIVE.....	3
	B. CAUSES OF SECONDARY FIRES.....	3
III	POSTATTACK FIRE MITIGATION.....	6
	A. OBJECTIVE.....	6
	B. REDUCTION OF FIRE SPREAD.....	6
	C. MINIMIZE PETROLEUM, OIL, AND LUBRICANT FIRE RESPONSE.....	7
	D. CORRECT PRIORITIZATION OF FACILITIES.....	8
	E. SPLINTER PROTECTION.....	10
	F. VEHICLE HARDENING.....	12
	G. CHEMICAL WARFARE PROTECTION.....	13
	H. REDUNDANT SURVIVABLE COMMAND, CONTROL, AND COMMUNICATIONS.....	14
	I. DEVELOPMENT OF WAR PLANS AND POLICIES.....	15
	J. SURVIVABLE WATER SUPPLY.....	18
	K. UPGRADE INSTALLED SYSTEMS.....	18
	L. WARFIGHTING TRAINING PROGRAM.....	19
	M. BOMB-DAMAGED HAS DOORS.....	20
	N. BASE ELECTRICITY.....	20
	O. OTHER PROJECTS.....	21
IV	RECOMMENDATIONS.....	23
	A. FIRE SPREAD.....	23
	B. POL SYSTEMS.....	24
	C. FACILITY PRIORITIZATION.....	25
	D. SPLINTER PROTECTION.....	25
	E. IMMEDIATE RESPONSE CAPABILITY.....	27
	F. CHEMICAL ENVIRONMENT.....	27
	G. COMMAND, CONTROL, AND COMMUNICATIONS.....	28
	H. PLANS AND POLICY.....	28
	I. WATER DISTRIBUTION SYSTEM.....	30
	J. INSTALLED SYSTEMS.....	30
	K. TRAINING.....	30

TABLE OF CONTENTS

(Continued)

Section	Title	Page
L.	BOMB-DAMAGED HAS DOORS.....	32
M.	BASE ELECTRICITY.....	32
N.	OTHER PROJECTS.....	32
	REFERENCES.....	34

SECTION I

INTRODUCTION

A. OBJECTIVE

The objective of this research was to evaluate ways of reducing the severity of the firefighters' postattack environment and to define fire mitigation measures that will increase fire protection's contributions to aircraft sortie generation. — *Continued on DD 1473*

The report supports the Air Force Engineering and Services Center (AFESC) Fire Protection Technology (RDCF) effort to mitigate the fire-causing potential of a conventional weapons attack on an airbase. The report supports Major Command (MAJCOM) efforts to produce a firefighter Statement of Operational Need (SON), and may be implemented by operational commands to develop procedures that will reduce the number and severity of fires in the postattack environment. This document builds on the Air Base Survivability Capability Demonstration (code-named SALTY DEMO) analysis (Reference 1) and the AFESC Firefighting Postattack Assessment (Reference 2).

B. BACKGROUND

In the postattack environment, the fire department will be faced with numerous fires, extensive damage, and injured personnel requiring emergency rescue and medical care. The fire department's task of getting to firefighting and rescue locations will be complicated by unexploded ordnance (UXO), craters, pavement damage, and facility debris. Firefighting and rescue must be accomplished with fixed numbers of people, equipment, and material in a chemical environment. Over time, attrition will cause a steady decline in numbers of firefighters, fire vehicles, and agent levels. The fire chief must make critical decisions concerning which fires are fought, which fires are allowed to burn, which people are rescued, and which people are left to buddy care. Other decisions will affect the launch and recovery of aircraft, response to returning battle damaged aircraft, and operation of fixed and mobile aircraft arresting systems. These actions must be taken in an environment with multiple facility fires, complicated by the probability of fires spreading when broken water mains eliminate access to firefighting agents.

C. SCOPE/APPROACH

Peacetime and wartime fire protection operations differ. Peacetime operations and training do not adequately prepare firefighters for a wartime environment. Previous fire protection efforts have focused almost solely on peacetime operations, with the primary objectives being to save lives and property and to increase the salvage value of facilities and aircraft. Peacetime operations are based on the concept that a facility fire and an aircraft crash will not occur at the same time, unless they are a part of the same incident. Additionally, only one structure fire or aircraft crash would

be expected to occur simultaneously. The opposite will be true in wartime. Multiple, simultaneous facility fires and rescue requirements, as well as numerous aircraft responses, will occur during and after each airbase attack. Home-station Prime BEEF training does not adequately prepare firefighters for what they will encounter in the postattack environment. The recent addition of firefighter training at HQ AFESC, Detachment 2, is a step in the right direction, but much work remains to be done for firefighters to be able to stay alive, to protect vital personnel and equipment, and to support sortie generation in the wartime environment.

The approach taken in this effort was to define the firefighting postattack environment and to develop passive measures to reduce the severity of this environment.

SECTION II

SECONDARY FIRES

A. OBJECTIVE

The objective of this section is to compare the secondary fire starts and fire spread resulting from World War II, nuclear attack, earthquakes, and tornadoes to conventional explosives. Two major assumptions will be discussed. The first is that today's construction materials will not allow mass fires or firestorms to result from air attacks on European airbases. The second assumption is that all fires will have progressed beyond their point of origin before base damage assessment is complete, a firefighting priority sequence is established, and actual firefighting begins.

B. CAUSES OF SECONDARY FIRES

1. Secondary Fires

A secondary fire is defined as a fire caused by blast effects or other nonthermal effects of conventional weapon detonation.

2. World War II

The levels of damage occurring during World War II bombing of German cities are discounted in today's environment. The Allies' bombing of Hamburg resulted in mass fires and firestorms that created widespread damage (Reference 3). This type of fire will not occur in today's postattack environment because the surface density of wood in structures will not support a firestorm, and the building density of a NATO airbase is far less than a European industrial city. Additionally, the same level of saturation bombing is not expected, i.e., 400 to 500 planes in a wave, with several waves attacking the city. Consequently, secondary fire causes must be analyzed using computer-modeling principles, instead of relying solely on historical data.

3. Nuclear Explosions

During nuclear attacks, secondary fires most likely will result from bringing together flammable materials and energy sources that are normally separated or insulated from one another. According to McAliffe and Moll (Reference 4), secondary ignition frequencies are estimated at 0.006 per 1000 square feet of total floor area damaged by a blast overpressure of at least 2 pounds per square inch. Their study also shows that the most hazardous structures are wooden, the most hazardous fire sources are electrical and heating equipment, and the most hazardous occupancies are those storing high-energy materials, such as oil and chemicals. The analysis of mechanisms causing secondary fires indicate that indirect effects of flying debris and building collapse are more important than direct effects, such as ground shock and airblast. Although this study was based on a nuclear attack, the analysis is valid for a conventional war when the scale is reduced to coincide with conventional bombs; when the thermal, fire-causing factor is eliminated from

the conventional environment; and when the blast overpressure is reduced to the overpressure associated with conventional weapons. Flying debris and building collapse upset electrical appliances, break electric wires and gas pipelines, and puncture liquid and gas containers. These indirect effects appear to account for the high frequency of secondary fires from electrical and heating sources in buildings storing high-energy materials and in buildings constructed of wood and brick. Wood structures, the most vulnerable, are most likely to collapse, providing their own fuel.

4. Earthquakes

Fires, following earthquakes, are common and are used here as a means to evaluate the frequency of fires caused by building destruction. The forces involved in earthquakes are similar to the physical blast of explosions, although the earthquake force is transmitted through the ground, instead of predominantly through the air. The damage mechanisms of earthquakes differ from those of explosions; however, the resulting destruction is similar: buildings collapse, stoves and other appliances upset, electrical and gas lines break, etc. Therefore, earthquake experience may provide useful analyses in studying fires caused by nuclear and conventional blasts (Reference 4).

5. Tornado Fires

A general source was not found for published information on fires from tornadoes. However, the damage-causing mechanism of tornadoes and that of conventional explosives can be compared in terms of blast overpressure. One research report (Reference 5) describes the following damage mechanism found in tornadoes: "From the appearance of the destruction, the major damage is done, not by high winds, but by a low-pressure cell which is in the vortex of the funnel. Every building which was inspected had the appearance of exploding out, which would happen when the low pressure was equalized by the high pressure on the inside. As the low pressure funnel comes into an area, the pressure on the inside of the building remains at approximately 14.7 psi, while the low pressure has been estimated to be as much as 1/3 of an atmosphere less, which, being the case, would be about 5 psi differential pressure."

6. Conventional Explosives

Nuclear attack and earthquake data can be used to predict the number of fires per square foot of damaged floor area resulting from conventional bombing. Conventional high explosives involve forces comparable to that of nuclear explosions, and, in a few recorded disasters, have even involved forces of comparable size. Studies done during World War II on fires resulting from high-explosive bombs can be related to the atomic bomb experiences. Analysis indicates that fires resulting from high-explosive bombs caused an average of about 0.005 ignitions per 1000 square feet of building floor area damage. This figure is comparable to the 0.006 ignitions per 1000 square feet of building floor area damage resulting from nuclear explosion (Reference 4).

Many literature references are found concerning military explosions and the fire-causing potential of explosives. However, to our knowledge, only two major studies have been directed specifically to the analysis of secondary fires from bombings and other explosions. The first was a postwar British study of damage and fires from aircraft and flying bomb raids during World War II. The second was a US World War II study of fires and damage resulting from incidents involving the 500-pound, high-explosive, general-purpose (GP) bomb (Reference 4).

According to the British report on secondary fires resulting from aircraft bombing raids, the average number of ignitions was 0.8 per ton of high explosives. Unfortunately, the British study did not directly relate the frequencies of flying bomb fires to bomb tonnages, or to the amount of building destruction, although it did give data on these. Analysis to provide ignition-frequency estimates has been performed; the frequencies average about 0.005 fires per 1000 square feet of damaged floor area. The analysis also provides estimates of the number of fires per bomb ton. These estimates show an average value of 0.82 expected fires per ton of flying bombs. This estimate is close to the average value of 0.8 fires per ton of aircraft bombs. An analysis of flying bomb-damage, on a "per 1000 square feet of floor area" basis, by methods similar to those used for the Hiroshima and Nagasaki data, shows consistent values of about 0.005 fires per 1000 square feet of floor area. This value is close to the estimate for secondary fires when atomic bombs are used (Reference 4).

The US study was conducted by the National Defense Research Committee on ignitions resulting from incidents involving US 500-pound, GP bombs on European industrial buildings. This study concluded that, "The 500-pound US GP bomb had an appreciable incendiary value; in fact, the "MAE" (mean area of effectiveness) by fire was comparable in size to its MAE for causing high-explosive structural damage." The probability of fires starting by high-explosive (HE) bombs was estimated in several ways. The values center around 0.17, the extremes found in reasonable samples being 0.15 and 0.19. Five to 10 percent of the fires were not caused by direct hits and could be attributed to near misses or to spread from neighboring fire divisions. Comparing the probability estimates with fire frequencies of the A-bomb and the flying bomb is possible, if the fire probability is related to the average floor area damaged by a bomb. Such a comparison derives a frequency of 0.005 ignitions per 1000 square feet of damaged floor area. This comparison shows that the secondary fire frequencies derived in the analysis of the US 500-pound GP bomb analysis are similar in size to the fire frequencies derived from analysis of atomic bomb and flying bomb data (Reference 4).

SECTION III

POSTATTACK FIRE MITIGATION

A. OBJECTIVE

The objective of this effort was to assess systems that will contribute the most toward reducing the severity of the postattack environment firefighters must face immediately following an airbase attack. It will consider ways to decrease the required firefighter response to facilities and utilities so that firefighters can increase their support of combat sortie generation.

B. REDUCTION OF FIRE SPREAD

There are areas of a base where fire spread from one facility to another is likely. Fire spread in other base areas is unlikely and can be discounted. The following assumptions were made concerning postattack conditions.

1. USAF fire departments will not have the equipment to attack and extinguish all fires simultaneously,
2. The fires will have progressed beyond the point of origin before firefighters can safely leave the shelters,
3. Water supplies will be inadequate,
4. Response will be delayed by debris and craters,
5. Fires in fully involved facilities will be fought only when directed by the survival recovery center (SRC),
6. Mass fires will not occur and,
7. Firestorms will not occur.

Fire spread within the aircraft shelter complex is unlikely because of the distance between the hardened shelters. Fire spread from one munitions storage facility to another is unlikely because of the distance between the facilities and their concrete, earth-covered construction. The involvement of more than one storage igloo will result from a detonation of stored munitions.

Fire spread from one base structure to another in the cantonment areas (flightline, barracks, administrative) also is possible, although the probability is significantly less than in World War II. When fires have spread through a major portion of a building, including the spaces between the walls, it is likely the structure will burn completely in less time than it would take to extinguish the fire.

Stopping fire spread depends on the number of vehicles and firefighters, how capable they are, and how rapidly they engage the fires.

Firefighting is impractical when burning buildings are exposed to neighboring fires from which heating is sufficiently intense to sustain the fire and reignite the building if and when extinguishment was successful. Blast-damaged structures can be expected to burn in one-third to one-half the time required for undamaged structures. When a facility suffers significant loss of compartment integrity, as in the case of a bomb-damaged facility, the fire will spread faster than in an undamaged structure. The blast damage will enhance the fire buildup environment and provide easy routes for fire spread to adjacent compartments, making fire spread in the damaged buildings rapid and simultaneous in all directions with large flame areas (Reference 6). Confining the fire to the floor or to the area of origin and keeping the fire from penetrating concealed spaces, will lessen both the intensity of the fire and suppression operations (Reference 7).

C. MINIMIZE PETROLEUM, OIL, AND LUBRICANT FIRE RESPONSE

1. Bulk Storage

Fire spread is likely in petroleum, oil, and lubricant (POL) areas unless action is taken quickly to control the spilled fuel. Bulk storage fires can be extinguished; however, this requires massive amounts of extinguishing agents, water, equipment, and manpower. Extinguishing POL storage tank fires is difficult because of problems associated with applying the extinguishing agent to the fire. These problems include gusty, upward, fire-drafting air currents that carry the agent away from the fire; the inability of foam applied from the periphery of a large tank to flow and form a complete seal; and inverted or sunken roofs. Other problems are procedural and can be overcome by training and preplanning. Most USAF fire chiefs tend to attack these fires like an aircraft fire, instead of planning for a sustained and prolonged firefighting effort with adequate logistical support. The basic premise concerning POL fires is that storage tank fires will result from a direct hit, or from spilled fuel exposing the tanks. It is assumed that hot metal fragments penetrating the tanks will not cause ignition and that incendiary weapons will not be used in conjunction with fragmentation and GP bombs or bomblets. Given the level of effort and materials required to extinguish a POL storage tank fire, the recommended action is to let the fire burn, concentrating efforts on containment, instead of extinguishment.

2. Tank Construction

The probability of POL storage tanks igniting depends on the tank's construction. For example, cut-and-cover tanks are significantly less vulnerable than aboveground tanks. If such a tank ignited, it would burn contained, with little danger to surrounding tanks. If an aboveground tank ignited, the fire would have little effect on nearby cut-and-cover tanks. The aboveground fire could jeopardize nearby aboveground tanks; however, this danger is reduced by the distance between the tanks. Danger can be reduced further by using water curtains and by cooling the burning tank. If the initial explosion does not split the tank shell, the resulting fire will not cause the shell to rupture. The shell will remain intact throughout the fire and fold into the tank, above the liquid level, as the metal is heated and loses strength.

All USAF aboveground tanks (both open-top and cone-type roofs) have floating roofs. With such roofs, the danger of explosion from hot metal penetration is considered negligible, because there is no space for flammable vapors to accumulate. This assumption is true as long as the fuel level is maintained so the roof does not rest on the lower roof supports. Depending on the height of tank penetration, escaping fuel could be ignited by static electricity; however, this is unlikely. Cut-and-cover tanks are not equipped with floating roofs, since most of the fuel is underground, and vaporization is not as great a problem. Additionally, floating roofs do not work well in tanks having several columns. The emphasis in POL storage areas must be on controlling the location of spilled or burning fuel and on eliminating ignition sources in the vapor travel areas.

3. Distribution System

Potential fires resulting from damage to the POL distribution system during an airbase attack can be disastrous to the continual launch and recovery of aircraft. Most POL lines are underground with a required minimum covering of 2.5 feet. The POL lines are assumed to be buried between 2.5 and 3.5 feet and do not require further protection, except for pumping stations and dispensing locations, such as truck fill stands. Most POL fires, other than storage tanks, are expected to be extinguished relatively quickly, with minimum equipment and resources, if the fuel flow is controlled and stopped. Crater fires, resulting from direct hits, are of little consequence and can be allowed to burn if they do not threaten other equipment or resources. While the distribution system is expected to be damaged, if there is a resulting fire, allowing the fire to burn is an option that must be considered. The emphasis must be on protecting the distribution system, and if that fails, controlling the spilled fuel flow. Installing flexible joints and couplings in POL pipelines to reduce the blast and ground shock damage could reduce the number of expected breaks. The effects of an air attack could be reduced further by providing splinter protection for aboveground fuel processing facilities.

D. CORRECT PRIORITIZATION OF FACILITIES

A logical firefighting plan calls for prioritizing facilities by assigning them a numerical ranking based on their importance to postattack base recovery and sortie generation. Even within this system, the loss of one facility may have a greater impact on sortie generation than another grouped within the same priority listing. This makes exact and correct prioritization even more essential. AFESC is developing a computer simulation program to rank each building within a numerical priority, according to its importance to postattack launch and recovery. Therefore, separate and distinct criteria can be established for each priority grouping. Firefighters must be able to use this system to know in advance which fires to extinguish first and which to leave for last or, with limited resources, which to ignore completely. This approach will assure that resources will be expended where they will do the most toward supporting maximum sortie generation.

The priority system must be flexible, so fire chiefs may take actions necessary to support aircraft launch and recovery operations, control and

extinguish fires, mount critical rescue operations, and to return the base to its operational status as soon as possible. All fires cannot be handled simultaneously, and some important fires will have to wait. The number of facilities in each category must be small enough to allow clear-cut firefighting decisions.

1. Priority One

Priority One should pertain only to those facilities or areas which, if lost, would prohibit the Wing from accomplishing its mission. Priority One should include navigational aids, such as the Aircraft Control Tower, Tactical Air Navigation (TACAN), Ground Control Approach (GCA), and aircraft arresting systems. Priority One facilities probably should make up less than 1 percent of total base facilities.

2. Priority Two

Priority Two facilities are those which, if lost, would result in critical damage to the Wing's ability to launch and recover aircraft. Priority Two facilities include command and control functions, such as the Wing command post, intelligence center, squadron operations, SRC, security police operations, fire stations, damage control center (DCC), communications, and aircraft maintenance facilities. This category includes base water storage, treatment, and pumping stations; Civil Engineering (CE) facilities that house Rapid Runway Repair (RRR) equipment, and War Reserve Material (WRM) warehouses. Priority Two facilities should constitute less than 5 percent of total base facilities.

3. Priority Three

Priority Three facilities include those areas and facilities which, if lost, would seriously reduce the Wing's capability to continually launch and recover aircraft. Priority Three facilities include all electrical substations, medical facilities, POL, and munitions facilities. This category does not include individual power lines; pole-mounted transformers; individual tanks for facility heating; or small tanks used to support vehicles, generators, or aerospace ground equipment. Priority Three facilities should constitute 10 percent or less of total base facilities.

4. Priority Four

Priority Four facilities include those areas and facilities which, if lost, would result in minimum damage to the Wing's ability to continually launch and recover aircraft. Priority Four facilities include dining halls, warehouses, weapons and maintenance operations centers, and civil engineering and base motor pool facilities. The category does not include warehouses containing nonmission-critical material, such as household goods, government furniture, etc., or administrative facilities in vehicle maintenance or civil engineering compounds. Priority Four facilities should constitute 15 percent or less of total base facilities.

5. Priority Five

Priority Five facilities should include those facilities that, if lost, would have little or no impact on the Wing's ability to continually launch and recover aircraft. This category should include the majority of base facilities.

E. SPLINTER PROTECTION

1. Vehicles

Fire vehicle attrition can be reduced significantly by providing splinter protection. Fire vehicles are critical to aircraft launch and recovery and, as such, must be protected to ensure that they survive and can provide fire protection and rescue for Wing assets. It is assumed that crews will remain with the vehicle and that when the vehicle is protected, crew members will also be protected. Fire department vehicles are dispersed before an expected attack, with their dispersal locations based on the availability of space in aircraft shelters and other protected areas primarily designed to protect other resources. The fire department must compete for protective space which may not be available, and available space will not be tailored to fire protection. Dedicated splinter protected areas, positioned and designed specifically for firefighting vehicles, can dramatically improve the firefighting capability following an airbase attack and will reduce the competition for available protected space. AFESC currently has vehicle splinter protection under design. Equally important is the siting of splinter protection for the firefighting system. The Concept of Operations for Postattack Fire Protection and the Splinter Protection Siting technical reports are operability source documents for siting splinter protection.

2. Water Supplies

Providing splinter protection for only the vehicle and crews will not ensure postattack operability. Water is not expected to be available through the base water distribution and hydrant system. With the number of underground utilities on a base, a bomb that misses its intended target will still cause significant damage by rupturing utility lines. Consequently, water supplies to reservice fire equipment must be available and protected. Fire equipment has enough on-board water supplies to last approximately 1.5 to 2 minutes. If additional water is not available when the on-board stores are exhausted, firefighting will cease. Therefore, water supplies must be a part of the splinter protection system. Equipping splinter protected areas with deep wells and high-speed pumps is the most logical way to ensure the availability of water for firefighting in the postattack environment.

3. Agents

Firefighting agent availability is connected directly to the Wing's mission and plays a major role in postattack mitigation. Fire extinguishing agents usually are dispersed before an expected attack. Like vehicles, their dispersal locations are based on space availability in aircraft shelters and other protected areas. Again, the fire department must compete with other

base organizations for protective space, which may not be available. Dedicated splinter protected areas, designed specifically for firefighting agents, can significantly improve the current firefighting capability following an airbase attack. Crash fire vehicles have enough agents on board for approximately 8 to 10 minutes of maximum agent dispersal when water is available to reservice. Unless additional agents are available, the fire department cannot function when on-board agents are depleted. These resources must be protected and configured for rapid dispersal by having agents (Aqueous Film-Forming Foam (AFFF), Halon in cylinders, and dry chemical) loaded on trailers or by using other such means for rapid dispersal. Protection and dispersal should be provided for the fire departments on-hand stock and for base supply special levels. However, in US Air Forces Europe (USAFE) Halon cannot be dispersed because it is contained in permanently fixed tanks with individual capacities of 10-metric tons. These units must be dispersed away from the flight line high-threat area and splinter-protected to prevent tank damage that could deplete the base's entire stock of Halon. All agents should be located away from attack major aim points, such as the aircraft control tower and flight line. Agents located on the flight line or around the fire station are almost certain to be lost during an airbase attack.

4. Ancillary Equipment

Equally important is the need to provide splinter protection for ancillary equipment critical to fire department operations. This equipment includes Self-Contained Breathing Apparatus (SCBA), air compressor(s), air-purification equipment, fire hose, spare vehicle tires, and protective clothing. The actual amounts of equipment requiring protection should be established, based on the threat, expected damage, and attrition. SCBA cylinders are designed to last 30 minutes, but actually last less than one-half that time because of the volume of air required when a firefighter is under stress, trauma, and doing strenuous work. Air compressor(s) and purification equipment are critical to reservicing SCBA. While the new rebreather will reduce the reservicing frequency, reservicing will still be required, and the necessary equipment must be protected. Fire hose can be expected to be ruined frequently by debris, fires, or by abandonment because firefighters respond to a higher priority facility. Consequently, adequate stocks must be available and protected. Fire departments usually have only one of each type spare tire and wheel. Debris in the postattack environment is expected to necessitate frequent tire changes, and spare vehicle tires must be available and protected.

5. Fuel Supplies

Fire vehicle fuel supplies could become scarce in the postattack environment because of damage to tanks and the distribution system, contaminated fuel, and the loss of electrical power. Considering the amount of time fire vehicles are expected to operate, adequate fire protection support of sortie generation requires reliable fuel supplies to operate both gas and diesel engines for several days. These fuel tanks must be provided with splinter protection. The tanks should be provided with handpumps to eliminate the need for electricity to refuel the vehicles. AFESC has taken the necessary steps for some current and future crash/fire/rescue (CFR)

vehicles (P-19, 20, 23, 22, and 24) to operate on jet fuel. Once the older vehicles are replaced, gasoline and diesel fuel will become less critical.

6. Fire Communications Center

Fire Communications Centers (FCC) are the nerve centers for all fire protection operations. Splinter protection for these operational facilities is necessary for fire department support of aircraft launch and recovery, barrier engagements, rescue, and firefighting. All fire department operations are conducted from the FCC, including establishing the firefighting sequence, dispatching equipment, and redirecting the efforts as conditions change. Without these operational centers, the fire chief cannot successfully contribute to base recovery after attack.

7. Radio Net

In the postattack environment, communications between fire vehicles, the FCC, and senior department officials is necessary for success. Therefore, the fire/crash radio net base station and repeater units must be provided splinter protection to increase the probability of their surviving an airbase attack. Unless these radio units are protected, communications will not exist, and there will not be a coordinated effort to extinguish fires, to rescue entrapped personnel, and to quickly return the base to an operational condition. The lack of this communications net could result in the most essential fires not being fought, rescues not being performed, and aircraft launch and recovery not completely supported. Unprotected units will result in a fragmented fire department operation without a team effort toward a common goal.

F. VEHICLE HARDENING

Fire vehicles are not hardened for vehicle or crew protection against bombs, submunition blasts, or fragments. The firefighter faces a harsh environment following an attack. Debris and shrapnel-covered surfaces must be traversed quickly to meet fire response timelines. Unexploded bombs are hazards, as are antivehicle and antipersonnel munitions. In the early 1980s, Rapid Runway Repair research led to the development of methods, materials, and concepts for hardening civil engineering equipment. Methods of protecting vulnerable equipment areas with steel plates, filling tires with foam, and providing a cab with Lexan® windows were developed. This technology, already applied and validated on numerous pieces of civil engineering equipment, has direct application to the hardening needs of the firefighter. AFESC has an effort underway to design hardening for fire vehicles. This effort will result in fire vehicles capable of responding, regardless of submunitions. Traversing submunitions, debris, and pavement damage can be enhanced significantly by developing and deploying the air cushioned vehicle.

It also may be necessary to devote explosive ordnance disposal (EOD) personnel to each vehicle or train firefighters for the EOD function during wartime operations.

G. CHEMICAL WARFARE PROTECTION

1. Proximity Suits

The fire protection proximity gear provides inadequate protection for a chemical warfare (CW) environment and the CW gear provides inadequate protection for firefighting operations. In some cases, a combination of the two suits is worn, which does not provide protection for either environment. The need exists to field equipment suitable for both environments as soon as possible. The rebreather and proximity ensemble being developed by AFESC will provide this capability.

2. Survivable Collective Protection System

The original Survivable Collective Protection System (SCPS) was not designed for firefighters, and firefighters cannot use the unit without major changes to the entry configuration. SCPS storage spaces are designed for the CW ground ensemble and are inadequate for firefighter ensembles. Additionally, the current SCPS operational concept provides each member three CW ensembles stored in the SCPS, and decontamination is not an immediate concern. Because firefighters will not have spare ensembles, decontamination is an immediate concern and must be accomplished while each crew member is confined to the SCPS. The SCPS will have a major impact on mitigation because firefighters will then be able to decontaminate equipment, rest, recuperate, and then continue to operate in a CW environment. There are some opinions that the normal SCPS air movement will decontaminate the firefighters ensembles. If this theory proves reliable the decontamination problem will be reduced significantly. The need exists to develop and field the SCPS as quickly as possible. EOD personnel have a similar problem because their new CW ensembles prohibit them from using the SCPS as presently configured. Redesigning and reconfiguring the SCPS interior should be a joint firefighter, EOD effort.

3. Self-Contained Breathing Apparatus

Current SCBA has 30-minute air supply cylinders that usually last less than one-half that time. Recognizing the serious shortcomings of SCBA, HQ AFESC is developing a new concept which includes a helmet, communications, proximity clothing, and a rebreather to allow firefighters to operate in oxygen-deficient atmospheres and in a chemical environment without additional equipment. The rebreather has 6 hours of filtered air, 2 hours of supplied air, and provides more capability than found in other functional areas. Both SCBA and the rebreather must be reserviced and the stored air and the filters must be replaced in a chemical environment. These capabilities should be developed in conjunction with the reconfigured SCPS.

4. Vehicles

Except for protection from liquid agents, firefighters are not safer in the vehicle cab than they are outside the cab in the CW environment. Fire vehicles must be able to operate and provide protection for the crew in a CW environment. Future fire vehicle buy programs should include positive

pressure-sealed crew compartments with filtered air intakes that would allow firefighters to conserve their filtered and stored air in the protective ensemble when they must be outside the vehicle. AFESC has required that the new P-15 vehicle and the P-2 replacement (P-23) be equipped with a sufficient air system to supply three to four people for 1 hour. This system probably could be expanded to make up the 4-hour difference between the 8 hours provided by the new rebreather and the 12-hour shifts firefighters are expected to work in a combat environment.

H. REDUNDANT SURVIVABLE COMMAND, CONTROL, AND COMMUNICATIONS

1. Communications Van

Establishing a communications center in a tent or similar facility is not conducive to a wartime operation. Fire communication centers are vulnerable, and the need exists to develop alternate communications for fire department wartime operations. A better approach could be to develop a small, hardened communications van that does not rely on land-lines and other types of communications equipment. The van would be further protected by revetments and/or earth berms while operating in a fixed mode during the postattack. The van should be C-130 transportable, with a drive-on/off capability. This van should be equipped with programmable radios to eliminate the problem of fire vehicle radios operating on different frequencies, and with cellular telephones to eliminate the land-line problem. The van should be capable of becoming operational by raising antennas and providing electric power, and should be equipped with everything required for the fire chief to exercise command and control over the operation. This van can be used as a backup unit for the FCC and can provide onsite communications. Such a van has been partially developed by the Tinker AFB, Oklahoma fire department. Their concept deserves additional evaluation and testing.

2. Postattack Fire Response Assessment and Direction System

The fire chief and senior commanders must have real-time information in a wartime environment; therefore, an automated system is needed to provide this information. The fire chief must make quick and accurate decisions while under the stress of attack, numerous fires, rescue requirements, and other such emergencies. An automated system would meet this need and provide fire chiefs, commanders, and the SRC staff with real-time, fire protection decision criteria and operational directives in a wartime environment. The current system requires manual operation via charts, phone lines, maps, radio nets, books, and prefire plans. Information also must be passed through several individuals, increasing the risk of the most critical fires not being fought, the most available unit not being dispatched, and critical rescues not being performed. This system is not the state of the art and does not quickly provide the command element with the status of resources critical to sortie generation (i.e., fire vehicles, firefighters, and firefighting materials, such as water, AFFF, and SCBA).

The present system does not provide real-time information concerning aircraft response locations, barrier engagements, fires, facility and rescue requirements, and damage on the base assessed from infrared sensors, facility

alarms, telephone, damage assessment teams (DAT), radio nets, and verbal reporting. A system is required to provide the location of all deployed fire vehicles, immediate status of all fire vehicles after attack, firefighters, agents, and equipment. The AD/YQ project to develop and field a survivable base recovery after attack communications system will meet this need. However, for the system to be effective, fire protection requirements must be included. The planned system can be enhanced by equipping all mission-essential facilities with radio fire (RF) alarm transmission equipment. This RF equipment can provide a quick assessment of base facilities during the trans and immediate postattack periods.

The postattack fire response model is a key analytical tool to assist in dispatching the most effective equipment to the most important facility(s). By using the model, vehicles would be dispatched within the shortest response time and distance and they would have on-board computer remote terminals for data transfer. The system could direct available units to locations and provide specific instructions, such as extinguish the fire, perform rescue only, prevent fire spread, monitor, and provide the next or alternative assignment.

I. DEVELOPMENT OF WAR PLANS AND POLICIES

1. Weapons Laydown Analysis

The need exists to make firefighter postattack assessment computer software user-friendly and responsive to Air Force commanders, Base Civil Engineers (BCE), and fire chiefs so it can be used for wartime training and exercise evaluation. The Combat Base Assessment Model (CBAM) would be programmed to run on desk-top computers and would add the necessary software to make automatic calculations for bomb and aircraft type in relation to airfield damage. The system could be integrated with other postattack computer programs to develop an output at each model level for management, tactical evaluations, and training purposes. When developed, this system would provide command personnel with a tool to give current real-time data on which to base training and critical sortie generation decisions.

2. Crash/Fire/Rescue Vehicle (CFR) Time-Phased Force Deployment Listing

CFR vehicle availability has a direct impact on aircraft sortie generation. Presently, there is no system to identify excess or unneeded CONUS CFR vehicles when the Wing they are supporting has deployed and vehicle replacement codes are the only valid way to evaluate CFR reliability. Additional vehicles will be required to support a wartime operation, and deploying an unreliable vehicle will place an additional maintenance burden on an already overloaded staff. These additional vehicle requirements will be the result of attrition; multiple fires; and increased aircraft sorties, risk, and number of aircraft emergencies. Increased rapid intervention standby services will be required to support aircraft arresting system engagements, battle-damaged aircraft, aircraft operations from a minimum operating strip, hot refuelings, hot integrated combat turnarounds, and air evacuation aircraft. Fire vehicles are expected to experience increased downtime because of increased usage, battle damage, and spare parts shortages.

An automated plan is needed to deploy fire vehicles to the theater of operation. This automated system should include the most cost-effective combination of in-country versus CONUS pre-positioned CFR vehicles to support a wartime operation. The system could track aircraft deployments, releasing CFR vehicles for movement, and track Air National Guard and Air Force Reserve CFR resources, as these Prime BEEF teams are deployed. The system would include CFR availability, along with the location, such as in the host country, a nearby country, or in the CONUS. The system would include the capability to identify the most reliable CFR vehicle(s) for deployment. This system, called the Vehicle Reliability and Maintainability Information System (VRAMIS), already exists and would provide AFESC with effective means to analyze vehicle data to determine the overall reliability and maintainability (R&M) of CFR vehicles. This data would enable AFESC to use vehicle readiness data to support force deployment and contingency response operations. The data also would provide a centralized database network that could supply relevant information to efficiently and effectively manage the CFR vehicle fleet, as well as provide the state of readiness of the CFR vehicle fleet.

While some information exists in various databases that could potentially be used to determine CFR vehicle reliability, this information is not being used for two reasons. First, although there is a myriad of information that relates to the vehicles, the information is not organized into a structure conducive to R&M determination and analysis. Second, while data exist at all Air Force bases, the information is decentralized to the extent that AFESC cannot readily access and integrate the information.

CFR vehicles are critical to successfully performing the wartime airbase operability missions. For these vehicles, reliability criteria can be developed to provide information relative to the vehicle fleet's state of readiness. VRAMIS calculates reliability of vehicles that have been assigned critical, major component system codes. Critical codes are those that are absolutely essential to mission performance. From the critical code structure, a reliability value can be predicted for all critical vehicles. In addition to reliability, readiness information can be developed to provide functional users with the operational state of a particular part of the fleet. For example, AFESC could determine from VRAMIS, vehicles that are down for parts or vehicles down for maintenance (VDM) at a specific base. VRAMIS also could determine vehicles at each operational theater base that have the greatest probability of fulfilling mission parameters without major maintenance problems. Furthermore, VRAMIS provides the capability to deploy vehicles based on "best reliable" criteria, whereby the best vehicles from CONUS locations could be selected for time-phased deployment to contingency areas.

3. Materials

a. Aqueous Film-Forming Foam (AFFF)

AFFF is the prime extinguishing agent used by the USAF. Agent levels, both fire department bench stock and base supply special levels, are based on peacetime requirements and vehicle capacities. Agent levels are inadequate for POL tank firefighting, and these levels may not be adequate to

support a wartime operation. The need exists to evaluate agent levels, especially at USAFE and PACAF bases, to determine actual agent requirements for the postattack environment. Agent requirements should be based on the threat, expected damage, and attrition.

b. Other Agents

The two primary agents used by the USAF, other than AFFF, are Halon 1211 and dry chemical. Similar to AFFF, on-hand supplies of these agents, at the fire station and base supply, are based on peacetime and vehicle capacities, not on an operation requiring extinguishment of numerous fires resulting from an attack. A study should be initiated to determine the amounts of agent required to support fire-protection operations in a wartime environment and how best to disperse and protect the agents. These agent levels, like AFFF, should be based on the threat, expected damage, and attrition.

c. Ancillary Equipment

Ancillary equipment is required for fire protection to support sortie generation in the wartime environment. On-hand equipment, like agents, is based on the vehicle itself and on peacetime requirements. The current method of determining the types and quantities of ancillary equipment required may be inadequate to fully support fire protection in the postattack environment. This equipment includes proximity suits, SCBA, fire hose, air compressor(s), purification equipment, and other such equipment required for effective fire protection operations. A study should be initiated to determine exactly the types and quantities of equipment required.

4. Vehicle War Readiness Support Kits

Fire vehicle operability in the postattack environment will be critical to aircraft sortie generation. The need exists to develop a spare parts list and to pre-position spare parts for fire vehicles. Vehicle attrition in wartime demands that operational vehicles remain in service until damaged vehicles are repaired or replaced. The wartime spare parts pipeline is expected to be in disarray, and on-hand bench stock and special levels will be able to sustain the fleet for only a short time. Therefore, a need exists to determine the major components or subsystems that are expected to fail. This analysis can be performed using VRAMIS. When the analysis is complete, war readiness support kits should be assembled to support wartime fire protection. This kit would be stored at each high-threat base and would have adequate parts, based on the previous analysis, to reasonably assure that spare parts are available to support the fire vehicle fleet for at least 30 days.

5. Pamphlet and Checklist

There is no unclassified document outlining the environment firefighters will be exposed to in the postattack environment. The need exists to develop and publish a wartime environment pamphlet and checklist for firefighters. The document should extract unclassified sections of the SALTY

DEMO report (Reference 1), the AFESC Postattack Assessment (Reference 2), combined with a mitigation analysis, and make it available to each base fire chief and fire protection control team. The document should include a checklist to provide each Prime BEEF team with a guidance document for their home station training. In addition, having senior department officials attend intelligence briefings would better prepare firefighters for the wartime environment.

J. SURVIVABLE WATER SUPPLY

1. WRM for the Water System

During the SALT DEMO demonstration, fires could not be fought because of numerous waterline breaks. Most fires self-extinguished after consuming all available fuel. The lack of water after attack is expected to result in maximum impact on sortie generation, because the fire department will be incapable of extinguishing fires in critical facilities. Furthermore, if water is not available to reservice fire equipment, aircraft and crews could be lost once initial on-board water supplies are expended. The requirement to repair the water distribution system far exceeds current capabilities in terms of materials, procedures, and training. AFESC has an effort planned to develop parts lists, procedures, and training to expedite utility system repairs in the postattack environment. These WRM kits for the water distribution system will include all necessary tools and replacement parts, such as quick-connect couplings and splices, flexible repair hoses, and precast pipe anchors. The exact equipment and stock levels required will be established using the airbase attack analysis. The equipment will be dispersed and protected to increase the attack survival probability.

2. Alternate Water Supplies

Most bases have alternate water sources that can be used to increase the probability of water availability in the postattack environment. These sources include underground reservoirs, drilling deep wells, equipping the wells with high-speed pumps, and quick reservicing equipment for fire equipment. Other options include building additional underground protected tanks or reservoirs, both on and off-base, and strategically locating water bladders in revetted, low-risk areas. Additional options for increasing water availability include enlarging the base tanker fleet, and equipping swimming pools, cooling towers, and sound suppressors with fire department connections. A further option is to construct a redundant water distribution system and loop all water distribution systems to increase and provide a two-directional flow. Trailer-mounted, high-speed pumps to pump water from reservoirs would add a necessary dimension to reservicing crash trucks in the postattack environment. A study should be performed to determine which of these options or combinations of options would be the most effective in increasing the availability of water in the postattack environment.

K. UPGRADE INSTALLED SYSTEMS

Research efforts at AFESC have led to the development of a state-of-the-art fire protection system (FPS) for hardened aircraft shelters

(HAS). This system will reduce the probability of fire starts in HAS. Installing similar systems in other facilities that make major contributions to sortie generation will significantly reduce the severity of the postattack environment.

L. WARFIGHTING TRAINING PROGRAM

1. Deployment Task/Lesson Plans

The specific tasks firefighters are expected to perform in the combat environment need to be established. The task list should be a close examination of everything expected of firefighters to assist in base recovery after attack. Once these tasks are outlined, including the skill level required, the HQ AFESC, Detachment 2, Firefighter Prime BEEF Team Lesson Plans can be revised, as needed, to ensure that Air Force firefighters attending this training are presented the correct task and that it is accomplished at the required level. These tasks list are being established for all Civil Engineering Prime BEEF Teams, except firefighters.

2. Training Scenarios/Exercise Kit

A base-level exercise/demonstration kit should be developed and evaluated to support realistic exercise of base-level firefighting assets. The SALTY DEMO demonstration showed a Wing's ability to survive an attack, recover, and to conduct operations. Central to the demonstration's success was realistic, on-the-spot resource attrition and a realistic scenario. This scenario required a high degree of operational readiness from the participants and revealed system stresses which would have remained undetected in many traditional exercises. Because of the firefighting mission's critical impact on sortie generation, and the short supply of firefighting resources, the fire chief will face difficult choices in a changing and uncertain environment. Typical exercises, such as local SALTY Nation and Inspector General (IG), do not require the firefighting system to perform sufficient, multiple, concurrent tasks, and generally fail to task the firefighting system with the complicated scenario that would require the kind of management and decision making needed for wartime success. Once this scenario is developed, it can be provided to Detachment 2 for use in training, and to major air command fire/protection staffs.

3. Wartime Training Videos

Fire protection training video programs depicting the postattack environment should be developed for USAF firefighters. These programs would include specific or combined programs on subjects, such as command and control; specific fire response to different wartime situations, such as HAS, POL, munitions areas, and ordnance; and rescue procedures for fighter aircraft. The rescue video could be matched against the War Mobilization Plan (WMP) and each Prime BEEF Team could be provided with a rescue video for the aircraft they will support when deployed. The program can also be employed at Detachment 2 using the same matchup, providing rescue-knowledgeable firefighters when they arrive at their deployed location.

A weapons-effect video program can demonstrate to firefighters the level of damage expected. It could be tied with the threat, bomb loads, and aircraft in the same manner as the SALTY DEMO demonstration. The program could trace hot-bomb fragment travel distance, damage to different facility types from varying distances, and the problems with moving fire vehicles from the protected location to the fire site.

4. Training Courses

The Officer Corps, specifically commanders and engineers, must be aware of the environment firefighters will be exposed to during a war. Training courses offered by the Air Training Command and the Air Force Institute of Technology, particularly the Base Commanders Course, Contingency Engineering Course, and the Base Civil Engineering Orientation Course can expose these individuals to the postattack environment firefighters will experience. The firefighter postattack environment should be included in these training courses.

5. Firefighter Training Plan

To fight and win the war, firefighting forces must be organized and trained as units, not as individuals. This training must be consistent for CONUS-based organizations, regardless if they are active duty, Air National Guard, or Air Force. Prime BEEF teams will integrate into the host fire department and, once deployed in the combat environment, the unit's proficiency will determine the department's success. The proficiency of both the deployed and host firefighters depends on their being trained on the same subjects, and to the same skill level. Consequently, a single document should identify all training curricula and training resource requirements to enable the necessary funding to be obtained.

M. BOMB-DAMAGED HAS DOORS

Unless firefighters can gain access to the HAS interior, a fire, regardless of how small, could result in total destruction of the shelter and its contents. HAS doors that cannot be opened because of damage to the doors, pavement upheaval, or track damage present an overwhelming obstacle to firefighters in the postattack environment. Additionally, when weapons are stored in the shelter, their detonation could result in serious damage to other shelters. Such damage would seriously impact the Wing's ability to launch and recover aircraft. The need exists to develop, test, and verify procedures to open damaged HAS doors. The project also should include developing the necessary equipment and training.

N. BASE ELECTRICITY

Electricity is expected to be one of the main ignition factors in bomb-damaged facilities; arcing and short circuits quickly can ignite wood and other more combustible products. The fire hazard increases when flammable or combustible liquids come in contact with this ignition factor. The hazard becomes even more severe in facilities with higher voltage. Consequently, the

need exists to design, develop, test, and verify a single system to shut down all base electricity.

O. OTHER PROJECTS

1. Reduced AFFF Percentages

AFFF was reduced from 6 percent to 3 percent without impacting effectiveness. AFFF probably can be reduced further without a loss in effectiveness, but will have a remarkable impact on the amount of agent self-contained fire vehicles can carry. Reduced percentages also would significantly reduce transportation and storage requirements. Reduced storage space requirements will also reduce the amount of splinter protected space required.

2. Improved AFFF

AFFF is a marked improvement over previous mass application agents used by the fire protection community. However, additional improvements are possible, so AFFF will have a faster extinguishment time, along with reduced application rates and density. A feasibility study should be performed to assess the possibility of improving AFFF. Better sealing capability and reduced application and density rates could significantly reduce the difficulties in extinguishing POL tank and other large fires expected in the postattack environment.

3. Automatic Oscillating Turrets

Automatic oscillating nozzles exist and can improve fire protection in the postattack environment. Their use and feasibility have been proven, and the new P-19 vehicle is equipped with such nozzles. The task that remains is to retrofit all USAF crash vehicles with automatic oscillating turrets.

4. New Agents

The need for better and less expensive fuels is evident in many areas, including aircraft fuels. Therefore, future aircraft probably will not continue to use hydrocarbon fuels. New fuels are expected to require different agents and delivery systems. Consequently, a study should be initiated to evaluate future aircraft fuels to determine if current firefighting agents will be effective on these new fuels. Additionally, a replacement for Halon needs to be developed. The Environmental Protection Agency restrictions on Halon should make developing a Halon replacement a priority project.

5. Remote-Controlled Fire Vehicles

Much work has been done with remote-controlled vehicles; however, additional work is required to perfect these vehicles for fire use in the postattack environment. Remote-controlled vehicles could be used to fight fires in dangerous areas without exposing firefighters. Such vehicles would

be particularly valuable in the postattack environment and where weapons are involved.

SECTION IV

RECOMMENDATIONS

This section presents recommendations to reduce the severity of the firefighters' postattack environment and to increase fire protection support of aircraft sortie generation. These recommendations cover fire spread, POL systems, facility prioritization, splinter protection, immediate response capability, chemical environment, communications, plans and policy, water distribution system, installed systems, training, HAS doors, bare electricity, and other projects.

A. FIRE SPREAD

Fire mitigation efforts should be directed toward facilities constructed of wood and brick, because these facilities are the most likely to collapse from bomb damage. A structure should be allowed to burn if the following statements apply:

1. The facility has received significant blast or fire damage;
2. A significant loss of compartments has occurred;
3. The fire has spread through a major portion of the building, including the spaces between the walls;
4. The facility or contents are damaged to the point that sortie generation cannot be supported.
5. The function of the facility has been destroyed. Firefighting, in this case, should be limited to preventing the fire from spreading to other facilities. The following actions, some of which already are required, will further reduce fire spread in facilities:
 - a. Ensure the integrity of all fire walls and partitions.
 - b. Ensure the integrity and proper operation of all fire doors.
 - c. Prohibit storage of flammable liquids inside facilities at high-threat bases.
 - d. Ensure the subdivision of all attic spaces.
 - e. Install automatic fire-suppression systems in all Priority One facilities.
 - f. Install shadow or underwing protection in all aircraft maintenance facilities.
 - g. Program requirements to accomplish these objectives.

B. POL SYSTEMS

POL fires probably will not occur at the level previously assumed. However, when they do occur, POL fires will be a major problem to base recovery. The following actions are suggested to reduce this hazard:

1. If a POL tank is involved, allow it to burn. Concentrate on containing the spilled fuel and preventing fire spread.
2. Change the preplanning, training, and procedures for POL-tank firefighting to allow for sustained and prolonged firefighting. Emphasize logistical support and agent-distribution rates.
3. Field test and validate the theory that hot, metal, bomb fragments will not ignite aboveground POL tanks.
4. Establish the amount of AFFF required for POL tank fires, and stock this agent at all bases in high threat areas.
5. Field-test and validate the theory that a short-duration fireball will not ignite an aboveground POL tank.
6. Determine how close GP bomb impact must be to rupture a POL tank.
7. Develop procedures and directives through logistics channels to ensure that enough fuel remains in floating-roof tanks to keep the roof above the lower roof supports during war.
8. Analyze the impact time operations of flexible couplings and joints in POL piping to reduce the damage caused by bomb blasts and ground shock.
9. Provide splinter protection for all aboveground components of the POL distribution system.
10. Evaluate area-wide and individual installed fire suppression systems for POL tanks. Field-test a subsurface injection system for cut-and-cover tanks.
11. Develop a system to effect total area electrical shutdown.
12. Conduct a study to determine the impact of reinforcing POL spill control dikes to withstand a GP bomb near miss.
13. Develop procedures to control the fuel flow from ruptured, aboveground distribution system components.
14. Conduct a study on the effectiveness and impact of injecting fire suppression agents into existing POL piping.
15. Conduct a study on the effectiveness and impact of a hydrostatically extendable tower for POL tank firefighting.

C. FACILITY PRIORITIZATION

The facility priority system now in use does not recognize that the loss of one facility may have a much greater impact on sortie generation than the loss of another facility within the same priority ranking. Therefore, the following actions should be taken:

1. Using computer simulations, determine the facilities which contribute the most to aircraft sortie generation.
2. Develop a draft guidance document for the Air Force outlining a facility priority system developed from computer simulations.

D. SPLINTER PROTECTION

Splinter protection for fire protection resources is critical to fire protection's survival and operational capability in the postattack environment. The current method of protecting assets is unacceptable, because the expected attrition rate is beyond the fire department's absorption capability. AFESC has an effort underway to develop a definitive design for fire vehicle splinter protection. Equally important is siting for these splinter protected areas. Siting should be located where there is reasonable expectations of surviving the attack and will allow rapid access to mission critical facilities with minimum UXO exposure. The design should include protection for the following assets. Separate and specific protection for crews is not included because it is assumed that the crews will remain with the vehicles, and that if the vehicles are protected, crew members will be protected.

1. Vehicles

Protecting vehicles provides a reasonable assurance that they will survive splinter effects. Vehicle survival will have a major impact on fire-protection support of sortie generation; it also will reduce the requirement for replacement vehicles and will allow expedient base recovery.

2. Water

Deep wells or bladders equipped with high-speed pumps should be included at the splinter protected areas for the fire system.

3. Agents

Dedicated splinter protected areas designed specifically for firefighting agents can improve the current firefighting capability following an airbase attack. Additionally, configuring agents, both fire department stock and base supply special level, for rapid dispersal would increase this critical material's probability of surviving an attack. Furthermore, the 10-metric ton Halon storage tanks used in Europe must be splinter protected, since they cannot be dispersed.

4. Auxiliary Equipment

Fire department auxiliary equipment is as important as vehicles and agents to the fire department's support of base recovery after attack. This equipment must be protected and must survive an airbase attack. The following equipment requires protection:

a. Self-Contained Breathing Apparatus.

Without adequate SCBA, firefighters cannot enter a toxic or oxygen-deficient atmosphere to combat fires or to effect rescue.

b. SCBA Spare Cylinders.

These cylinders are essential to fire protection support of base recovery in the postattack environment. The 30-minute SCBA supply cylinders actually last less than one-half that time.

c. Air Compression(s) and Air Purification Equipment.

This equipment is critical to reservicing the equipment previously listed. While the new rebreather under development by AFESC will reduce the reservicing requirement, it will still be required.

d. Fire Hose.

Fire hose is expected to be ruined frequently by debris, fires, or abandonment to respond to higher-priority emergencies. It is critical that spare hose be available and protected to survive an airbase attack.

e. Spare Tires and Wheels.

Fire departments usually have available only one spare tire and wheel of each type available. Debris, bomblets, bomb fragments, etc., are expected to frequently ruin vehicle tires. Fire departments must possess an adequate number of spare tires and wheels, and these items must be protected.

f. Fuel Supplies for Fire Vehicles.

Fuel supplies are critical to the department's support of sortie generation. In the postattack environment, the fire department must have enough fuel for several days. Fuel supplies are expected to be limited, as a result of damaged tanks, damaged distribution systems, electrical power loss, etc. Consequently, fire-protection vehicle fuel supplies must be protected. The tanks also should be equipped with hand-pumps to eliminate the need for electricity refueling.

g. The Fire Communications Center.

The Fire Communications Center (FCC) is the fire protection operations nerve center and must be protected to allow continued operations following an attack. The fire department cannot adequately support aircraft

launch, recovery, barrier engagements, rescue, and firefighting without an operational FCC to establish priorities and to control vehicle response.

h. The Fire/Crash Radio Net.

This radio net is critical to the fire department's success in the postattack environment. The base radio station and repeater units are usually at different locations throughout the base. These units must be protected to increase the probability of the radio net functioning in the postattack environment. Without reliable communications, there cannot be a coordinated effort to extinguish fires, rescue trapped personnel, and to quickly return the base to an operational condition.

E. IMMEDIATE RESPONSE CAPABILITY

AFESC has an effort underway to design fire vehicle hardening. This project is needed to move the fire vehicle from the protected area to the fire site along the fastest and safest path. Protecting the vehicles will allow fire equipment to get to the fire or rescue site.

The air-cushioned vehicle will further negate the impact of unexploded ordnance, debris, pavement damage, and soil and weather conditions.

It also may be necessary to devote EOD personnel to CFR vehicles or to train firefighters in the EOD function for wartime operations.

F. CHEMICAL ENVIRONMENT

1. Proximity Suits

Firefighters cannot perform effectively in a chemical environment. Fire-proximity suits and chemical ensembles do not allow firefighters to operate in both oxygen-deficient and CW atmospheres. The proximity suit and rebreather under development by AFESC will provide this capability.

2. Survivable Collective Protection System

A SCPS configured for fire protection requirements will have a major impact on fire protection's support for aircraft launch and recovery. AFESC has an effort underway to reconfigure SCPS to meet fire protection and EOD needs. This project will develop decontamination processing procedures, and equipment required for firefighters and EOD personnel to use the SCPS.

3. Self-Contained Breathing Apparatus

SCBA cannot be reserviced in a chemical environment. As part of the SCPS effort, the technology and procedures to reservice SCBA while confined to the SCPS will be developed.

4. Vehicles

Fire vehicle crew compartments are not designed for operation in a chemical environment. Firefighters in the vehicles are protected from liquid agents but not from gaseous forms of chemical agents. A study should be conducted to determine the feasibility of equipping CFR vehicles with positive-pressure, sealed crew compartments or with a filtering system. The filtering system would allow firefighters to conserve both SCBA and stored air pressure until it is necessary to leave the vehicle to perform firefighting and rescue.

G. COMMAND, CONTROL AND COMMUNICATIONS

Reliable communication in the postattack environment is a key element to fire protection's support of sortie generation. Fire communications usually are consolidated in one location. A project should be initiated to develop the following:

1. A Small, Hardened, Communications Van

This van could be a backup to the main FCC, and for a bare-base operation. It should be C-130 transportable, equipped with programmable radios and cellular telephones, and capable of being put into operation by providing electrical power and raising antennas. The Tinker AFB fire department has partially developed such a communications unit. Their concept deserves additional evaluation and testing.

2. Postattack Fire Response Assessment and Direction System

This system will give senior commanders and the fire chief real-time information in a wartime environment. This system should be developed to provide the people in decision-making positions, (Wing commanders, SRC staff, fire chief) with the status and locations of critical fire resources. The system should have the capability to automatically dispatch the most available units(s) to the most required firefighting or rescue locations.

H. PLANS AND POLICY

1. Weapons Laydown for Training/Evaluation

CBAM should be programmed to be user-friendly and to run on desk-top computers. The system should include the necessary software to make automatic calculations for bomb and aircraft type in relation to airfield damage. When completed, this system could be used to create training exercises based on the real threat, tasking fire-protection personnel in the same manner they will be tasked in wartime. This system will allow firefighters to train as they will fight.

2. Crash/Fire/Rescue Vehicle Time-Phased Force Deployment Listing

Additional CFR vehicles will be required in a theater of operations to support aircraft sorties, multiple fires, increased risk, standby services,

and to replace vehicles lost through attrition. An automated system should be developed to handle all aspects of replacing vehicles in a theater of operations. The system should include vehicle reliability, location, and the most expedient means to move the vehicle.

3. Materials

Fire protection materials are based on peacetime operations and vehicle capacities. A study should be performed to determine the agent levels and other equipment required to support fire department operations in a wartime environment. The following material levels should be evaluated.

a. Aqueous Film-Forming Foam

Past experience has shown that on-hand AFFF is inadequate for POL storage tank fire suppression. Agent requirements should be based on the threat, damage, attrition, and AFFF required to extinguish all fires in the postattack environment. Vehicle capacities are not valid indicators of AFFF requirements.

b. Halon and Dry Chemical

Halon and dry chemicals, requirements, like AFFF, are based on peacetime requirements and vehicle capacities. On-hand supplies could be inadequate to support wartime operations. These agents should be evaluated, similar to AFFF, to establish the agent amounts required for a wartime operation.

c. Ancillary Fire-Protection Equipment.

As with agents, ancillary fire protection equipment is based on peacetime requirements and may be inadequate. Consequently, this equipment should be evaluated in the same manner as agents and the required equipment levels adjusted, as necessary. The equipment requiring evaluation includes proximity suits, SCBA, fire hose, rescue tools, and air-purification equipment.

4. War-Readiness Support Kits

Fire vehicle spare parts, both bench stock and special levels, like agents, are based primarily on peacetime operations. A study should be performed on the CFR fleet to determine the vehicle parts expected to fail in a wartime operation. From these results, a spare parts kit should be developed, similar to the kits established for aircraft. The vehicle analysis could be performed using the available VRAMIS. This support kit should be positioned at each high-threat base or area.

5. Mitigation Pamphlet

A postattack mitigation pamphlet and checklist should be developed and provided to each USAF fire chief and fire protection Prime BEEF command and control team. The pamphlet should contain extracted unclassified sections

of the SALTY DEMO report and the AFESC Postattack Assessment, along with a checklist for wartime fire protection.

I. WATER DISTRIBUTION SYSTEM

The base water distribution system requires special attention. Past experience has shown that water for firefighting will be in short supply in the postattack environment. Water is critical to fire protection's contributions to recovering the base after attack. Accordingly, the following actions should be taken:

1. Parts lists and procedures should be developed. The parts should be stocked, and training conducted to expedite water distribution system repairs in the postattack environment. AFESC has a planned effort to develop expedient utility repairs.

2. A study should be performed to determine the most effective means for increasing the availability of water for firefighting in the postattack environment. Alternative water sources include the following:

- a. Deep wells equipped with high-speed pumps and quick-reservicing equipment.
- b. Underground water reservoirs, both on and off base.
- c. Strategically located and protected water bladders.
- d. Increasing the base tanker fleet.
- e. Swimming pools, cooling towers, and sound suppressors be equipped with pumps and fire department connections, to improve the probability of water availability.
- f. A redundant water system.
- g. Looped water distribution systems.

J. INSTALLED SYSTEMS

AFESC has a study underway to estimate the value of installed fire suppression systems and their contributions to sortie generation. The study primarily addresses HAS. It should be expanded to include mission critical facilities that contribute most to sortie generation. The study should focus on using RF transmission equipment to provide a quick facility assessment during the trans and postattack.

K. TRAINING

In the postattack environment, the fire department must accomplish its job with extensive damage to the base, in a CW environment, with numerous casualties, while suffering attrition of firefighters, equipment, and agents. Peacetime operations do not adequately prepare firefighters for the wartime

environment. Consequently, warfighting should become the number one priority. Increased training should be developed and provided to all CONUS military firefighters. A concentrated effort must be made to determine exactly what will be required of firefighters in the wartime environment, and the funding resources required for all training requirements.

1. Deployment Task/Lesson Plans

A task list of everything firefighters are expected to do in a contingency operation should be developed. From this list, the Detachment 2 Lesson Plan should be changed, if necessary, and the task list included in AFR 92-1 and AFR 93-3 for Prime BEEF home station training.

2. Training Scenarios/Exercise Kit

Local exercises, such as SALTY Nations, IG, etc., usually do not task fire protection to the level needed during combat. Accordingly, a realistic exercise kit, based on SALTY DEMO and the postattack assessment, should be developed and provided to the MAJCOMS.

3. Wartime Training Videos

Videos are today's recognized media for training. Several videos could be produced that would have a major impact on fire-protection readiness. They include specific or combined videos on the following:

- a. Command and Control,
- b. Fire Responses to Different Wartime Situations,
- c. POL and Munitions-Area Firefighting,
- d. Ordnance,
- e. Rescue for Fighter Aircraft,
- f. Weapons Effects, and
- g. HAS Fire System.

As appropriate, these videos could be matched with the WMP, used at Detachment 2, and each Prime BEEF Team supplied with video programs consistent with their deployed location.

4. Training Courses

The firefighters postattack environment and concept of operations should be included in certain Air Training Command and Air Force Institute of Technology courses, specifically, the Fire Marshal Orientation, Base Commanders Course, Contingency Engineering Course, and the Fire Chiefs Technology Course. The individuals attending these courses must be aware of

the postattack environment. Exposing them to this environment will assure their support in better preparing firefighters for the postattack environment.

5. Firefighter Training Plan

Training requirements are listed in several places, e.g., AFR 92-1, 93-3, International Fire Service Training Association, and MAJCOM supplements. Some requirements are the same, others are not, and no single reference source outlines the requirements and curricula. A single document would ensure that all firefighters are trained in wartime firefighting to the same level, ensuring capable, proficient Prime BEEF teams that could integrate into host departments without extensive in-theater training.

L. BOMB-DAMAGED HAS DOORS

Quick access to HAS by firefighters is critical to preventing a small, insignificant fire from turning into a disastrous situation. Access to HAS during normal conditions is time-consuming; with damaged doors, pavement upheaval, etc., it becomes impossible. Consequently, a study should be initiated to determine the feasibility and to identify methods and equipment for opening damaged HAS doors.

M. BASE ELECTRICITY

Electricity will be one of the main ignition factors in bomb-damaged facilities. Consequently, eliminating this ignition factor will significantly reduce the severity of the firefighters' postattack environment. A study should be initiated to design, develop, test, and to verify a single system to shut down all base electricity.

N. OTHER PROJECTS

1. Reduced AFFF Percentages

The more agent fire vehicles can contain without reservicing, the more effective the vehicles are in the postattack environment. Testing and evaluating lower percentage AFFF will reduce reservicing and will require a smaller splinter-protected area.

2. Improved AFFF

A study should be performed to determine if AFFF's density and application rates can be improved. AFFF, with a faster extinguishing time, would allow postattack fires, especially POL tanks, to be extinguished faster.

3. Automatic Oscillation Turrets

Manually operated vehicle turrets should be replaced with automatically oscillating turrets. Such a device could have a major impact on postattack fires because the agent could be used more effectively, resulting in crews being able to extinguish more fires before the vehicle requires reservicing.

4. New Agents

A conceptual study should be initiated to explore new extinguishing agents. Future aircraft probably will not use hydrocarbon fuels, and if the change from hydrocarbon fuels occurs, effective fire protection must be available. New aircraft fuel may require new agents and delivery systems.

5. Remote-Controlled Fire Vehicles

A study should be initiated to solve problems associated remote-controlled fire vehicles. When the problems are solved, remote controlled vehicles should be tested for fire protection use in the postattack environment. Such vehicles can be particularly valuable in the environment involving weapons.

REFERENCE LIST

1. Gearhart, J. J., et al., SALTY DEMO Rapid Runway Repair Capability Demonstration, ESL-TR-85-53, Vol. I, Engineering and Services Laboratory, Air Force Engineering and Services Center, Tyndall AFB, FL, June 1987, SECRET.
2. Storm, J. H., Freathy, A. L., and Patterson, R. E., Firefighting Postattack Assessment (U), BDM/W-85-0794-TR, The BDM Corporation, 7915 Jones Branch Drive, McLean, VA, December 1985, SECRET.
3. Miller, C. F., Firefighting Operations in Hamburg, Germany During World War II, URS 7004 URS Research Company, 1971.
4. McAliffe, J., and Moll, K., Secondary Ignitions in Nuclear Attack, Stanford Research Institute, SRI Project 5106, July 1965.
5. Blain, B. J., Tornado Structural Damage Report, U.S. Weather Bureau, August 1957.
6. Vodvanka, F. J., Full-Scale Burns in Urban Areas, URS Work Unit 2534E, "Fire Spread Between Structures," The Research Institute, June 1965.
7. Martin, S. B., Ramstad R. W., Goodale T., and Start C. A., Effects of Airblast on Urban Fire Response, URS Research Company, URS 705-5, May 1969.